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MONETARY AND FISCAL POLICIES IN BRAZIL AND THE BEHAVIORAL APPROACH UNDER THE INFLATION-TARGETING REGIME

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Thesis submitted to the Postgraduate Program in Economics of the Faculty of Economics, Administration, Accounting, and Public Policy Management of the University of Brasília as a requirement for the degree of Doctor of Economics.

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“O mercado se rege por critérios de eficiência e rentabilidade, não de justiça ou de equidade. Ele é um soberbo órgão de criação de riqueza, mas não um mecanismo competente de distribuição de renda” (José Guilherme Merquior).

RAPHAEL JOSÉ PEREIRA FREITAS

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Ministry of Planning and Budget - MPO)

To my beloved mother,

Your unwavering faith in me has guided me along the paths of education and personal fulfillment. You have always been by my side. Your unconditional love weaves the pages of my story. I dedicate this Thesis to the woman who taught me that dreams are like chapters in an endless book, and that with perseverance and passion, you can write your own successful narrative.

May every discovery and achievement represented in this Thesis be a tribute to your love, your wisdom, and your unwavering belief in me.

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ABSTRACT

This Thesis examines the interaction between monetary and fiscal policies in Brazil, focusing on the implications of bounded rationality in economic modeling. It seeks to compare the impacts of rational and behavioral approaches on macroeconomic variables in response to policy shocks, aiming to provide a deeper understanding of Brazil's economic dynamics. The study utilizes a new Keynesian Dynamic Stochastic General Equilibrium (DSGE) model with Bayesian estimation, analyzing quarterly data spanning from 2000Q1 to 2023Q4. The model evaluates the differential responses of macroeconomic variables — GDP, primary surplus and deficit, private consumption, inflation, public debt and interest rate — under rational and behavioral approaches. The analysis reveals that, while the rational approach is theoretically consistent, its assumptions of instantaneous adjustments and fully rational agents render it less applicable to Brazil's economic context. In contrast, the behavioral approach better captures the gradual adjustments and adaptive responses of economic agents, accounting for cognitive limitations and biases. This research contributes to the field of behavioral macroeconomics by applying the concept of bounded rationality to Brazil, an economy marked by structural volatility and adaptive policy dynamics. Finally, by integrating recent scenarios, such as the effects of the COVID-19 pandemic, this manuscript broadens the understanding of how economic shocks impact selected macroeconomic variables. As a result, it not only advances theoretical economic modeling but also serves as a practical tool to guide the formulation of more effective public policies tailored to the complexities of the Brazilian economy.

Keywords: Bayesian inference; Cognitive biases; Economic forecasting; Fiscal-monetary interaction.

POLÍTICAS MONETÁRIA E FISCAL NO BRASIL E A ABORDAGEM COMPORTAMENTAL SOB O REGIME DE METAS PARA A INFLAÇÃO

RESUMO

Esta Tese examina a interação entre as políticas monetária e fiscal no Brasil, com foco nas implicações da racionalidade limitada na modelagem econômica. O objetivo é comparar os impactos das abordagens racional e comportamental sobre variáveis macroeconômicas em resposta a choques de política, buscando proporcionar uma compreensão mais profunda das dinâmicas econômicas do Brasil. O estudo utiliza um modelo DSGE novo-keynesiano com estimativa Bayesiana, analisando dados trimestrais de 2000T1 a 2023T4. O modelo avalia as respostas diferenciais de variáveis macroeconômicas — PIB, superávit e déficit primário, consumo privado, inflação, dívida pública e taxa de juros — sob as abordagens racional e comportamental. A análise revela que, embora a abordagem racional apresente consistência teórica, suas suposições de ajustes instantâneos e agentes plenamente racionais a tornam menos aplicável ao contexto econômico brasileiro. Por outro lado, a abordagem comportamental captura de forma mais precisa os ajustes graduais e as respostas adaptativas dos agentes econômicos, considerando as limitações cognitivas e os vieses comportamentais. Esta pesquisa contribui para o campo da macroeconomia comportamental ao aplicar o conceito de racionalidade limitada ao Brasil, uma economia marcada por volatilidade estrutural e dinâmicas de políticas adaptativas. Por fim, ao integrar cenários recentes, como os efeitos da pandemia de COVID-19, esta pesquisa amplia a compreensão sobre como choques econômicos afetam as variáveis macroeconômicas analisadas. Assim, o manuscrito não apenas avança a modelagem econômica teórica, mas também serve como uma ferramenta prática para orientar a formulação de políticas públicas mais eficazes, adaptadas às complexidades da economia brasileira.

Palavras-chave: Inferência bayesiana; Vieses cognitivos; Previsão econômica; Interação fiscal-monetária.

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
BNDES	National Bank for Economic and Social Development - Brazil
CPI	Consumer Price Index
DSGE	Dynamic Stochastic General Equilibrium
FOCs	First Order Conditions
GDP	Gross Domestic Product
Gov't	Government
H0	Null Hypothesis
H1	Alternative Hypothesis
IES	Intertemporal Elasticity of Substitution
IPCA	Brazilian consumer price index
IRFs	Impulse Response Functions
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
MMC	Maximized Monte Carlo
NZSIM	New Zealand's Structural Inflation Model
PAC	Brazilian Growth Acceleration Program
PP	Phillips-Perron
Post.	Posterior
RAMSES	Sweden's Riksbank Aggregate Macromodel for Studies of the Economy
SD	Standard deviation
Selic	*Sistema Especial de Liquidação e Custódia*
SPE	Economic Policy Secretariat - Brazil
ToTEM	Canada's Terms-of-Trade Economic Model
US	United States of America
VAR	Vector Autoregressive

CONTENTS

1 INTRODUCTION

The interaction between fiscal and monetary policies plays a crucial role in determining an economy's macroeconomic stability and growth. Over the years, both policymakers and economists have debated the efficacy of different approaches to managing this interaction, with the rational expectations model serving as the foundation for much of the traditional analysis. However, recent advancements in economic modeling have emphasized the importance of integrating behavioral elements, which account for bounded rationality and cognitive biases that influence decision-making processes among economic agents.

In this context, this Thesis delves into the complexity of these interactions by comparing the effects within both the rational and behavioral approaches. To this end, we utilize a new Keynesian DSGE model with Bayesian estimates tailored to the Brazilian economy. Using quarterly data spanning from 2000Q1 to 2023Q4, this study highlights how agents' responses to fiscal and monetary policy shocks vary under rational versus behavioral assumptions. It is also important to note that this manuscript represents an extended and revised version of Freitas (2025).

The core hypothesis of this research suggests that the behavioral approach, which includes aspects of bounded rationality and cognitive biases, more accurately reflects the historically observed behavior of Brazilian economic policies compared to the purely rational approach. This assumption is grounded in the observation that Brazilian economic policies tend to exhibit more gradual and adaptive responses to changes, which is characteristic of behavioral dynamics.

This Thesis does not adopt the assumption of full employment, relying instead on a new Keynesian model that incorporates nominal rigidities and labor market frictions. While situated within the orthodox macroeconomic tradition, due to its use of microfoundations and rational expectations, the new Keynesian approach diverges from traditional neoclassical models by acknowledging that such imperfections can prevent automatic market adjustment and the attainment of full employment, resulting in involuntary unemployment. This perspective is particularly relevant in the context of the Brazilian economy, which is characterized by fiscal volatility, inflationary pressures and behavioral responses from economic agents.

The findings highlight that the behavioral approach offers a more accurate representation of Brazil's economic dynamics by accounting for cognitive biases and adaptive behaviors that are fundamental to real-world decision-making. While the rational approach provides valuable theoretical perspectives, its reliance on assumptions of fully rational agents and instantaneous adjustments proves misaligned with the realities of economic behavior, particularly within the Brazilian context.

By incorporating bounded rationality, the behavioral approach captures the nuanced ways in which economic agents respond to shocks, emphasizing the gradual adjustments and behavioral approaches observed in practice. This perspective does not diminish the theoretical appeal of rational approaches but highlights that their assumptions are less suited to the complexities of real-world economies. Recognizing that unlimited rationality is an idealized construct, this study broadens the understanding of economic dynamics and policy interactions, particularly in Brazil.

Ultimately, this research emphasizes the importance of integrating behavioral elements into macroeconomic models to better capture the realities of fiscal and monetary policy interaction. This approach provides a foundation for developing more effective and adaptive policy strategies that align with the distinctive characteristics of Brazil's economic environment.

It is crucial to clarify that this study does not aim to explore scenarios of fiscal or monetary dominance, nor does it delve into issues related to the zero lower bound on nominal interest rates. Instead, this research highlights the importance of considering the interaction between monetary and fiscal policies, recognizing that the impact of one policy cannot be fully understood without accounting for the influence of the other and the broader economic environment.

Due to the complexity of the subject and the broad scope of interactions between fiscal and monetary policies, we opted to present this work in a book format, rather than the essay-based approach typically used in thesis. The book format allows for a deeper and more detailed exploration of both theoretical and empirical aspects, providing sufficient space to extensively discuss both the theoretical foundations and the analysis of data and results. This structure ensures better organization of the chapters and allows for a cohesive development of ideas and remarks, aligning with the importance of the topic. Moreover, it provides room for a presentation of the Brazilian economic landscape during the analyzed period.

In addition to this Introduction, this Thesis comprises six further chapters. Chapter 2 provides a literature review, while Chapter 3 examines the behavior of the Brazilian economy in recent years. Chapter 4 details the methodology and model framework. Chapter 5 presents the data. Chapter 6 discusses the results, focusing on the impacts of positive shocks to both the nominal interest rate and government consumption. Finally, Chapter 7 offers concluding remarks.

2 BACKGROUND ON MONETARY AND FISCAL POLICIES

The effectiveness of monetary policy in strengthening the credibility of monetary authorities has been a pivotal area of study within macroeconomics. Seminal papers such as Kydland and Prescott (1977) on the rules versus discretion approach, Barro and Gordon (1983a, 1983b) on reputation and Rogoff (1985) on the principles of autonomy, transparency and delegation, have significantly influenced the evolution of monetary policy structures. This academic discourse paved the way for the adoption of inflation targeting regimes, with New Zealand's early 1990s model serving as a notable example. These frameworks aimed to enhance the credibility of monetary authorities through the establishment of clear policy guidelines, aligning with theoretical models like Taylor's (1993) rule and Woodford's (2001) analysis of optimal interest rate rules.

The integration of fiscal policy into this discourse has increasingly gained traction, recognizing that monetary and fiscal policies can either counterbalance or complement each other. Expansionary fiscal policies can boost aggregate demand and potentially increase inflation, while contractionary monetary policies, through higher interest rates, can dampen aggregate demand and help control inflation. Uncoordinated policies may lead to undesirable outcomes such as excessive inflation or economic downturns. This growing awareness led to a surge in research focusing on the interactions between monetary and fiscal policies, such as the pioneering paper of Sargent and Wallace (1981), which introduced the concepts of monetary and fiscal dominance and highlighted the importance of policy coordination.

Alesina and Tabellini (1990) explore how alternating policymakers with different preferences use government debt strategically in an economy influenced by electoral outcomes. Their analysis shows that each government accumulates debt to influence the policy choices of future administrations, particularly in terms of government spending. Leeper (1991) investigates the interactions between monetary and fiscal policies in a stochastic framework, identifying policies as either active or passive based on their response to government debt shocks. Leeper's setup provides a foundation for understanding fiscal financing's role in price determination and policy interactions. Sims (1994) improves on Leeper (1991) by moving beyond his analysis of local linear approximations to the full model solution. Ball and Mankiw (1995) propose a theory that explains supply shocks and their impact on the short-run Phillips curve through relative-price changes and nominal price adjustment frictions. They show that inflation is influenced by the distribution of relative-price changes.

The theoretical landscape expanded with contributions from Alesina and Tabellini (1990), Leeper (1991), Sims (1994), Ball and Mankiw (1995), Woodford (1995, 2003) and

Cochrane (2001), culminating in the development of the Fiscal Theory of the Price Level. This theory illustrates how public debt levels can influence price levels even in scenarios where monetary policy remains unaffected by fiscal dominance.

The new Keynesian literature highlights not only the need for optimal interaction between monetary and fiscal policies but also stresses that both must operate under a unified intertemporal government budget constraint. Building on this perspective, researchers such as Bénassy (2003), Benigno and Woodford (2003), Muscatelli, Tirelli and Trecroci (2004), and later Schmitt-Grohé and Uribe (2004, 2007), Persson, Persson and Svensson (2006) and Çebi (2012) expanded the analysis by demonstrating how the interdependence of policy actions directly shapes macroeconomic stability and the transmission of shocks across the economy.

In Brazil, several studies have analyzed the interplay between monetary and fiscal policies and their impact on economic growth. For instance, Hillbrecht (2001) highlights that the adoption of an efficient inflation-targeting regime is necessarily linked to the joint coordination of monetary and fiscal policies. Similarly, Mendonça (2003) views such coordination as a more suitable framework for achieving Brazil's macroeconomic objectives. Fialho and Portugal (2005) examine, via Vector Autoregressive (VAR) models, the presence of monetary or fiscal dominance regimes in Brazil following the "Real Plan". They conclude that coordination between policies did occur, but it was sustained by a substitution of roles, with monetary policy being predominant for most of the period analyzed. Santos *et al*. (2015) examined the relationship between monetary and fiscal policies and Brazilian GDP growth spanning from 2000 to 2014, highlighting the significant role of policy variables. De Paula, Modenesi and Pires (2015) investigated policy coordination during the international financial crises, noting varying effectiveness across different crises.

Afonso, Araújo and Fajardo (2016) analyze the origins and evolution of monetary and fiscal institutions in Brazil, focusing on the framework for inflation control, and conclude that, in addition to the "Real Plan", other institutional reforms were also decisive for achieving monetary stabilization. Carvalho *et al*. (2016) estimate the direct and indirect fiscal costs of positive interest rate shocks using VAR models with data ranging from 2003 to 2013. Their findings indicate that, given the significant stock of international reserves, fiscal costs emerge from a more restrictive fiscal policy operating through the exchange rate channel, underscoring the need for effective coordination rather than merely slowing the pace of reserve accumulation. The evolution of monetary policy and its interaction with fiscal stimuli was further explored by Barros and Lima (2018), providing insights into policy dynamics over time. Finally, Melo and Gomes da Silva (2019), using the GMM System for the period from 2003 to 2017, investigate the interaction between these policies and identify a countercyclical monetary stance, although they find no evidence of full coordination between monetary and fiscal instruments.

In the Latin American context, Sánchez *et al*. (2018) examine the effects of fiscal and monetary policies on inflation and public debt in Mexico from 1981 to 2016, employing a Markov-switching DSGE model. Their results suggest that monetary dominance throughout the entire period would have reduced the average inflation rate to 13.2%, below the observed rate, whereas full fiscal dominance would have led to an inflation rate of 42% and a public debt level five times higher than recorded.

Regarding the use of DSGE models by central banks, there is wide international adoption, including Canada's Terms-of-Trade Economic Model (ToTEM), Sweden's Riksbank Aggregate Macromodel for Studies of the Economy (RAMSES), Norway's Norwegian Economy Model, Chile's Extended Model for Analysis and Simulations, Colombia's Policy Analysis Tool Applied to Colombian Needs and New Zealand's Structural Inflation Model (NZSIM). In Brazil, the Stochastic Analytical Model with a Bayesian Approach (SAMBA) has been developed by the Central Bank of Brazil. These models have proven valuable tools for both monetary authorities and academic researchers.

For example, Cateau *et al.* (2009) use the ToTEM to evaluate welfare gains from shifting from inflation targeting to price-level targeting under imperfect credibility, finding that such gains reverse after 13 years. Adolfson *et al*. (2011, 2014) explore the RAMSES model to design optimal policy projections and assess the trade-off between stabilizing inflation and the output gap in Sweden, emphasizing that outcomes depend on the measure of potential GDP used in the loss function. Kamber *et al*. (2016) estimate the NZSIM for New Zealand and demonstrate that foreign shocks account for more than one-third of the country's GDP growth, while models with adaptive expectations outperform those with rational expectations. Lastly, Fasolo *et al*. (2024) present an updated version of the Brazilian SAMBA model, which is utilized for macroeconomic projections and monetary policy analysis and incorporates price stickiness and structural shocks characteristic of the Brazilian economy.

Finally, the emergent field of behavioral economics, which gained prominence through the seminal papers of Thaler (1980) and Kahneman (2003), began to challenge traditional economic paradigms by emphasizing the influence of cognitive and emotional biases on decision-making. This evolution laid the foundation for behavioral macroeconomics, integrating psychological insights into macroeconomic models traditionally grounded in rational expectations.

Building on this foundation, Andrade, Cordeiro and Lambais (2019) explored a behavioral shift within the new Keynesian approach, focusing on how agents perceive the future (or, more precisely, how they might fail to fully comprehend it). Their introduction of the concept of "cognitive discounting" demonstrates that individuals undervalue distant future events, undermining standard assumptions about forward-looking behavior in macroeconomic modeling. Subsequently, Dotta and Andrade (2021) constructed and estimated a behavioral new Keynesian DSGE model tailored to the Brazilian economy. Their manuscript incorporates bounded rationality for households and firms and simulates scenarios of monetary and fiscal dominance, generating insights for improving coordination between these policies in emerging markets.

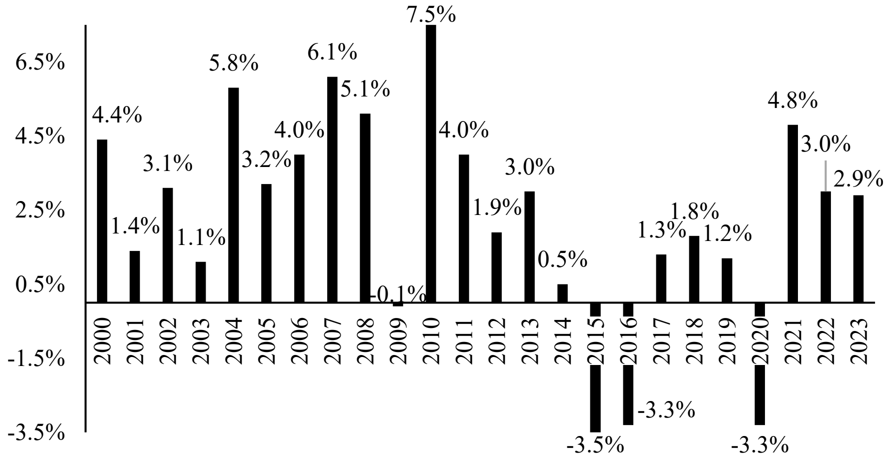
In parallel, Hirose *et al*. (2023) advanced the literature by employing a behavioral new Keynesian model that also incorporates the zero lower bound on nominal interest rates. Using a Bayesian nonlinear approach with US data, they found that models embedding behavioral elements outperform purely rational models. Their findings reveal notable bounded rationality among both households and firms, which expands the conditions for credible estimation and reduces the effectiveness of forward guidance policies. Complementarily, Benchimol and Bounader (2023) examined how cognitive and emotional biases shape macroeconomic policy outcomes, advocating for a more holistic policy framework that integrates behavioral elements into the design and evaluation of economic measures. Their study reinforces the relevance of considering human behavior when analyzing policy effectiveness, especially in volatile macroeconomic environments.

Most recently, Freitas (2025), presented in an abridged and less comprehensive form of this Thesis, analyzed the interaction between monetary and fiscal policies in Brazil, focusing on how rational and behavioral responses of agents affect key macroeconomic variables such as GDP, inflation and consumption. Using a DSGE model with data spanning from 2000 to 2022, he examined how shocks to public spending and interest rates propagate throughout the Brazilian economy, offering an updated perspective on policy transmission under behavioral dynamics.

3 BRAZILIAN ECONOMY UNDER THE INFLATION-TARGETING REGIME

In the early 2000s, the Brazilian economy experienced a significant period of growth, culminating in a 5.8% expansion of GDP in 2004, as depicted in Figure 1. This growth occurred alongside well-managed inflation rates, detailed in Figure 2.

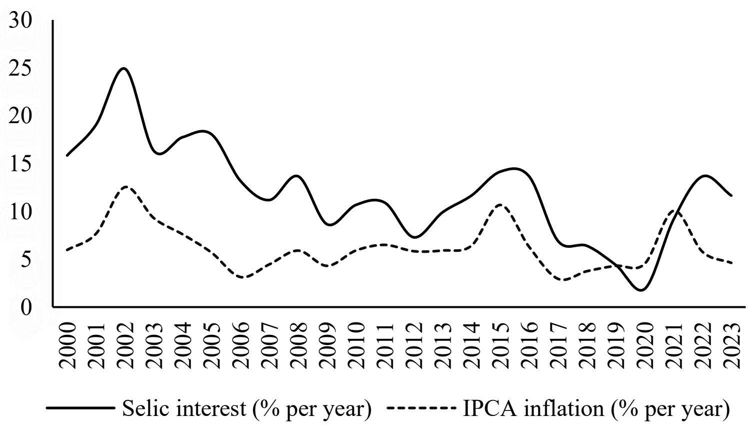
Figure 1 - GDP (% per year)



Source: Brazilian Institute of Geography and Statistics (2024b).

These achievements were largely due to the effective implementation of economic policy measures. A pivotal moment came in 2008, when Brazil's sovereign credit rating was upgraded to investment grade, which contributed to a decrease in interest rates, as shown in Figure 2. This upgrade, along with the influence of three rounds of quantitative easing by the US Federal Reserve, played a significant role in the appreciation of the Brazilian Real during this time.

Figure 2 - Selic interest rate (% per year) and IPCA inflation (% per year)



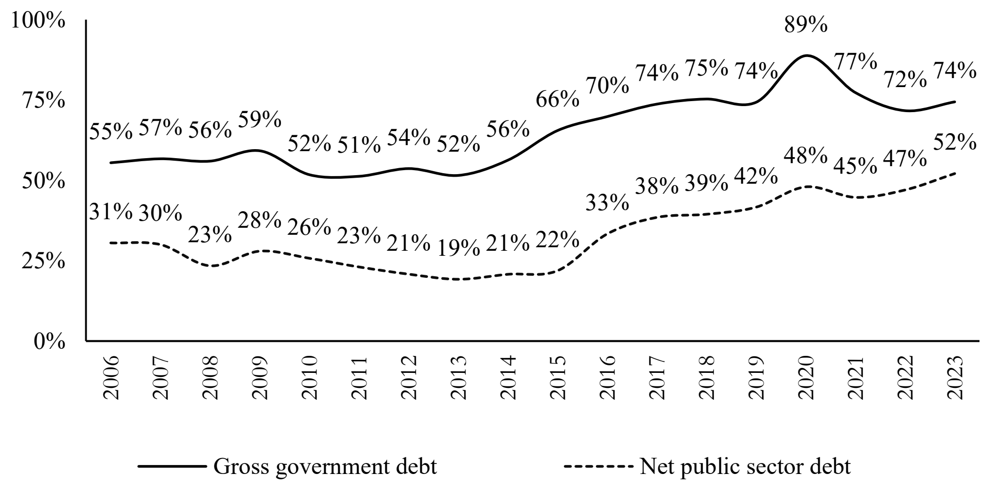
Sources: Central Bank of Brazil (2024e) and Brazilian Institute of Geography and Statistics (2024a).

The international financial crisis of 2008 profoundly impacted Brazil, leading to a slight contraction of -0.1% in GDP in 2009 (Figure 1). In response, the Brazilian government, through the Economic Policy Secretariat - Brazil (SPE, 2010), enacted a series of countercyclical measures from 2008 to 2010 aimed at stabilizing the economy:

- Fiscal relief measures: These included tax reductions on financial transactions, industrial products and contributions to social security financing;
- Economic stimulus initiatives: Notably, the Brazilian Growth Acceleration Program (PAC) and the "My House, My Life" housing initiative;
- Support from state-owned banks: Various actions to bolster economic stability and growth; and
- Monetary stimulus measures: Reductions in reserve requirements and cuts in the Selic interest rate.

These measures mirrored those adopted in other countries facing similar economic downturns. By early 2011, coinciding with the inauguration of a new president, Brazil's economic outlook was optimistic. The country had recovered swiftly from the 2008 crisis, with the GDP surging by 7.5% in 2010. Building on the previous administration's efforts, the new government continued with economic stimulation policies. In 2012, it launched the "Greater Brazil" Plan, a comprehensive strategy aimed at enhancing the national economy (SPE, 2011).

Figure 3 - Public debt (% of GDP)

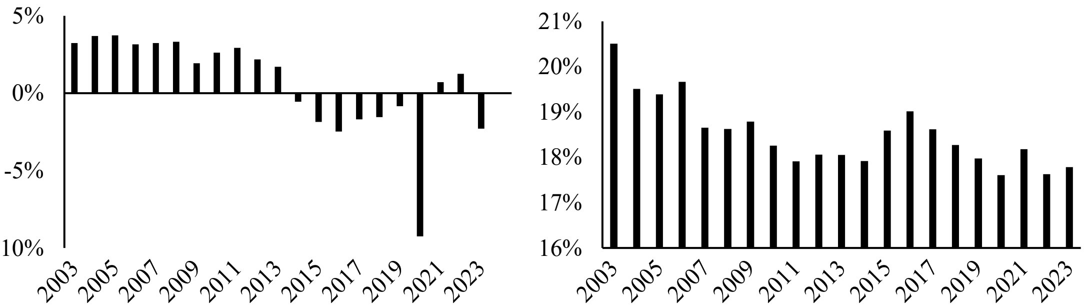


Sources: Central Bank of Brazil (2024b, 2024d).

Additionally, the government leveraged the National Bank for Economic and Social Development - Brazil (BNDES) to promote the expansion of select firms, dubbed "national champions". Under this initiative, the National Treasury Secretariat issued public debt securities and transferred the proceeds to BNDES, which then provided these selected companies with loans at preferential interest rates. This policy significantly impacted public finances, leading to a marked increase in the government's gross debt, as illustrated in Figure 3.

During this period, Brazil implemented several interventions to address economic challenges. Notably, the Tax on Financial Operations was increased and adjustments were made to the exchange rate system in response to the "Currency War". This term refers to the significant influx of capital primarily resulting from quantitative easing measures in developed countries (SPE, 2012). The Brazilian macroeconomy management involved various interventions such as boosting consumption through state-owned banks, artificially reducing prices in the energy sector, and controlling administered prices for public transportation and gasoline. These measures, which included Contributions for Economic Domain Intervention and price controls at refineries, aimed to delay price adjustments and consequently limit the increase in IPCA inflation.

Figure 4 - Primary result (% of GDP) and government consumption (% of GDP)



a) Primary result (% of GDP, 12-month basis) b) Government consumption (% of GDP)

Sources: Central Bank of Brazil (2024c) and Brazilian Institute of Geography and Statistics (2024b).

Despite these efforts, the inflation eventually reached the target's upper limit in 2011 (6.5% per year) and 2014 (6.4% per year). After necessary price adjustments and facing international shocks in food prices, inflationary pressures surged to double-digit levels (10.67% per year) in 2015, as illustrated in Figure 2. A fiscal expansion characterized this period, with significant measures involving benefits and tax exemptions impacting Brazil's public accounts, particularly affecting primary surpluses and debt levels as shown in Figures 3 and 4. Notable was the reduction in payroll taxes, which had a fiscal impact estimated at R$100 billion from 2011 to 2018 and tax exemptions amounting to approximately R$466 billion from 2011 to 2015 (Gomes da Silva; Fishlow, 2021).

In 2009, a trend of decreasing public debt was observed, particularly in gross government debt. However, this trend reversed in 2011, primarily due to resource transfers to

BNDES and a significant increase in repurchase agreements by Central Bank of Brazil. With growing budgetary constraints, the government resorted to fiscal maneuvers, which were later deemed irregular by the Federal Court of Accounts, leading to a substantial increase in public debt (Figure 3). The challenges intensified with the corruption investigations of "Operation Car Wash", significantly eroding trust among economic agents and contributing to a severe recession with GDP contractions of -3.5% in 2015 and -3.3% in 2016 (Figure 1).

External factors such as the slowdown of the Chinese economy, declines in commodity prices and the beginning of interest rate hikes in the US exacerbated the economic downturn. Despite measures taken by the new government that took office after the impeachment of President Dilma Rousseff to roll back fiscal incentives and initiate a debt renegotiation process with Brazilian states, Brazil experienced its most severe recession to date, marked by high unemployment rates, stagnant GDP growth and escalating public debt.

In response, the National Congress approved the Spending Ceiling Law in 2016 to limit the growth of public expenditures over the next decade, a significant shift considering the government consumption had risen from 14% to 24.5% of GDP over 25 years [see Brazil (2016)]. This law was part of broader efforts expected to be complemented by pension reform, although political challenges in 2017 and the subsequent presidential election in 2018 hindered the full realization of this agenda (Giambiagi; Tinoco, 2021).

The onset of a new government in 2019 promised a renewed focus on economic reforms, with a conservative approach to various policies and a commitment to maintaining inflation expectations at desired levels. However, the significant reform passed during this period was the pension reform in 2019. Political challenges and other pressing issues complicated the implementation of further reforms [see Brazil (2019)].

The challenges continued into the early months of the new government, compounded by political conflicts and a lack of clear direction, which escalated with the outbreak of the novel coronavirus pandemic in early 2020. Like other nations, Brazil faced a sharp economic downturn. In response, the government implemented fiscal measures, including a war budget that allowed for an increased fiscal deficit without violating fiscal rules, and provided emergency financial assistance to families, which temporarily alleviated economic strain but also had inflationary impacts (Figure 2).

The immediate result of this scenario was an increase in the public deficit and domestic debt. Thus, from 2020 to 2023, the Brazilian economy went through a period marked by significant challenges, largely stemming from the novel coronavirus pandemic and its consequences for productive sectors and the country's macroeconomic structure. However, economic recovery began in 2021 with the advancement of vaccination efforts and the gradual resumption of economic activities. Despite this, the recovery was uneven and slow. Inflation became a concerning factor, driven by rising international commodity prices and the devaluation of the real against the dollar. Brazilian monetary policy had to adopt a more restrictive stance, raising the Selic rate to contain inflation, which, in turn, hindered sustainable economic growth. The current government began amid the ongoing war in Ukraine, which resulted from Russia's invasion of its neighbor in February 2022, due to concerns about its possible membership in the North Atlantic Treaty Organization. From 2022 to 2023, the Brazilian economy still faced structural challenges, such as high unemployment and social inequality, as well as the ongoing fiscal crisis. The government maintained expansionary fiscal policies to stimulate the economy, but this intensified the debate over the long-term sustainability of public debt. At the same time, efforts were made to improve infrastructure and enhance regional integration, especially with the relaunch of projects and strategic partnerships with other Latin American countries (Lima; Ives, 2024).

Finally, 2023 was marked by the introduction of the new PAC and the adoption of a comprehensive fiscal framework to replace the Spending Ceiling. The new PAC, relaunched in 2023, is a Brazilian government initiative aimed at boosting economic development through large-scale infrastructure investments, promoting modernization across the country and attracting both public and private capital. Key features of the new PAC include expanded credit, improvements in concession mechanisms and public-private partnerships, and strengthened regulatory and environmental licensing frameworks. These measures are crucial for providing the private sector with legal certainty and streamlined access to resources needed for participation in major infrastructure projects, including highways, ports and energy sectors. The new PAC also emphasizes technological innovation, particularly in the context of decarbonizing the economy, reinforcing Brazil's commitment to environmental and climate agendas [see Casa Civil (2024)].

The fiscal framework introduced in 2023 represents a departure from the previously restrictive approach to public expenditures. The Spending Ceiling, which limited annual public spending increases to the previous year's inflation rate, was often criticized for constraining investments in essential sectors such as health and education, especially during economic downturns. This new fiscal framework aims to balance fiscal responsibility with flexibility in priority investments, enabling sustainable economic growth. It introduces a system where the growth of public expenditure is tied to revenue performance rather than to fixed inflation rates, allowing public spending to expand as revenues increase, provided that predefined limits are respected. This approach is intended to reduce the fiscal deficit and stabilize public debt over the medium and long term, providing greater predictability and credibility to the economic outlook (IPEA, 2023).

4 METHODOLOGY AND MODEL OVERVIEW

The methodological approach adopted in this Thesis is based on new Keynesian DSGE models, estimated using Bayesian estimates, which are widely used by academics and central banks around the world. These models allow for a more detailed and in-depth analysis, since they are based on microeconomic optimization. An example of this can be seen in the studies by Bénassy (2002), which pave the way for understanding price and wage rigidities, and in the paper by Christiano, Eichenbaum and Evans (2005), which later explores how these nominal rigidities influence the dynamic effects of monetary policies.

This research specifically employs a new Keynesian approach within the broader DSGE framework, characterized by its inclusion of nominal rigidities — such as price and wage stickiness — and frictions that allow monetary policy to have real effects in the short term. While the DSGE methodology is versatile and can represent different theoretical approaches, the new Keynesian specification is particularly suitable for analyzing the transmission of monetary policy shocks and the role of aggregate demand. This choice aligns with the objective of capturing the short-term dynamics central to monetary policy evaluation, distinguishing it from other DSGE models that may not incorporate these frictions and, therefore, focus primarily on long-term real side fluctuations.

As discussed by Andrade, Cordeiro and Lambais (2019), one of the major difficulties in estimating parameters in these models lies in the correct identification of these parameters. Identification, in this context, refers to the ability to distinguish the specific effects of each parameter in the model and estimate them accurately. However, this type of modeling can face identification problems, especially when the number of observed variables is limited. This is because different combinations of parameters can generate similar results in the observable variables, making it difficult to obtain exact estimates.

DSGE models are characterized by a theoretical and stochastic structure that describes the interactions between different economic agents over time. In this scenario, Gabaix (2020) highlights the existence of two main approaches: rational and behavioral. About the structure of the model proposed in this research, it will be built on the ideas of Gabaix (2020), but adapted to the particularities of the Brazilian context, allowing a comparison between the rational and behavioral approaches. This proposal makes room for the inclusion of a behavioral approach, while maintaining the monetary and fiscal parameters commonly used in Central Bank of Brazil models, including the most recent ones.

Furthermore, the proposed model is medium-term, dynamically stable, and adheres to the non-negativity constraint. It consists of blocks representing the representative agent, firms, monetary policy and fiscal policy. Behavioral parameters are incorporated into both the Euler equation and the new Keynesian Phillips curve, offering an alternative perspective on the behavior of economic agents and its implications for the model's dynamics.

With this, the Thesis seeks to contribute to a richer and more contextualized analysis of the Brazilian economy, while at the same time testing the robustness of the two approaches (rational and behavioral) in evaluating economic policies and their implications for the country's macroeconomic stability.

4.1 Representative agent

We begin by analyzing the intertemporal optimization of consumers, drawing from the frameworks of Clarida, Galí and Gertler (1999), Woodford (2003) and Christiano, Eichenbaum and Evans (2005), with some adjustments. In this context, we consider a representative agent who maximizes their intertemporal utility subject to a budget constraint:

$$U = \sum_{t=0}^{\infty} \beta \left(\frac{c_t^{1-\nu} - 1}{1-\nu} \right) \tag{1}$$

where U is the utility function, β is the intertemporal discount factor $(0 < \beta < 1)$, c_t is private consumption and ν is the risk aversion parameter.

The utility function presented in Equation (1), which exhibits constant relative risk aversion, is subject to the following budget constraint:

$$c_t = B_{t+1} = (1 + R_t)B_t + w_t - T_t \tag{2}$$

where c_t is the consumption, B_{t+1} is the stock of securities in the immediately subsequent period, R_t is the rate of return on securities, B_t is the stock of securities, w_t is the real salary and T_t are the taxes paid.

Thus, the Lagrangian for this problem is expressed as:

$$L = \sum_{t=0}^{\infty} \beta \left\{ \frac{c_t^{1-\nu} - 1}{1-\nu} + \lambda_t [(1 + R_t)B_t + w_t - T_t - c_t - B_{t+1}] \right\} \tag{3}$$

where L is the Lagrangean, β is the intertemporal discount factor $(0 < \beta < 1)$, c_t is the consumption, ν is the risk aversion parameter, λ_t is the Lagrange multiplier, R_t is the rate of return on securities, B_t is the stock of securities, w_t is the real salary, T_t are the taxes paid and B_{t+1} is the stock of securities in the immediately subsequent period.

The First Order Conditions (FOCs) for c_t are as follows:

$$\beta c_t^{-\nu} - \lambda_t = 0 \tag{4}$$

$$-\lambda_t + \beta^{t+1}\lambda_{t+1}(1 + R_{t+1}) = 0 \tag{5}$$

where β is the intertemporal discount factor $(0 < \beta < 1)$, c_t is the consumption, ν is the risk aversion parameter, λ_t is the Lagrange multiplier, β^{t+1} is the intertemporal discount factor in the immediately subsequent period $(0 < \beta < 1)$, λ_{t+1} is the Lagrange multiplier in the immediately subsequent period and R_{t+1} is the rate of return on securities in the immediately subsequent period.

By substituting λ_t into the FOCs [equations (4) and (5)], we derive the Euler equation:

$$\frac{c_{t+1}}{c_t} = [\beta(1 + R_{t+1})]^{\frac{1}{\nu}} \tag{6}$$

where c_{t+1} is the consumption in the immediately subsequent period, c_t is the consumption, β is the intertemporal discount factor $(0 < \beta < 1)$, R_{t+1} is the rate of return on securities in the immediately subsequent period and ν is the risk aversion parameter.

Rational approach models depict economic agents as rational optimizers who aim to maximize an objective function while facing specific constraints. These models are extensively used in economic research due to their straightforwardness and ability to produce precise analytical outcomes. They are particularly effective for examining specific economic issues, such as the impact of monetary or fiscal policies in various scenarios.

One commonly adopted monetary regime is inflation targeting, which, even when applied implicitly, aims to strengthen the commitment to economic agents. In response to a cost shock, monetary policy seeks to restore the price level and nominal GDP to their pre-shock values. According to Clarida, Galí and Gertler (1999), the monetary authority's commitment in such scenarios is supported by the benefits of anchoring policy in future expectations. However, in behavioral models, the situation changes. The advantages of the monetary authority's commitment to economic agents become less significant. After a positive cost shock, the authority no longer perceives a need to induce deflation or return inflation to its original level. This suggests that an inflation targeting regime may be less appropriate when economic agents exhibit non-rational behavior.

Additionally, rational models are widely used to study economic behavior over an agent's lifetime. Within this broader framework is the inheritance model, where economic agents make decisions with the prospect of transferring resources or wealth to future generations, such as their descendants. These decisions involve factors like investment, consumption, savings, insurance, intergenerational transfers and other forms of resource allocation [see Marglin (2021)].

By employing a rational model, it becomes possible to explore choices related to inheritance and life-cycle behavior. In this context, economic agents are assumed to act as utility maximizers, factoring in their time preferences, budget constraints and rational expectations. It is worth mentioning that not all rational models are explicitly designed to include inheritance as a central element. These models provide a broad framework applicable to a wide range of economic contexts, including studies of lifetime behavior and inheritance-related decisions [see Freitas (2025)].

Households are the consumers that earn income from businesses. They pay fixed taxes to the government and have the option to invest in government bonds. The initial derivation of the Euler equation under rational approaches considers rational expectations and consumption shocks. However, the behavioral approach modifies this equation to reflect agents' cognitive and behavioral limitations, incorporating an inattention macro-parameter (M), which measures cognitive discounting of the future. The initial derivation of the Euler equation in Equation (6) can be extended to account for rational and behavioral expectations and consumption shocks, aligning with Gabaix's (2020) formulation:

$$c_t = ME_t[c_{t+1}] - \frac{1}{\sigma}(r_t - E_t[\pi_{t+1}]) + \frac{1}{\sigma}(-\Delta\epsilon_{t+1}^{c}) \tag{7}$$

where c_t is private consumption, M is an inattention macro-parameter measuring cognitive discounting of the future ($0 < M < 1$), E_t is a expectation operator, c_{t+1} is consumption in the immediately subsequent period, σ is the IES ($\sigma = 1.3$), r_t is the nominal interest rate, π_{t+1} is the CPI inflation in the immediately subsequent period and $\Delta\epsilon_{t+1}^{c}$ denotes the first difference of the consumption shock in the subsequent period. The parameter M reflects the degree of behavioral influence in the model. $M = 0$ represents a fully behavioral model, while $M = 1$ corresponds to a fully rational model. Intermediate values of M indicate a spectrum, with values closer to zero being more behavioral and those closer to one being more rational.

Considering the idiosyncrasies of the Brazilian economy, the deductions above and the findings of Fasolo *et al*. (2024), the aggregate demand equation is expressed as:

$$y_t = s_c c_t + s_g g_t \tag{8}$$

where y_t is real GDP, s_c is a parameter for private consumption ($s_c = 0.8$), c_t is private consumption, s_g is the steady state of government consumption ($s_g = 0.2$) and g_t is government consumption. Concerning the apparent overestimation of the parameter for private consumption, the parameters for both private and government consumption were calibrated to reflect the behavior of observed economic data in an open economy, albeit imperfectly. The goal is for the dynamics presented to more closely align with actual economic dynamics.

4.2 Firms

The inattention parameter (M) reflects a non-standard aspect of cognitive discounting, indicating that agents do not fully grasp the economy's path over time. This becomes more evident when considering events further out on the time horizon, raising doubts about how much expectations can capture economic behavior. Gabaix (2020) suggests that while agents project the future, these projections are constrained by an eventual convergence to the economy's steady state. This approach highlights the behavioral aspect of the model being proposed. The idea that agents perceive a limit to the time horizon suggests that their expectations are no longer entirely rational. Consequently, the effect of future events on present expectations is restricted.

Continuing, these behavioral limitations in expectations influence broader economic dynamics, including the interaction between firms, labor and production. Firms utilize labor to produce final goods, which are then consumed by both households and the government. In this context, drawing from Gabaix (2020), the new Keynesian Phillips curve can be expressed as:

$$\pi_t = M\beta E_t[\pi_{t+1}] + \lambda_t + \left(\frac{\sigma}{s_c} + \frac{1+\phi}{1-\alpha} - 1\right)(y_t - y_t^n) \tag{9}$$

where π_t is the CPI inflation, M is an inattention macro-parameter ($0 < M < 1$), β is the intertemporal discount factor ($\beta = 0.989$), E_t is a expectation operator, π_{t+1} is the CPI inflation in the immediately following period, λ_t is a Lagrange multiplier ($\lambda = 1.13$), σ is the IES ($\sigma = 1.3$), s_c is a parameter for private consumption ($s_c = 0.8$), ϕ represents the inertia of the marginal cost/GDP ratio ($\phi = 1$), α is a parameter for the share of capital in setting inflation ($\alpha = 0.448$), y_t is real GDP and y_t^n is natural GDP.

It is important to highlight that the inattention parameter (M) maintains the same value in both equations (7) and (9) since it represents an expectational factor rather than being associated with a specific variable. Furthermore, when the macro-level inattention parameter (M) is linked to the intertemporal discount factor (β), it results in a smoothing of the expectations horizon. This causes future expectations to have a reduced impact on current behavior.

The natural GDP equation is expressed as follows:

$$y_t^n = \left[\frac{s_c(1+\phi)}{\sigma(1-\alpha)+s_c(\phi+\alpha)}\right](\epsilon_t^a+1)+m_c+\log(1-\alpha)-\epsilon_t^c \tag{10}$$

where y_t^n is natural GDP, s_c is a parameter for private consumption ($s_c = 0.8$), ϕ is the inertia of the marginal cost/GDP ratio ($\phi = 1$), σ is the IES ($\sigma = 1.3$), α is a parameter for the share of capital in defining natural GDP ($\alpha = 0.448$), ϵ_t^a captures random technology shocks with a 50% inertia with respect to lagged shocks, m_c is the marginal cost of firms as a function of natural GDP and ϵ_t^c captures random consumption shocks.

The equation for the marginal cost of firms as a function of natural GDP is given by:

$$m_c = \left(\frac{\sigma}{s_c}+\frac{1+\phi}{1-\alpha}-1\right)(y_t^n) \tag{11}$$

where m_c is the marginal cost of firms as a function of natural GDP, σ is the IES ($\sigma = 1.3$), s_c is a parameter for private consumption ($s_c = 0.8$), ϕ is the inertia of the marginal cost/GDP ratio ($\phi = 1$), α is a parameter for the share of capital in defining natural GDP ($\alpha = 0.448$) and y_t^n is natural GDP. It is important to note that equations (8) and (9) are derived from Gabaix (2020) and have been calibrated according to Fasolo *et al*. (2024) to capture the idiosyncrasies of the Brazilian economy.

4.3 Monetary policy

Considering the idiosyncrasies of the Brazilian economy and the paper of Fasolo *et al*. (2024), the monetary authority follows a Taylor rule to determine interest rates, which is expressed as:

$$r_t = \gamma_r r_{t-1} + (1-\gamma_r)[\gamma_\pi \pi_t + \gamma_y(y_t - y_t^n)] + \epsilon_t^r \tag{12}$$

where r_t is the nominal interest rate, r_{t-1} is the lagged nominal interest rate, γ_r is the interest rate smoothing ($\gamma_r = 0.5$), π_t is the CPI inflation, γ_π is the inflation parameter ($\gamma_\pi = 1.5$), y_t is the real GDP, y_t^n is the natural GDP, γ_y is the GDP parameter ($\gamma_y = 0.5$) and ϵ_t^r captures monetary shocks, considering that the natural rate of interest and the inflation target are constant in the steady state.

This rule incorporates a parameter for interest rate smoothing, as monetary authorities typically avoid abrupt changes and aim to prevent significant surprises for economic agents. Freitas (2025) suggests that institutional communication — whether through reports or meeting minutes — plays a crucial role in aligning key economic variables with the authority's approach to interest rate adjustments. Consequently, monetary shocks tend to unfold gradually, often manifesting as cycles of rate increases or decreases. This smoothing process results in more measured responses from the affected variables.

4.4 Fiscal policy

Drawing upon the findings of Fasolo *et al*. (2024), the Brazilian fiscal framework can be articulated, comprising the public debt equation, the government consumption equation and the primary surplus equation. In this context, the public debt equation will be given by:

$$b_t = r_t + \rho(b_{t-1} - \pi_{t-1} - \Delta y_t) - (\rho - 1)s_t \tag{13}$$

where b_t is the public debt, r_t is the nominal interest rate, ρ is the nominal interest accumulation factor ($\rho = 1.011$), b_{t-1} is the lagged government deficit, r_{t-1} is the lagged nominal interest rate, Δy_t is the first difference of real GDP and s_t is the primary surplus/GDP. This equation models the variation in public debt in response to changes in interest rates, inflation, GDP growth and the primary surplus.

The government consumption equation is given by:

$$g_t = \gamma_g g_{t-1} + (1 - \gamma_g)(\phi_s s_{t-1}^*) - \phi_b b_{t-1} + \epsilon_t^g \tag{14}$$

where g_t is government consumption, γ_g is the government consumption smoothing parameter ($\gamma_g = 0.2$), g_{t-1} is the lagged value of government consumption, ϕ_s is the primary surplus parameter ($\phi_s = 0.5$), s_{t-1}^* is the deviation of the surplus from its target — where both values are lagged, γ_b is the government deficit parameter ($\phi_b = 0.05$), b_{t-1} is the lagged government deficit and ϵ_t^g captures fiscal shocks.

Finally, the equation for the primary surplus is given by:

$$s_t = \bar{b} + \phi_s(s_{t-1} - \bar{b}) + \phi_{\bar{s}}(\bar{s}_t - \bar{b}) + s_g \epsilon_t^s \tag{15}$$

where s_t is the primary surplus/GDP, $\bar{b}$ is the long-term value of the primary deficit/GDP, ϕ_s is the primary surplus parameter ($\phi_s = 0.5$), s_{t-1} is the lagged value of the primary surplus/GDP, $\phi_{\bar{s}}$ is the parameter for the primary surplus/GDP target ($0 < \phi_{\bar{s}} < 1$), $\bar{s}_t$ is the primary surplus/GDP target, s_g is the steady state of government consumption ($s_g = 0.2$) and ϵ_t^s captures shocks from government consumption but given in the primary surplus. This equation reflects how the primary surplus in the current period is influenced by the surplus from the previous period, adjusting towards a steady-state level.

It should be noted that equations (12)-(15) represent an idiosyncratic addition to Gabaix's (2020) model, with parameters calibrated similarly to Fasolo *et al*. (2024). In rational models, as argued by Gabaix (2020), Ricardian Equivalence holds, meaning that fiscal policy has no effect. However, when behavioral parameters are introduced, agents cannot perfectly anticipate future taxes. This implies that tax cuts and transfers have a stimulative effect that is not fully accounted for in traditional economic literature, particularly in the short term. The agent's partial myopia suggests that tax policies are more effective when implemented in the present.

Moreover, fixed parameters cannot fully capture transitions between periods of austerity, countercyclical expansion and spending-cap arrangements. We therefore chose a univariate fiscal block to keep the model both parsimonious and identifiable, focusing on the government's average response dynamics to shocks. The endogenous fiscal shocks in equations 14 and 15 were incorporated to account for temporary deviations arising from discrete regime shifts, allowing the overall rule structure to accommodate exceptional fluctuations without increasing the number of fixed parameters. Looking ahead, we could explore extensions with regime-dependent parameters (for example, a Markov-switching framework or debt-level–dependent coefficients), but such enhancements are left for future paper due to the additional estimation costs and data limitations in each subperiod. In this way, we preserve the transparency and robustness of our baseline specification while acknowledging avenues for refinement to capture distinct fiscal regimes.

Appendices A through C present the smoothing of the model's main shocks for both the rational and behavioral approaches, respectively, while Appendix D summarizes the key equations of the model.

Additionally, it is worth mentioning that the modeling approach follows Gabaix (2020), a macroeconomic framework that is also applicable to smaller economies, such as Brazil. The parameter values have been updated based on the recent findings of Fasolo *et al*. (2024), which focus on the Brazilian economy, ensuring the model accurately captures the unique characteristics of the Brazilian economic behavior under analysis.

5 DATA

For the estimations in this Thesis, the Dynare/Matlab package will be utilized, along with a quarterly dataset spanning from 2000Q1 to 2023Q4, using equations that have already been log-linearized. The following is the set of variables that will be observed:

- Government consumption (g_t): quarterly government consumption (% of GDP). Source: Brazilian Institute of Geography and Statistics (2024b).
- Brazilian CPI (IPCA) inflation (π_t): quarterly accumulated IPCA inflation. Source: Brazilian Institute of Geography and Statistics (2024a).
- Selic nominal interest rate (r_t): quarterly Selic nominal interest rate. Source: Central Bank of Brazil (2024e).
- Real GDP index (y_t): quarterly real GDP index, seasonally adjusted by Brazilian Institute of Geography and Statistics, base year of 1995. Source: Brazilian Institute of Geography and Statistics (2024b).

5.1 Descriptive statistics

Table 1 presents descriptive statistics of the observed economic variables in our model: government consumption (g_t), IPCA inflation (π_t), the Selic nominal interest rate (r_t) and real GDP index (y_t).

Table 1 - Descriptive statistics of the observed variables

Statistics	Government consumption (g_t)	IPCA inflation (π_t)	Selic nominal interest rate (r_t)	Real GDP index (y_t)
Mean	18.73 % of GDP	1.53% per quarter	2.91% per quarter	152.62
Median	18.57% of GDP	1.42% per quarter	2.88% per quarter	163.49
Minimum	17.45% of GDP	-1.06% per quarter	0.47% per quarter	109.00
Maximum	20.51% of GDP	6.19% per quarter	6.02% per quarter	183.94
SD	0.79% of GDP	0.95% per quarter	1.16% per quarter	23.11

Note: 96 observations (from 2000Q1 to 2023Q4).
Sources: Brazilian Institute of Geography and Statistics (2024a, 2024b) and Central Bank of Brazil (2024e).

The mean government consumption is 18.73% of GDP, indicating that this expenditure represents almost one-fifth of the Brazilian GDP. The median, very close to the mean, at 18.57% of GDP, suggests a balanced distribution of government consumption around this central value, with observations ranging from a minimum of 17.45% to a maximum of 20.51% of GDP. This shows that variable remained relatively stable throughout the observed period.

Regarding IPCA inflation, the mean is 1.53% per quarter, with a slightly lower median of 1.42%. The minimum recorded was a deflation of -1.06% per quarter, while the maximum reached was an inflation of 6.19% per quarter. This wider variation in inflation suggests periods of significant volatility in consumer prices. As for the nominal Selic interest rate, the mean was 2.91% per quarter and the median was 2.88% per quarter. The rate fluctuated between a minimum of 0.47% per quarter and a maximum of 6.02% per quarter, reflecting substantial adjustments in monetary policy in response to varying economic conditions.

The real GDP index showed a mean of 152.62, with a higher median of 163.49, reflecting variations in economic performance over time. The minimum recorded was 109 and the maximum was 183.94, demonstrating considerable fluctuations in the country's economic activity during the analyzed period.

The standard deviation, which measures the dispersion of data around the mean, varies according to the variable: 0.79% of GDP for government consumption, 0.95% per quarter for IPCA inflation, 1.16% per quarter for the Selic nominal interest rate and 23.11 for the real GDP index. These values indicate different levels of volatility among the variables, with inflation and the Selic rate showing greater instability compared to government consumption and real GDP. These data, derived from 96 observations (from 2000Q1 to 2023Q4), are crucial for understanding the nuances of the Brazilian economy and were collected from reliable sources: Central Bank of Brazil (2024e) and Brazilian Institute of Geography and Statistics (2024a, 2024b).

5.2 Seasonality and stationarity

The observed variables for the model analysis include government consumption, IPCA inflation, the Selic nominal interest rate and real GDP. A crucial step in this analysis is examining the seasonality of these variables, as understanding their seasonal characteristics is essential for proper model development.

It is important to note that GDP has already been deseasonalized by Brazilian Institute of Geography and Statistics (2024b), eliminating the need for further deseasonalization of this variable. Regarding government consumption, a comparison between the adjusted and original series using the Census X-13 method reveals patterns with a high degree of symmetry, indicating the absence of significant seasonality. Similarly, both the Selic nominal interest rate and IPCA inflation show a great degree of symmetry between the original and adjusted series, as expected from macroeconomic literature, suggesting these variables also lack evident seasonality.

The Selic nominal interest rate, which is the basic interest rate for the Brazilian economy, is set by Central Bank of Brazil and adjusted according to the needs of monetary policy, not seasonal factors. It is used to control inflation and stabilize the currency, reacting more to macroeconomic and political conditions than to seasonal patterns.

Similarly, the IPCA inflation can show variations due to changes in commodity prices or administered price adjustments, but these are not necessarily seasonal. In Brazil, although there may be some seasonality in food prices due to harvest issues, the index is designed to minimize these effects, reflecting an overall view of inflation without clear seasonal patterns. Consequently, the original series of all these observable variables were used in the analysis.

When analyzing time series, it is vital to evaluate stationarity and seasonality to establish a robust foundation for further analysis and forecasting. Unit root tests are essential statistical methods used to determine whether a time series is stationary or contains a unit root, implying that the series follows a random walk. Three of the most common tests for this purpose are the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Each test uses different approaches to examine stationarity and unit roots in time series, with distinct mathematical formulations, assumptions and statistical methods [see Dickey and Fuller (1979), Phillips and Perron (1988) and Kwiatkowski *et al*. (1992)].

Table 2 - Stationarity test of the observed variables

Statistics	**Government consumption (g_t)**	**IPCA inflation (π_t)**	**Selic nominal interest rate (r_t)**	**Real GDP index (y_t)**
a) ADF (H0: unit root, use of the Akaike Info Criterion)				
Critical value at 5%	-2.89	-2.89	-2.89	-2.89
t-statistic (level)	-2.31 (0.17)	-4.04** (0.00)	-2.73 (0.07)	-1.10 (0.71)
t-statistic (first diff.)	-10.68** (0.00)	-13.21** (0.00)	-6.41** (0.00)	-9.12** (0.00)
Inference	I(1)	I(0)	I(1)	I(1)
b) PP (H0: unit root, use of the Akaike Info Criterion)				
Critical value at 5%	-2.89	-2.89	-2.89	-2.89
t-statistic (level)	-2.17 (0.22)	-6.37** (0.00)	-2.08 (0.25)	-1.10 (0.71)
t-statistic (first diff.)	-10.99** (0.00)	-25.99** (0.00)	-4.87** (0.00)	-9.08** (0.00)
Inference	I(1)	I(0)	I(1)	I(1)
c) KPSS (H0: stationarity, use of the Newey-West Bandwidth criterion)				
Critical value at 5%	0.46	0.46	0.46	0.46
LM-statistic (level)	1.02**	0.22	0.76**	1.11**
LM-statistic (first diff.)	0.20	0.08	0.06	0.15
Inference	I(1)	I(0)	I(1)	I(1)

Note: ** denotes statistical significance at the 5% level. Values in brackets represent p-values. All tests were conducted using only the intercept.
Sources: Brazilian Institute of Geography and Statistics (2024a, 2024b) and Central Bank of Brazil (2024e).

In this sense, Table 2 presents the results of a series of unit root tests applied to macroeconomic observable variables: government consumption, IPCA inflation, Selic nominal interest rate and real GDP index. These tests are used to determine whether the variables have a unit root, meaning they are non-stationary, or if they become stationary after differentiation.

In the ADF test, the critical value at the 5% significance level is -2.89 for all variables. This means that to reject the Null Hypothesis (H0) of a unit root (i.e., non-stationarity), the test statistic must be lower than this value. For the government consumption, the level statistic is -2.31, which is not low enough to reject the unit root hypothesis, as it is greater than the critical value. However, when the series is differenced, the statistic drops to -10.68, significantly lower than the critical value of -2.89, suggesting that the series becomes stationary after the first difference, classifying it as I(1). The IPCA inflation, on the other hand, has a level statistic of -4.04, which is below the critical value, allowing us to reject the H0 and classify it as stationary at the level, or I(0).

The Selic nominal interest rate has a level statistic of -2.73, which, like government consumption, does not reject the unit root in level. However, after the first difference, the statistic drops to -6.41, well below the critical value, indicating the series becomes stationary. A similar pattern is observed for the real GDP index, with a level statistic of -1.10, insufficient to reject the unit root, but the statistic of -9.12 after the first difference confirms that the series is stationary after this transformation.

The PP test results show similar consistency with the ADF. At the 5% significance level, the critical value remains -2.89. For government consumption, the level statistic of -2.17 also fails to reject the unit root, but the statistic after the first difference is -10.99, indicating stationarity after the first differencing. The IPCA inflation has a level statistic of -6.37, confirming its stationarity at the level, as observed in the ADF test. The Selic, with a level statistic of -2.08, and the real GDP, with -1.10, follow the same pattern: both are non-stationary at the level but become stationary after the first difference, with statistics of -4.87 and -9.08, respectively.

KPSS test also reveals important information about the stationarity of the analyzed macroeconomic variables. In the KPSS test, which tests the H0 of stationarity instead of a unit root, the critical value at 5% is 0.46. For government consumption, the level statistic of 1.02 is greater than the critical value, suggesting that the series is not stationary but becomes stationary after the first difference, with a statistic of 0.20. For IPCA inflation, the level statistic of 0.22 is below the critical value, confirming that the series is stationary, corroborating the results from the other tests. The Selic has a level statistic of 0.76, higher than the critical value, indicating non-stationarity at the level, but the statistic of 0.06 after the first difference confirms its stationarity. The GDP, with a level statistic of 1.11, is also non-stationary, but the series becomes stationary after the first difference, with a statistic of 0.15. Thus, the KPSS test confirms that most variables become stationary after the first difference, except for IPCA, which is stationary at the level.

As presented in Table 2, the unit root test was initially applied to the complete database; however, it is essential to account for possible structural breaks over time, particularly in an economy subject to significant shocks and regime changes, such as Brazil. In this context, Table 3 presents the results of the ADF test with the inclusion of structural breaks, considering relevant economic and political turning points. These breakpoints were strategically selected to capture the impacts of events that shaped the country's economic dynamics, such as the fiscal expansion policy adopted from 2011Q2, the recession that began in 2014Q1 and the implementation of the Spending Ceiling Law in 2017Q1. For further details on these scenarios, see Chapter 3 of this Thesis.

Table 3 - ADF stationarity test of the observed variables with structural break

Statistics	**Government consumption (g_t)**	**IPCA inflation (π_t)**	**Selic nominal interest rate (r_t)**	**Real GDP index (y_t)**
a) Breakpoint: 2011Q2 (H0: unit root test, use of the Schwarz Criterion)				
Critical value at 5%	-3.75	-3.75	-3.75	-3.75
t-statistic (level)	-2.64 (0.10)	-4.06** (0.02)	-3.36 (0.10)	0.44 (0.50)
t-statistic (first diff.)	-10.65** (0.00)	-12.94** (0.00)	-6.33** (0.00)	-9.22** (0.00)
Inference	I(1)	I(0)	I(1)	I(1)
b) Breakpoint: 2014Q1 (H0: unit root test, use of the Schwarz Criterion)				
Critical value at 5%	-3.76	-3.76	-3.76	-3.76
t-statistic (level)	-2.42 (0.10)	-4.05** (0.04)	-2.99 (0.10)	0.08 (0.50)
t-statistic (first diff.)	-10.62** (0.00)	-13.06** (0.00)	-6.37** (0.00)	-9.25** (0.00)
Inference	I(1)	I(0)	I(1)	I(1)
c) Breakpoint: 2017Q1 (H0: unit root test, use of the Schwarz Criterion)				
Critical value at 5%	-3.51	-3.51	-3.51	-3.51
t-statistic (level)	-2.82 (0.09)	-4.18** (0.00)	-3.14 (0.09)	-1.44 (0.10)
t-statistic (first diff.)	-10.62** (0.00)	-13.06** (0.00)	-6.39** (0.00)	-9.01** (0.00)
Inference	I(1)	I(0)	I(1)	I(1)

Note: ** denotes statistical significance at the 5% level. Values in brackets represent p-values. All tests were conducted using only the intercept and innovational outlier.
Sources: Brazilian Institute of Geography and Statistics (2024a, 2024b) and Central Bank of Brazil (2024e).

Analyzing the results, it can be observed that government consumption exhibited non-stationary behavior at level, being classified as I(1) in all evaluated periods. For instance, at the 2011Q2 breakpoint, the t-statistic at level was -2.64, above the critical value of -3.75, indicating the presence of a unit root. However, stationarity was confirmed at the first difference, with a t-statistic of -10.65. In contrast, IPCA inflation showed a different characteristic, being stationary at level, i.e. I(0), throughout all the analyzed breakpoints. This behavior reflects the greater resilience of inflation to structural shocks, possibly due to the inflation targeting regime implemented in 1999, which provided greater control over inflation dynamics (Table 3).

The Selic nominal interest rate, used as the main monetary policy instrument, also exhibited non-stationary behavior at level — confirming it as I(1) across all evaluated quarters. For instance, at the 2017Q1 breakpoint, the t-statistic at level was -3.14, again above the critical value of -3.51, but stationarity was achieved at the first difference with a t-statistic of -6.39. This dynamic suggests that the nominal interest rate responded more sensitively to economic and political shocks, reflecting frequent monetary policy adjustments in response to economic conditions, such as the implementation of the Spending Ceiling Law. Finally, the real GDP showed non-stationary behavior at level, confirming it as I(1), with t-statistics consistently above the critical values. For example, at the 2017Q1 breakpoint, the t-statistic was -1.44 compared to the critical value of -3.51. Stationarity at the first difference suggests that product variability over time is driven by long-term shocks and structural changes affecting the broader economy (Table 3).

The inclusion of structural breaks in the unit root tests reveals significant dynamics in the analyzed variables, highlighting the effects of public policies and critical economic events on the behavior of the time series. This approach underscores the importance of considering economic and political contexts when modeling time series, ensuring greater precision in interpreting results and formulating economic strategies. Nevertheless, when comparing the results presented in tables 2 and 3, it is evident that the inferences regarding the stationarity of the variables remain consistent across both tests when considering the variables individually. As a DSGE model relies on stationary variables to ensure stability and avoid explosive dynamics, the classifications are essential for model construction. In the case of Selic nominal interest rate, real GDP and government consumption, the variables are classified as I(1) — meaning they become stationary only after applying the first difference. For this reason, the first difference will be applied to these variables in the modeling process, enabling the use of stationary series.

On the other hand, IPCA inflation is classified as I(0), indicating that it is already stationary at its level and therefore does not require additional transformations for subsequent analysis. The statistical significance of the results, denoted by double asterisks (**), supports the inferences made, with a 5% significance level. It is worth emphasizing that the data used in this analysis were obtained from reliable sources — namely Brazilian Institute of Geography and Statistics (2024a, 2024b) and Central Bank of Brazil (2024e) — which reinforces the credibility of the inferences presented. This rigor in data collection and processing ensures the robustness and reliability of the results, providing a solid foundation for the development of more detailed economic analyses.

Given the results of the unit root tests presented in Tables 2 and 3, we opted not to apply more modern tests, such as the Zivot-Andrews test, for several reasons: (a) the primary goal of this analysis was to assess the stationarity of the observed macroeconomic variables and the traditional tests applied are widely accepted and sufficient for this purpose, especially when dealing with univariate time series; and (b) these tests are computationally simpler and more robust in the context of our dataset, which does not show clear indications of structural breaks or nonlinearities that would require the more complex methods associated with the newer tests. Furthermore, the consistency of results across the different tests applied provides a reliable foundation for understanding the stationarity properties of the variables. Finally, given the relatively small sample size, more advanced tests could lead to overfitting or misinterpretation of subtle data nuances. Thus, the applied unit root tests provide a solid foundation for understanding the dynamic properties of these macroeconomic indicators without the need for more sophisticated tests that require greater computational power.

5.3 Treatment

After completing all the necessary stationarity and seasonality analyses, the treatment applied to each of the variables is outlined in Table 4. These modifications are crucial for preparing the data for robust economic analysis by removing seasonal patterns and stabilizing long-term trends.

Table 4 - Treatment of the observed variables

Variable	Treatment
Real GDP index (y_t)	Seasonal adjustment by source and first difference.
Government consumption (g_t)	First difference.
IPCA inflation (π_t)	No treatment.
Selic nominal interest rate (r_t)	First difference.

Note: 96 observations (from 2000Q1 to 2023Q4).
Sources: Brazilian Institute of Geography and Statistics (2024a, 2024b) and Central Bank of Brazil (2024e).

The Selic nominal interest rate and government consumption underwent a first-difference treatment. This technique, which subtracts the previous period’s value from the current one, is a standard approach in time series analysis to achieve stationarity by mitigating the impact of lingering trends and cyclical variations. IPCA inflation did not receive any specific treatment. This decision is supported by the inflation series’ inherent stationarity, as evidenced by previous tests indicating no need for further transformation to stabilize the series for analytical purposes. Real GDP index was treated comprehensively, beginning with seasonal adjustment performed by Brazilian Institute of Geography and Statistics (2024b), followed by a first-difference transformation. These dual treatments effectively remove seasonal patterns and stabilize the series, making the product data more reliable for evaluating economic conditions and trends.

The adoption of first differences for the GDP, government consumption and the Selic nominal interest rate series is grounded in its objectivity in removing long-run trend components without relying on filters — such as the Hodrick and Prescott (1997) filter — whose parameter choices can be arbitrary. By working with period-to-period changes, the trend path is stripped out directly, simplifying model specification and avoiding biases introduced by cut-off points or smoothing penalties. This approach thus focuses the analysis exclusively on the economic fluctuations of interest, ensuring that estimated policy responses capture genuine cyclical variations rather than structural trend shifts.

It is important to highlight that, although the model does not explicitly include series for inflation and output expectations in the dataset, it implicitly incorporates these expectations through the structure of the equations and the estimated parameters. The model preserves theoretical coherence by adhering to the traditional framework of new Keynesian DSGE models, which implicitly integrate expectations. This is consistent with the relevant literature, including papers by Clarida, Galí and Gertler (1999), Woodford (2003) and Christiano, Eichenbaum and Evans (2005). Parameter calibration based on established research, followed by Bayesian estimation, ensures that the model accurately reflects agents' expectations, even in the absence of explicit expectations data. This methodology ensures the model's predictions align with the observed behavior of economic agents. The model's structure was adjusted to accommodate the specific characteristics of the Brazilian economy, including shocks and parameters tailored to capture local economic dynamics.

6 RESULTS

6.1 Priors and posteriors of the parameters

A DSGE model, unlike simpler structures, provides a more detailed and theoretically grounded framework to capture the complexity of macroeconomic interactions. By incorporating additional equations, the model allows for richer microfoundations that more accurately depict the behavior of consumers, firms and governments, particularly under the influence of behavioral deviations. These deviations, as highlighted by the varying M values in Table 5, account for decision-making influenced by heuristics, diagnostic biases or cognitive limitations. Our DSGE model employs Bayesian estimation with 100,000 iterations using Markov Chain Monte Carlo methods, ensuring robust parameter inference. This approach follows the framework outlined by Metropolis *et al.* (1953) and Robert and Casella (2004).

Table 5 - Estimated parameters of the proposed model

Parameter	**Prior mean**	**Post. SD**	**Distribution**	**Post. mean**	**Prior SD**
a) Rational approach ($M = 1$): 100% rational					
Intertemporal discount factor (β)	0.989	0.05	normal	0.8864	0.0191
IES (σ)	1.3	0.05	normal	1.2551	0.0491
Interest rate smoothing (γ_r)	0.5	0.25	beta	0.9147	0.0272
Inflation (γ_π)	1.5	0.75	gamma	2.0247	0.7707
GDP (γ_y)	0.5	0.25	gamma	0.2793	0.1339
Primary surplus (ϕ_s)	0.5	0.05	beta	0.4770	0.0547
Government deficit (ϕ_b)	0.05	0.05	Inverse gamma	0.5365	0.1772
b) Behavioral approach ($M = 0.8$): 80% rational and 20% behavioral					
Intertemporal discount factor (β)	0.989	0.05	normal	0.8802	0.0216
IES (σ)	1.3	0.05	normal	1.2585	0.0491
Interest rate smoothing (γ_r)	0.5	0.25	beta	0.9464	0.0227
Inflation (γ_π)	1.5	0.75	gamma	1.7776	0.7033
GDP (γ_y)	0.5	0.25	gamma	0.2461	0.1181
Primary surplus (ϕ_s)	0.5	0.05	beta	0.4596	0.0495
Government deficit (ϕ_b)	0.05	0.05	Inverse gamma	0.6658	0.0618
c) Behavioral approach ($M = 0.6$): 60% rational and 40% behavioral					
Intertemporal discount factor (β)	0.989	0.05	normal	1.1421	0.0446
IES (σ)	1.3	0.05	normal	1.2839	0.0495
Interest rate smoothing (γ_r)	0.5	0.25	beta	0.1674	0.0877
Inflation (γ_π)	1.5	0.75	gamma	0.1226	0.0445
GDP (γ_y)	0.5	0.25	gamma	0.0118	0.0059
Primary surplus (ϕ_s)	0.5	0.05	beta	0.4880	0.0508
Government deficit (ϕ_b)	0.05	0.05	Inverse gamma	0.0858	0.0104

Note: 90% confidence interval.
Source: Data derived from the conducted estimates.

Table 5 presents the Bayesian estimation results, detailing the priors and posteriors of the parameters, with the calibrated means corresponding to equations (9)-(14). Graphical representations of these priors and posteriors can be found in Appendices E through G, providing a visual complement to the numerical results and enhancing interpretability. These priors, derived from established literature, were consistently applied across all approaches to ensure comparability, while the observed data informed the posterior distributions. By including a richer set of observable variables and additional structural equations, the model constrains the parameter space more tightly and allows the data to exert stronger influence, resulting in sharper posterior distributions in the Bayesian estimation. This ensures the model not only aligns with theoretical rigor but also adheres closely to real-world dynamics, making it both predictive and empirically relevant.

In this context, the behavioral DSGE approach demonstrates its effectiveness by capturing the nuanced interplay of macroeconomic factors, as highlighted in the analysis comparing the rational and behavioral approaches. The model was evaluated under three distinct setups: a fully rational approach ($M = 1$) and two behavioral configurations: $M = 0.8$ and $M = 0.6$. This comparative framework allows for an in-depth understanding of how different levels of rationality and behavioral biases influence economic dynamics, demonstrating the adaptability of the behavioral models while maintaining coherence with the rational benchmark.

This process involved defining prior distributions for the parameters based on existing literature and economic insights, followed by updating these distributions using the observed data to obtain the posterior distributions. The initial prior values were derived from the literature relevant to this analysis: Gabaix (2020) and Fasolo *et al*. (2024). These priors reflect the pre-data knowledge of the parameters. Once the observed data was incorporated, the prior distributions were updated to generate posterior distributions, representing the revised estimates informed by empirical evidence.

It is important to highlight that, while there is a set of parameters to be estimated, the complete proposed model also includes calibrated equations. The analysis of the estimated parameters in the proposed model, as shown in Table 5, demonstrates consistency with the structural model across several key dimensions. The intertemporal discount factor (β), a critical parameter in household utility functions, exhibits slight variations across the three approaches. Under the fully rational approach ($M = 1$), the parameter is estimated at 0.8864, slightly lower than the prior mean of 0.989. In the predominantly behavioral approaches ($M = 0.8$ and $M = 0.6$) the parameter remains at 0.8802 and 1.1421, respectively, suggesting that while behavioral dynamics influence this parameter, the divergence only becomes pronounced at $M = 0.6$, indicating a departure from near-rationality. The IES (σ) shows a high degree of stability across approaches, reflecting its robustness in capturing consumption dynamics. Estimated values range from 1.2551 ($M = 1$) to 1.2585 ($M = 0.8$) and 1.2839 ($M = 0.6$), with minimal deviation from the prior mean of 1.3. These results suggest that even under more behavioral assumptions, the consumption response to intertemporal choices remains consistent.

More pronounced differences emerge in parameters such as interest rate smoothing (γ_r) and inflation parameter (γ_π). For the first, the rational approach ($M = 1$) produces a high estimate of 0.9147, indicating a strong inclination for smoothing interest rate changes. In the behavioral approaches, this parameter decreases to 0.9464 ($M = 0.8$) and drops sharply to 0.1674 ($M = 0.6$), reflecting a significant reduction in the ability of agents to anticipate and smooth changes. The inflation parameter (γ_π) follows a similar pattern, with values declining from 2.0247 ($M = 1$) to 1.7776 ($M = 0.8$) and a dramatic drop to 0.1226 ($M = 0.6$), indicating that agents with stronger behavioral tendencies are far less sensitive to inflationary signals.

The primary surplus parameter (ϕ_s) remains relatively stable across behavioral approaches, with estimates ranging narrowly from 0.4596 ($M = 0.8$) to 0.4880 ($M = 0.6$), underscoring consistent fiscal responses. Under the fully rational model (M=1), the estimated value is 0.477. In contrast, the government deficit parameter (ϕ_b) shows significant variation, increasing from 0.5365 ($M = 1$) to 0.6658 ($M = 0.8$) but dropping sharply to 0.0858 ($M = 0.6$). This suggests that as M decreases, fiscal dynamics become increasingly volatile, reflecting the limited capacity of agents with strong behavioral tendencies to form stable expectations about public deficits. For the GDP parameter (γ_y), the variation is more pronounced. While the value is 0.2793 ($M = 1$), it falls to 0.2461 ($M = 0.8$) and drops drastically to 0.0118 ($M = 0.6$), highlighting that the prevalence of behavioral expectations severely reduces sensitivity to GDP, complicating the interpretation and management of output fluctuations in behaviorally biased contexts.

The transition from $M = 0.8$, which is close to the rational approach, to $M = 0.6$, which significantly deviates from it, highlights an important trend: the parameters most sensitive to behavioral assumptions — interest rate smoothing (γ_r), inflation parameter (γ_π) and government deficit parameter (ϕ_b) — show increasingly divergent behavior. This indicates that as behavioral expectations dominate, agents' responses to policy shocks become less predictable and more influenced by short-term heuristics or biases, leading to diminished policy effectiveness. Parameters such as intertemporal discount factor (β) and IES (σ), on the other hand, demonstrate resilience to these shifts, underscoring their fundamental role in intertemporal decision-making regardless of the rationality level.

These results provide valuable perspectives on rational and behavioral approaches within the Brazilian economy. This analysis reveals the growing impact of behavioral approaches, emphasizing the need for public policies to account for such behavioral dynamics to ensure effectiveness in scenarios where agent rationality is compromised. The combined approach of defining priors based on established literature and updating them with observed data ensures that the estimates are robust and relevant to the analysis. This methodology increases the consistency and credibility of the model equations and their economic forecasts (Table 5).

Moreover, the choice of identical priors for the three approaches reflects a methodological commitment to maintaining comparability across the approaches. These priors are calibrated based on existing literature and serve as a common starting point, ensuring that differences in results are exclusively attributable to variations in behavioral assumptions, such as the level of M. However, the posteriors vary across all parameters due to the dynamic interaction between the model's components. Even parameters not directly influenced by M — such as the intertemporal discount factor (β) or the IES (σ) — are recalibrated based on the interplay of equations and observed data. This occurs because, in DSGE models, parameters do not function in isolation. Parameter estimates are interdependent, indicating that changes in behavioral shocks alter economic equilibria and affect global statistical inference. Consequently, the emergent system behavior, captured through Bayesian estimation, leads to coherent and data-informed adjustments, even for parameters seemingly unrelated to the behavioral focus.

We opted not to employ the Maximized Monte Carlo (MMC) test — which seeks to produce the most conservative possible p-value in the presence of nuisance parameters — because our study does not involve tests whose null distributions depend on such parameters. Consequently, applying the MMC would be methodologically misplaced and would require intensive Monte Carlo simulations, demanding excessive computational time and resources without yielding meaningful gains in robustness or precision over the conventional methods already in use. Moreover, since our model parameters are directly defined based on established literature, there are no unknown nuisance parameters to maximize over, further obviating the need for MMC. For further details on the MMC test, we recommend consulting Rodriguez-Rondon and Dufour (2024).

The Brazilian economy, especially since the inflation targeting regime, has been characterized by a series of mostly positive shocks, both in terms of government consumption and the Selic interest rate. These shocks are often characterized as the result of expansionary fiscal and contractionary monetary policies. Positive shocks to government spending, such as those seen in economic stimulus programs or large public investments, aim to boost aggregate demand and promote GDP growth, while increases in the Selic rate are used as a tool to control inflation by restricting consumption and credit. Thus, the Brazilian economic scenario tends to feature this type of interaction between fiscal and monetary policies, with government stimuli on the one hand and contractionary monetary adjustments on the other. The choice to model positive shocks to both government consumption and the Selic rate in our DSGE model reflects this structural reality of the Brazilian economy. These shocks represent the government's response to crises, in which Brazilian government spending increases to stimulate the economy, while the Central Bank of Brazil raises interest rates to contain inflationary pressures resulting from increased demand. By focusing on these types of shocks, the modeling is aligned with observed reality. To confirm this specificity of the Brazilian economic structure, we suggest reading the manuscripts by Giavazzi, Goldfajn and Herrera (2005) and Alves and Palma (2024).

Furthermore, the focus on positive shocks in both monetary and fiscal policies is theoretically justified within the framework of DSGE models. These models generally operate under the assumptions of linearity and symmetry, meaning that negative shocks tend to produce effects that mirror those of positive shocks. As a result, analyzing negative shocks would not yield new insights, as the outcomes would simply be symmetrical opposites. Therefore, concentrating on positive shocks aligns with the empirical reality of the Brazilian economy, where such shocks are more prevalent, and optimizes the relevant economic analysis by avoiding redundant results. Since negative and positive shocks are typically symmetrical, focusing on the latter simplifies the analysis without compromising its accuracy. This approach is further supported by the results presented in Smets and Wouters (2007).

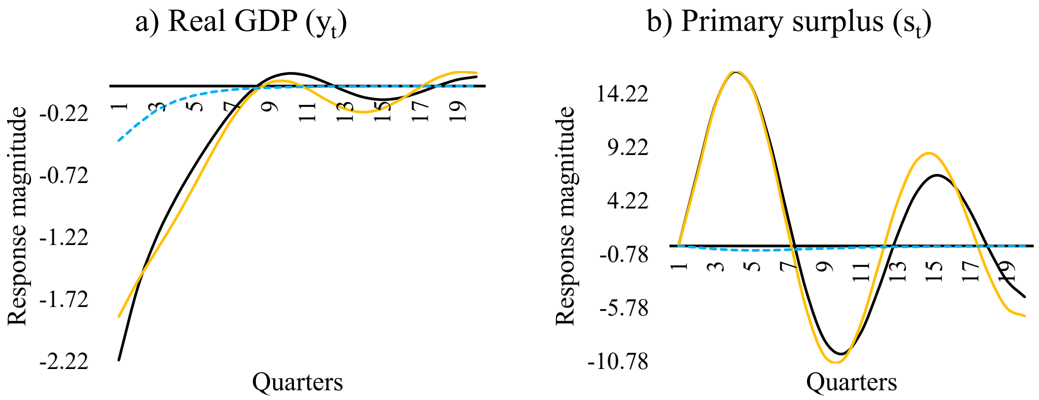
Thus, in the following subtopics, the IRFs are presented, detailing the effects of positive shocks in the interest rate and government consumption, illustrating how these variables influence macroeconomic equilibrium.

6.2 Interest rate positive shocks

To improve the analysis of the interaction between monetary and fiscal policies, we must delve deeper into their behaviors. Next, we will examine Brazilian monetary policy in detail (see Figures 5 to 7). The responses are organized by variable, with each figure displaying the responses to the same shock for both the rational and behavioral approaches. The selected macroeconomic variables' reactions to contractionary monetary policy, specifically interest rate positive shocks, are presented. The vertical axis of the graphs represents the magnitude of the response, while the horizontal axis depicts time in quarters. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$. The shocks applied are of one standard deviation and the responses analyzed include real GDP, primary surplus, CPI inflation, private consumption and public debt.

The analysis of the IRFs highlights distinct dynamics between the rational approach, the behavioral approach with $M = 0.8$ and the behavioral approach with $M = 0.6$ in response to an interest rate positive shock. These differences, both in magnitude and trajectory, provide critical perceptions into the implications for the Brazilian economy. From a theoretical standpoint, macroeconomic literature suggests that a positive interest rate shock is expected to lead to a contraction in GDP due to reduced investment and consumption, followed by gradual stabilization as the economy adjusts to the new monetary conditions. The rational approach aligns closely with this expectation, showing a sharp initial decline in GDP of -2.21 in the first quarter, gradually tapering off to -0.65 by the fifth quarter. This trajectory reflects the assumption that agents are fully informed and respond optimally to policy changes, resulting in an immediate and pronounced adjustment followed by stabilization. In contrast, the behavioral approach with $M = 0.8$ displays a less severe initial decline in GDP of -1.86 in the first quarter. The subsequent trajectory mirrors the rational approach but with smoother adjustments, reaching -0.81 by the fifth quarter. This pattern indicates that agents, while exhibiting some cognitive or informational constraints, still react in a manner that approximates rational expectations. The reduced initial magnitude acts as a buffer, aligning with theoretical predictions of a tempered adjustment when agents are not fully forward-looking. The behavioral approach with $M = 0.6$ diverges significantly, with a much smaller initial contraction of -0.44 in the first quarter and a sluggish decline over time, stabilizing at -0.08 by the eighth quarter. This response suggests a limited sensitivity to policy changes, indicative of higher inertia in agents' behavior. The slow and muted adjustment deviates from theoretical literature, as it implies insufficient transmission of monetary policy, potentially undermining its effectiveness in curbing inflation or stabilizing GDP during economic fluctuations (Figure 5, Chart "a").

Figure 5 - IRFs: Interest rate positive shocks (GDP and primary surplus)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$.
Source: Graphs generated from the conducted estimates.

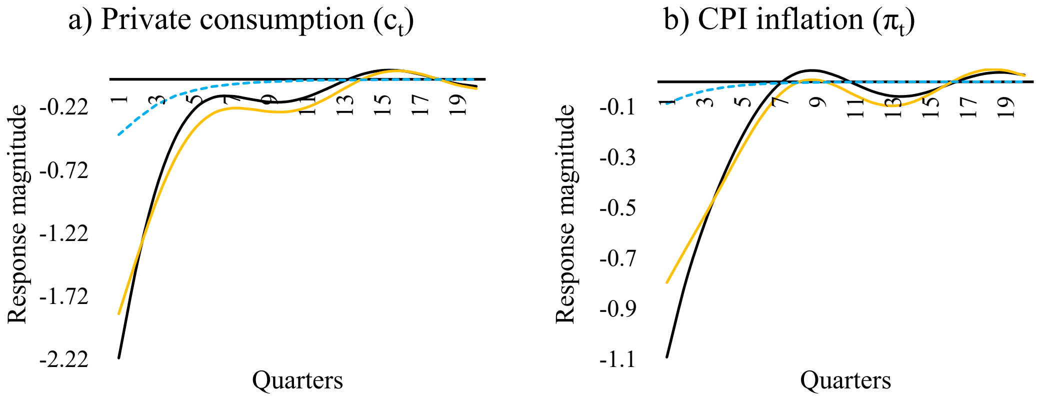
These differences are quantitatively stark. The rational approach shows the largest GDP contraction in both magnitude and speed, emphasizing its efficiency in reflecting the immediate impacts of monetary policy. However, the abruptness of this adjustment could exacerbate short-term volatility, posing risks in an economy like Brazil's, where structural vulnerabilities such as inflation inertia and market volatility are prevalent. The behavioral approach with $M = 0.8$ strikes a balance, providing a significant yet smoother adjustment, which may enhance stability without compromising policy transmission. Conversely, the behavioral approach with $M = 0.6$ fails to generate a sufficiently robust response, rendering it less suitable for an economy requiring swift and decisive policy impacts. For the Brazilian economy, these findings underscore the importance of selecting an approach that balances theoretical rigor with practical applicability. While the rational approach offers theoretical efficiency, its assumption of frictionless adjustments and absence of cognitive biases renders it fundamentally unrealistic in capturing the complexities of real-world economies. The sharp initial shocks it predicts, while mathematically consistent, fail to account for the inherent behavioral rigidities and biases that drive economic decision-making, particularly in a context like Brazil's. In contrast, behavioral models provide a more nuanced lens by incorporating the bounded rationality and heuristics that characterize actual agent behavior. Among the behavioral approaches examined, the approach with $M = 0.6$ produces gentler adjustments but risks insufficient policy effectiveness, as its overly gradual responses may underestimate the urgency of fiscal corrections. The approach with $M = 0.8$, however, strikes a critical balance, capturing the essence of agent expectations while mitigating excessive volatility. Its smoother adjustment trajectory reflects the behavioral realities of economic decision-making, resulting in a more stable and resilient fiscal environment. This approach aligns with Brazil's economic challenges, where cognitive biases and adaptive behaviors dominate (Figure 5, Chart "a").

Regarding the primary surplus, the rational approach shows a significant upward adjustment in the variable, beginning from negligible initial effects and peaking at 16.25 by the fourth quarter before tapering slightly to 14.93 in the fifth quarter. This trajectory aligns closely with macroeconomic theory, where a rise in interest rates is expected to strengthen fiscal performance by reducing inflationary pressures and improving debt servicing metrics. The sharp and rapid nature of this adjustment reflects the assumption that agents are fully informed and respond optimally to policy changes. The behavioral approach with $M = 0.8$ exhibits a similar upward trajectory, with the surplus reaching 16.34 by the fourth quarter and tapering to 14.89 by the fifth quarter. While the initial response is smoother than in the rational approach, the overall adjustment remains significant and closely aligned with theoretical literature. This suggests that, although agents face cognitive or informational constraints, their behavior remains sufficiently forward-looking to capture key dynamics of fiscal improvement following monetary policy interventions. The behavioral approach with $M = 0.6$, in contrast, presents a weaker and inconsistent response. The primary surplus declines slightly in the initial quarters, stabilizing at a marginally negative value of -0.42 by the fifth quarter. This pattern indicates significant inertia in agents' behavior, leading to an inadequate adaptation to monetary policy changes. The lack of a substantial or consistent adjustment diverges from theoretical literature, where higher interest rates should bolster fiscal balances. The rational approach, while theoretically appealing, falls short of capturing the complexities and nuances of real-world fiscal dynamics. Its assumption of frictionless adjustments and the absence of cognitive biases result in sharp and unrealistic fiscal responses, often overestimating the economy's capacity to adapt instantaneously to shocks. This lack of alignment with observed economic behavior undermines its practical applicability. The behavioral approach with $M = 0.6$, though reflective of bounded rationality, fails to generate effective policy transmission, offering overly muted adjustments that do little to support fiscal consolidation or economic stability. Finally, the behavioral approach with $M = 0.8$ emerges as the most realistic and effective framework, balancing theoretical rigor with the adaptive behaviors and gradual adjustments observed in practice. By producing significant fiscal adjustments through smoother and more plausible response trajectories, it aligns with the behavioral realities of economic agents, providing a stable and sustainable foundation for fiscal policymaking (Figure 5, Chart "b").

About private consumption, the rational approach demonstrates a sharp initial decline in consumption of -2.21 in the first quarter, with a gradual recovery over subsequent quarters.

This steep adjustment aligns with macroeconomic theory, where higher interest rates reduce disposable income and investment, leading to an immediate contraction in consumption. The speed and magnitude of the adjustment reflect the assumption of fully informed and rational agents who optimize their consumption decisions in response to policy changes. The behavioral approach with $M = 0.8$ exhibits a less abrupt decline, with consumption falling to -1.86 in the first quarter. Although the response is smoother compared to the rational approach, it remains significant and largely consistent with theoretical literature. This suggests that agents, despite facing cognitive or informational constraints, adapt in a manner that captures the broader dynamics of consumption contraction following a monetary policy shock. The reduced initial intensity of the response acts as a buffer, mitigating the short-term economic impact. In contrast, the behavioral approach with $M = 0.6$ presents a much weaker and slower response, with consumption declining by only -0.44 in the first quarter and stabilizing at -0.09 by the fifth quarter. This muted adjustment indicates significant inertia in agents' behavior, suggesting that they are less sensitive to changes in interest rates. The limited magnitude and delayed adjustment deviate from theoretical predictions, raising concerns about the effectiveness of monetary policy transmission in this framework (Figure 6, Chart "a").

Figure 6 - IRFs: Interest rate positive shocks (private consumption and CPI)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$.
Source: Graphs generated from the conducted estimates.

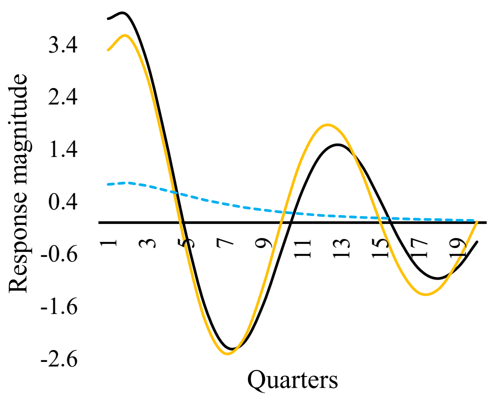
The rational approach, despite its theoretical consistency in modeling monetary policy impacts, fails to capture the behavioral nuances of real-world economic agents. Its sharp and abrupt responses overlook the cognitive biases and adaptive behaviors that characterize decision-making, leading to unrealistic and potentially destabilizing short-term volatility. This disconnects from observed economic realities undermines its practicality in dynamic and vulnerable economies. The behavioral approach with $M = 0.6$, while incorporating bounded rationality, suffers from an overly muted and delayed response, which can compromise policy effectiveness in situations demanding swift action to stabilize the economy. The behavioral approach with $M = 0.8$, however, bridges these gaps, balancing theoretical alignment with empirical plausibility. Its smoother adjustment trajectory reflects the gradual and adaptive nature of consumption dynamics, making it particularly well-suited for economies prone to structural vulnerabilities and external shocks (Figure 6, Chart "a").

Regarding CPI inflation, the rational approach shows a significant and immediate decline, beginning at -1.09 in the first quarter and turning positive from the eighth quarter onward. This sharp initial reduction is consistent with macroeconomic theory, where a rise in interest rates suppresses aggregate demand, leading to a reduction in inflationary pressures. The steep trajectory reflects the assumption that agents are fully informed and respond optimally to policy changes, allowing for a direct and effective transmission of monetary policy. The behavioral approach with $M = 0.8$ shows a less pronounced initial decline, with CPI inflation decreasing to -0.80 in the first quarter and reaching zero by the eighth quarter. Although the initial response is smoother, it remains significant and largely aligned with theoretical literature. This suggests that agents, while constrained by cognitive or informational limitations, adapt sufficiently to capture the broader inflation dynamics following a monetary shock. The reduced severity of the initial decline provides a buffer against abrupt economic disruptions (Figure 6, Chart "b").

Conversely, the behavioral approach with $M = 0.6$ reveals a far weaker and slower response, with CPI inflation declining by only -0.09 in the first quarter and stabilizing at -0.01 by the fifth quarter. This muted adjustment indicates significant inertia among agents, resulting in an inadequate adaptation to monetary policy changes. While the rational approach achieves the desired inflation reduction effectively, its sharp and rapid impact may introduce short-term volatility and economic strain. The behavioral approach with $M = 0.6$, with its weak and delayed response, fails to deliver meaningful results, undermining the credibility and effectiveness of monetary policy. The behavioral approach with $M = 0.8$ offers a practical balance, achieving significant inflation control while mitigating short-term disruptions (Figure 6, Chart "b").

Macroeconomic literature suggests that an interest rate positive shock, such as an increase in the Selic rate, should initially increase public debt due to higher debt servicing costs. Over time, as the economy adjusts and fiscal consolidation measures take effect, the debt trajectory is expected to stabilize or even decline if the fiscal framework is robust. Under the rational approach, public debt increases significantly in the first quarter, reaching 3.89 and peaking at 3.96 in the second quarter before beginning to decline. By the fifth quarter, public debt exhibits a slight decrease to -0.20, signaling a full adjustment and a return to fiscal discipline. This trajectory aligns closely with theoretical literature, as the initial surge reflects the impact of higher interest rates on debt servicing, followed by stabilization as fiscal adjustments mitigate the debt burden. The sharp and precise nature of this adjustment highlights the assumption that agents are fully informed and optimize their responses to policy changes. The behavioral approach with $M = 0.8$ also shows an initial increase in public debt, starting at 3.30 in the first quarter and peaking at 3.56 in the second quarter. However, the magnitude of the response is slightly less pronounced than in the rational approach. By the fifth quarter, public debt declines to -0.48, indicating a smoother adjustment process compared to the rational framework. This response suggests that agents, while exhibiting some cognitive or informational constraints, adapt in a way that largely captures the forward-looking behavior necessary for fiscal consolidation. The smoother trajectory is consistent with a dampened initial impact of monetary policy shocks, which may reduce short-term volatility while achieving long-term stabilization (Figure 7).

Figure 7 - IRFs: Interest rate positive shocks (public debt)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$. Source: Graphs generated from the conducted estimates.

In contrast, the behavioral approach with $M = 0.6$ shows a markedly weaker and less consistent response. Public debt increases only marginally in the first quarter, reaching 0.73, without moving into negative territory. This trajectory indicates significant inertia among agents, as they are less responsive to policy changes and fail to internalize the long-term fiscal dynamics effectively. The lack of a meaningful adjustment diverges from theoretical literature, underscoring the limitations of this framework in ensuring robust fiscal outcomes. The rational approach and behavioral approach with $M = 0.8$ closely align with the expected dynamics of public debt following a monetary policy shock. The rational approach captures the full magnitude of the adjustment but may introduce heightened short-term volatility due to its sharp initial increase. Conversely, the moderate behavioral approach offers a smoother adjustment process, mitigating short-term disruptions while still achieving fiscal stabilization. The behavioral approach with $M = 0.6$, however, falls short of theoretical benchmarks, as its weak and incomplete adjustment fails to deliver the fiscal consolidation expected in response to tighter monetary policy. The rational approach, while effective in achieving fiscal consolidation, may exacerbate short-term economic volatility, posing risks in a context of fragile stability. The behavioral approach with $M = 0.6$, on the other hand, lacks the responsiveness needed to manage fiscal challenges effectively (Figure 7).

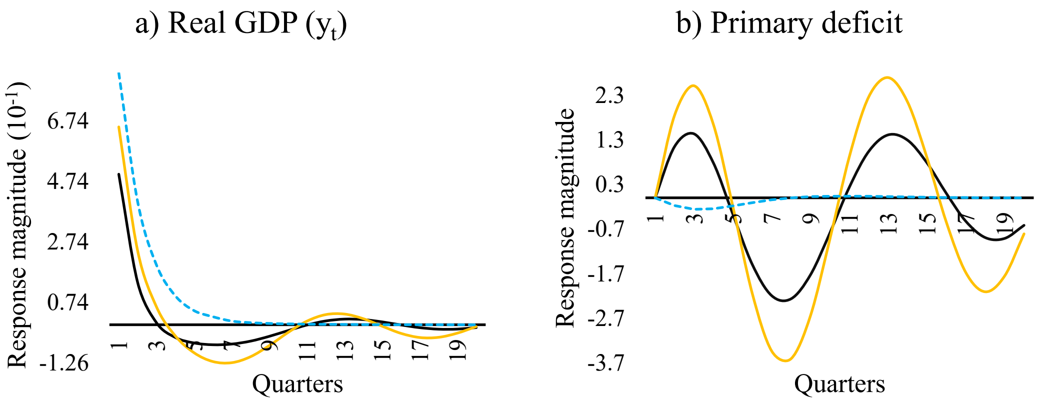
Although interest rate negative shocks, typically associated with expansionary monetary policies, were not examined in our study, a graphical illustration of such scenarios is provided in Appendix H for reference.

6.3 Government consumption positive shocks

Next, we will examine Brazilian fiscal policy in detail (see Figures 8 to 10). The responses are organized by variable, with each figure displaying the responses to the same shock for both the rational and behavioral approaches. The selected macroeconomic variables' reactions to expansionary fiscal policy, specifically government consumption positive shocks, are presented. The vertical axis of the graphs represents the magnitude of the response, while the horizontal axis depicts time in quarters. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$. The shocks applied are of one standard deviation and the responses analyzed include real GDP, primary deficit, CPI inflation, private consumption and the Selic nominal interest rate.

In the rational approach, the initial response of GDP to an increase in government consumption is approximately 0.498 but declines rapidly, reaching negative values by the fourth quarter. This behavior aligns with macroeconomic literature, which predicts an initial positive response due to the fiscal multiplier effect but suggests this effect tends to dissipate or even reverse in the medium term because of crowding-out effects. The IRFs confirm this theoretical expectation, demonstrating a moderate initial impact and a swift reversal. In the behavioral approach with $M = 0.8$, the initial impact is higher (0.654) and the decline in the response over time is more gradual compared to the rational approach, maintaining positive values for a longer duration. This greater persistence in response is attributed to behavioral biases that amplify the perceived short-term benefits of fiscal interventions, delaying the adverse effects of economic adjustments. Behavioral literature suggests that this approach better captures the cognitive imperfections and adaptive expectations of economic agents. In contrast, the behavioral approach with $M = 0.6$ shows the highest initial response magnitude (0.833) and an even more prolonged persistence of positive effects, with GDP remaining above the baseline level until the eighth quarter. This behavior reflects the greater sensitivity of agents to fiscal stimuli, potentially driven by overly optimistic diagnoses of the future impacts of public policies. While this characteristic is initially advantageous, it may introduce significant volatility in economies that rely on stable expectations to avoid amplified economic cycles. Comparing the three approaches considering macroeconomic theory and the Brazilian economic context, the rational approach appears more aligned with long-term stability. In contrast, the behavioral approaches demonstrate greater initial efficacy but carry the risk of future instability due to the prolonged persistence of fiscal responses. GDP's response to a fiscal shock is expected to be positive in the short term but diminish in intensity due to factors such as aggregate supply adjustments and budgetary constraints — a pattern clearly reflected in both the rational and moderate behavioral approaches. However, the IRF results also suggest that elements of the behavioral approach with $M = 0.8$, by capturing stronger short-term responses, could be valuable for maximizing the impact of fiscal policies during recessions, provided they are combined with mechanisms to mitigate the risks of excessive persistence and misaligned expectations (Figure 8, Chart "a").

Figure 8 - IRFs: Gov't consumption positive shocks (GDP and primary deficit)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$. Source: Graphs generated from the conducted estimates.

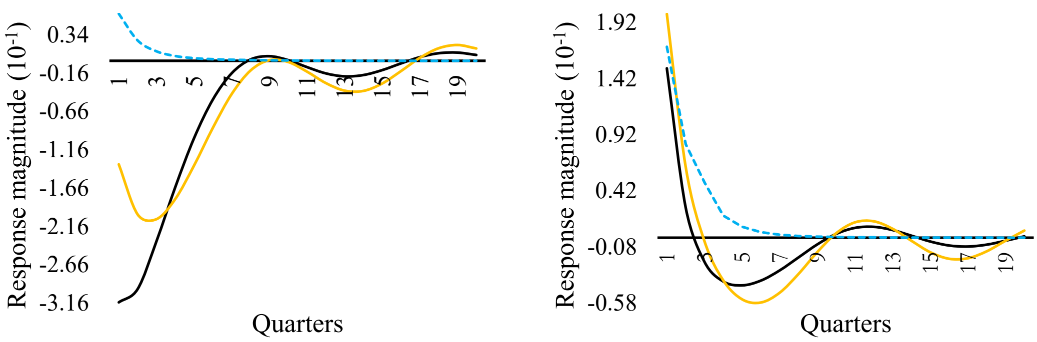
In the rational approach, the initial response of the primary deficit to a positive shock of government consumption is practically zero, followed by a significant increase in the second and third quarters, peaking at 1.43 before beginning to decline. This behavior aligns with macroeconomic theory, which suggests that an increase in public spending initially pressures the deficit due to higher expenditures, before fiscal adjustments or revenue growth begins to mitigate the impact. The progressive decline after the peak is also consistent with the expectation that, as the effects of fiscal stimulus dissipate, the deficit gradually returns to equilibrium. In the behavioral approach with $M = 0.8$, the initial response is similarly close to zero, but the impact on the deficit becomes more pronounced in subsequent quarters, peaking at 2.51 in the third quarter — nearly double the level observed in the rational approach. This behavior reflects the influence of behavioral biases that lead agents to underestimate the future fiscal costs associated with increased government consumption. As a result, the perception that future negative impacts will be limited or manageable reduces the urgency to implement contractionary fiscal policies. Consequently, agents prioritize short-term benefits, such as stimulating economic activity, while neglecting the necessary adjustments to contain the rising deficit, allowing for an amplification of fiscal imbalances in the short term (Figure 8, Chart "b").

On the other hand, the behavioral approach with $M = 0.6$ exhibits a distinct pattern. After an initial response close to zero, the deficit experiences a significant decline in subsequent quarters, reaching a minimum of -0.25 in the third quarter. This result suggests that agents may be reacting with overly pessimistic diagnoses of the future costs of increased government spending, adjusting their behavior to preemptively compensate for the anticipated long-term impacts. This negative and unstable response is inconsistent with the expected macroeconomic pattern, which predicts short-term increases in the deficit before a gradual convergence to equilibrium. The standard macroeconomic expectation is that the primary deficit will initially increase in response to a positive shock of government consumption, with a gradual return to equilibrium as economic and fiscal adjustments take place. The rational approach, although aligned with the expected theoretical behavior, proves unrealistic for any economic context because an economy inherently involves cognitive biases and, therefore, cannot rely on unlimited rationality in any scenario. In a more practical scenario, the behavioral approach with $M = 0.8$ significantly amplifies the initial impact. While this amplification can be useful for maximizing short-term stimulus, it also increases the risk of prolonged fiscal imbalances. On the other hand, the approach with $M = 0.6$ shows considerable deviations from the expected pattern, suggesting that its practical application is problematic, especially in economies that rely on fiscal stability. Given this, the approach with M=0.8, even without precise knowledge of the cognitive bias level, seems to be the most suitable for real economic contexts. Despite the uncertainty surrounding the exact bias, it provides a more pragmatic way to deal with the complexity of economic decisions, allowing for a more flexible adaptation to market conditions (Figure 8, Chart "b").

Private consumption in the rational approach responds negatively to a government consumption shock. The initial response is a decline of -3.15 in the first quarter, followed by a slow recovery in subsequent quarters. In the second quarter, the impact remains significant (-2.98) but steadily decreases until the fifth quarter (-1.01). This behavior aligns with macroeconomic literature, which predicts that an increase in government spending may lead to crowding-out effects. In this context, private consumption is displaced due to greater competition for resources in the market, such as rising interest rates or shifts in private investment. The IRFs confirm this expectation, highlighting that the rational approach theoretically captures the compensatory effects between the public and private sectors. In contrast, the behavioral approach with $M = 0.8$ shows a smaller initial negative impact (-1.35 in the first quarter) compared to the rational approach, but the effect persists more significantly over time. By the third quarter, for example, the response remains negative (-2.06), though less pronounced than in the rational approach. This smoother trajectory suggests that economic agents in this approach internalize the shock's effects more gradually, initially underestimating the negative impacts on private consumption. Behavioral literature suggests that this pattern may result from optimism biases or reduced sensitivity to budget constraints in the short term, leading to a more muted but not necessarily less persistent response (Figure 9, Chart "a").

Figure 9 - IRFs: Gov't consumption positive shocks (private consumption and CPI)

a) Private consumption (c_t) b) CPI inflation (π_t)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$. Source: Graphs generated from the conducted estimates.

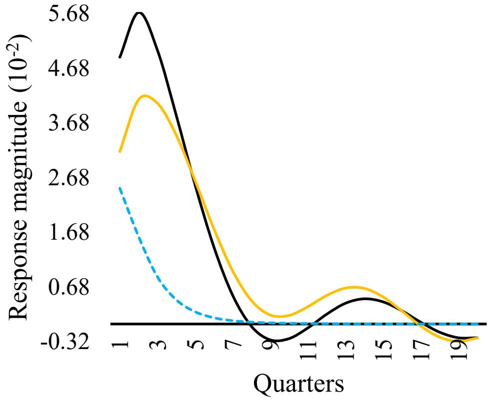
The behavioral approach with $M = 0.6$ shows an unexpectedly positive initial response, with private consumption increasing by 0.61 in the first quarter. In subsequent quarters, this positive response diminishes rapidly but remains positive through the fifth quarter. This behavior suggests that agents under this approach tend to overestimate the initial benefits of increased government spending, believing that fiscal stimulus will generate significant multiplier effects on private consumption. However, this optimism may be excessive, as it does not align with expected macroeconomic behavior, which typically associates government consumption shocks with private consumption displacement in scenarios of resource scarcity. In economies with idle capacity, multiplier effects may dominate, generating positive responses in private consumption. However, in economies facing supply constraints or rigid monetary policies, crowding-out effects are more likely to prevail, leading to negative responses. (Figure 9, Chart “a”).

Regarding inflation and the rational approach, an initial positive impact is observed in the first quarter, with CPI inflation increasing by 0.14, followed by a gradual reduction over time, turning negative as early as the third quarter (-0.02). This behavior aligns with macroeconomic literature, which suggests that increased government spending can create short-term inflationary pressures due to higher aggregate demand before subsiding through economic adjustments, such as contractionary monetary policies or supply-side accommodations. The IRFs for this approach effectively capture the expected effects, showing a moderate initial response that adjusts over time. Under the behavioral approach with $M = 0.8$, the initial response of inflation to the shock is more pronounced, with an increase of 0.20 in the first quarter. This rise is followed by a slower decline, with negative values appearing only in the fourth quarter (-0.03) and of a lesser magnitude than in the rational approach. This behavior reflects a behavioral bias where agents tend to react optimistically to fiscal stimuli, amplifying the initial impacts on inflation but adjusting their expectations more slowly than in the rational approach. The greater persistence of inflationary effects suggests an underestimation of future economic constraints, prolonging the positive impact of aggregate demand in the short term. In the behavioral approach with $M = 0.6$, the initial impact is also positive but of intermediate magnitude (0.17), with a more gradual decline over time, maintaining positive values until the eighth quarter. This response indicates that agents overdiagnose the effects of fiscal stimulus in the short term, maintaining higher inflationary expectations even as the economy begins to adjust to the shock. This behavior is less consistent with standard macroeconomic theory, which typically predicts a quicker return to inflationary stability in well-anchored economies (Figure 9, Chart “b”).

A government consumption positive shock is expected to generate initial inflationary pressures, which gradually dissipate as monetary and fiscal adjustment policies take effect. The rational approach reflects this expectation, with moderate and temporary impacts on inflation. The behavioral approach with $M = 0.8$, on the other hand, captures a stronger initial effect but may prolong inflationary imbalances in a scenario of poorly anchored expectations. Meanwhile, the approach with $M = 0.6$ appears less compatible with theoretical fundamentals in the Brazilian context, showing greater inflation persistence than would be expected in a stable economy (Figure 9, Chart "b").

Finally, the rational approach exhibits the highest initial magnitude of response in the nominal interest rate. The response peaks in the second quarter, with values exceeding 0.05, gradually declining in subsequent quarters. This dynamic aligns with macroeconomic literature: in response to a shock in government consumption, it is expected that the nominal interest rate will react proportionally, reflecting contractionary monetary policies in scenarios of increased public spending. On the other hand, the behavioral approach with $M = 0.8$ shows a lower response compared to the rational approach. Its peak is slightly lower, at around 0.041 in the second quarter, with a sharper decline in subsequent quarters. This difference reflects the reduced weight given to future expectations in the behavioral framework, which tempers the interest rate's reaction to the initial shock. Although less responsive, the dynamic still suggests a predictable relationship between increased public spending and monetary adjustments, albeit with less intensity. The behavioral approach with $M = 0.6$, however, demonstrates the lowest magnitude of response among all approaches. The initial peak occurs in the first quarter (0.025) and the response nearly dissipates by the seventh quarter. This result highlights the impact of distorted expectations under a more limited perception of the economic agent regarding the long-term consequences of the shock (Figure 10).

Figure 10 - IRFs: Gov't consumption positive shocks (Selic nominal interest rate)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$.
Source: Graphs generated from the conducted estimates.

This observed interplay between fiscal and monetary dynamics highlights the unique challenges posed by behavioral rigidities in the Brazilian context. Historically, public spending in Brazil has exhibited limited discipline, often driven by social demands rather than strict adherence to macroeconomic constraints. This tendency is further reflected in the IRFs, where fiscal shocks amplify aggregate demand, and monetary adjustments, while effective in curbing inflation, struggle to enforce sufficient fiscal discipline. These dynamics, as supported by the literature [see Carvalho *et al*. (2016), Barros and Lima (2018), Melo and Silva (2019), Besarria, Maia and Nobrega (2020), Fasolo *et al*. (2024) and Freitas (2025)], emphasize the importance of integrating behavioral considerations into policy modeling to better capture the complex interactions between fiscal and monetary shocks in emerging economies like Brazil.

Although government consumption negative shocks, typically associated with contractionary fiscal policies, were not examined in our study, a graphical illustration of such scenarios is provided in Appendix I for reference.

7 CONCLUDING REMARKS

This Thesis explored the interaction between monetary and fiscal policies in Brazil, focusing on the implications of bounded rationality in economic modeling. The study examined the differential impacts of rational and behavioral approaches on specific macroeconomic variables following monetary and fiscal policy shocks. Using a new Keynesian DSGE model with Bayesian estimation, the analysis covered quarterly data from 2000Q1 to 2023Q4, providing a comprehensive comparison between the two approaches.

The findings of this study provide valuable perspectives on the dynamics of fiscal and monetary policies in Brazil, emphasizing the comparison between rational and behavioral approaches. While the rational approach demonstrates theoretical consistency in capturing the effects of economic shocks, it assumes instantaneous adjustments and fully rational agents, disregarding the behavioral rigidities and cognitive biases inherent to real-world economies. This limitation makes the rational approach fundamentally unrealistic, particularly in the Brazilian context, which is characterized by structural volatility, inflationary pressures and adaptive responses from economic agents.

Behavioral approaches, on the other hand, exhibit a greater ability to capture the gradual adjustments and smoother dynamics observed in the interaction between fiscal and monetary policies. The results indicate that, even when accounting for varying degrees of cognitive biases and myopia, the economy inherently operates in a behavioral manner, thereby validating the relevance of these approaches. Among them, the behavioral approach with $M = 0.8$ proved especially robust, balancing significant short-term responses with a gradual convergence to equilibrium, avoiding the abrupt impacts predicted by the rational approach and the insufficient adjustments observed in models with higher levels of myopia, such as $M = 0.6$.

By capturing the effects of fiscal and monetary shocks more realistically, the behavioral approach underscores the importance of integrating agents' cognitive limitations into macroeconomic models. For fiscal shocks, the behavioral framework more accurately reflects the interplay between increased public spending and the dynamics of output and public debt, while for monetary shocks, it better reproduces the gradual adjustments in interest rates and the trajectory of inflation.

In conclusion, this study reinforces that behavioral approaches not only provide a more realistic representation of economic interactions in Brazil but also offer a stronger foundation for designing integrated and effective fiscal and monetary policies. By acknowledging that the Brazilian economy operates with cognitive biases and bounded rationality, this research contributes to advancing discussions on how to model and implement economic policies in the country with greater precision and relevance.

Despite the inclusion of behavioral agents, this analysis is consistent with Lucas' Critique. The essence of the Critique is not exclusively tied to the use of rational expectations but rather to the idea that economic agents adjust their behavior in response to policy changes. Lucas (1976) argued that traditional econometric models failed to account for these behavioral adjustments, regardless of how expectations are formed. Future research could explore scenarios involving fiscal or monetary dominance, examine the implications of a zero lower bound on nominal interest rates and investigate the interaction between exchange rate policy and other economic policies. These studies would deepen the understanding of economic policy dynamics and contribute to more effective public policy formulation. Finally, this study enhances the understanding of economic policy dynamics through the lens of bounded rationality, offering valuable insights into the interaction between monetary and fiscal policies in the Brazilian context. The findings significantly contribute to guiding Brazil toward more sustainable economic development.

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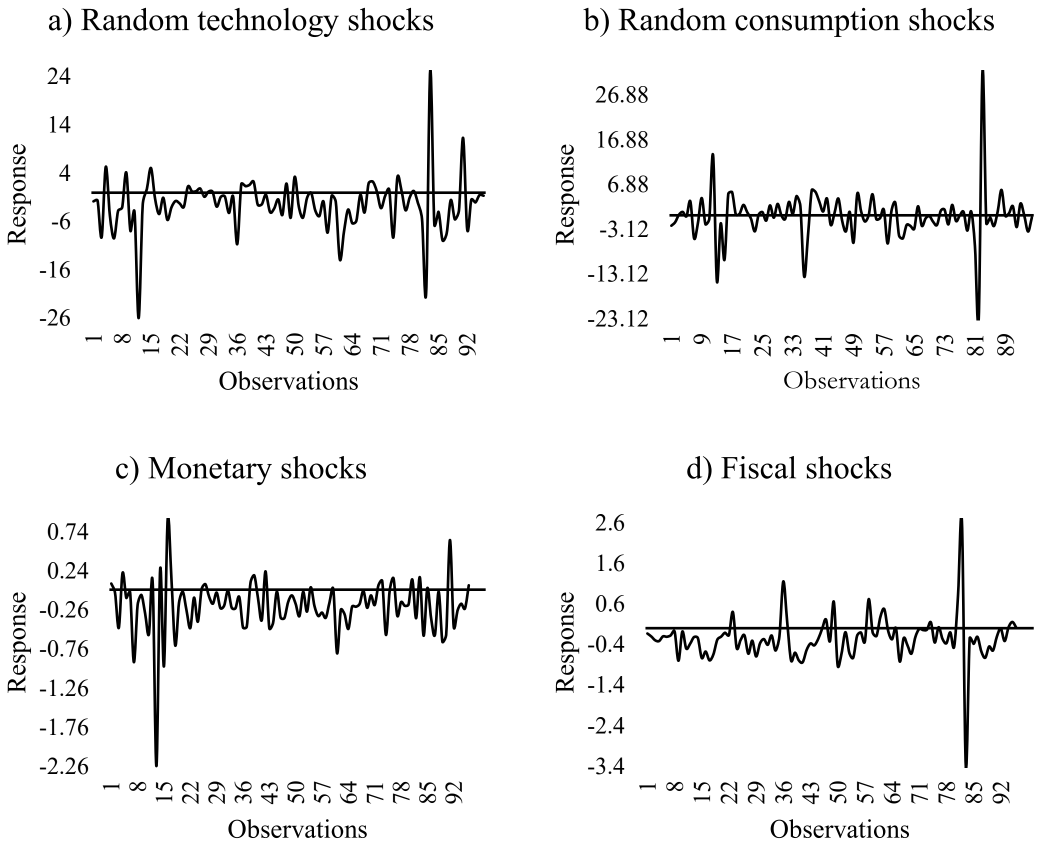
APPENDIX A - SMOOTHED SHOCKS FROM RATIONAL APPROACH (M=1)

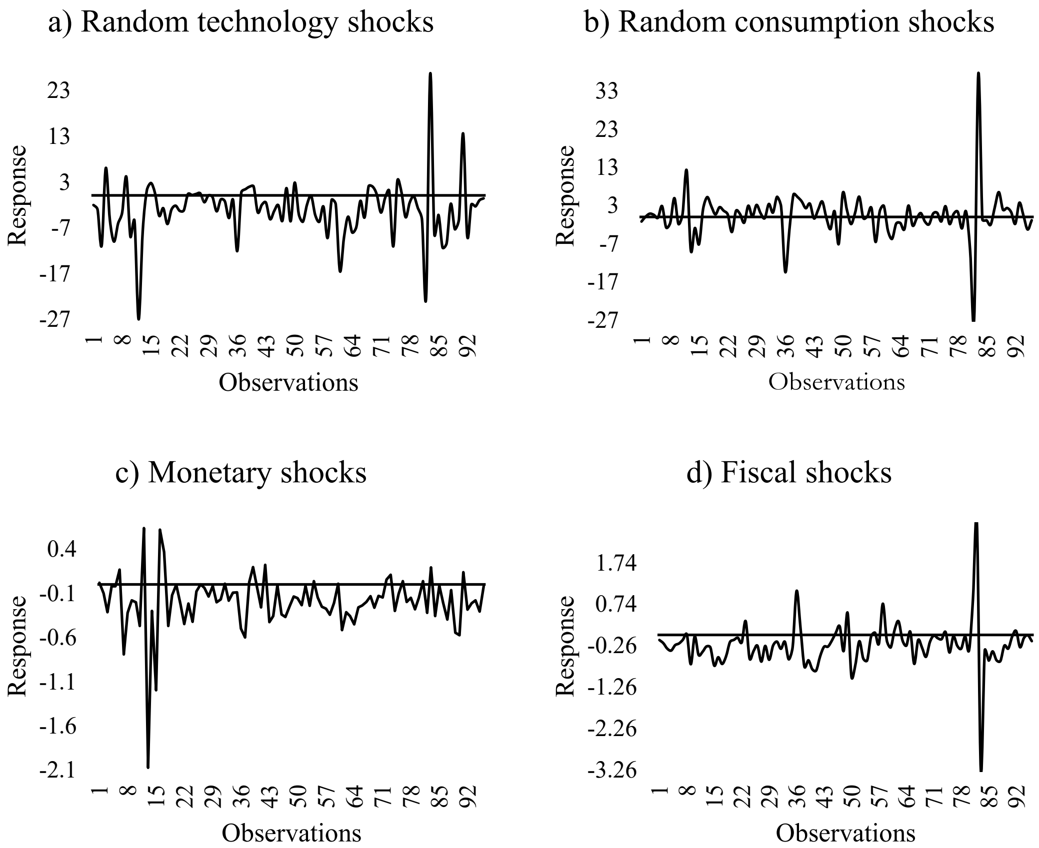
Figure 11 - Smoothed shocks from rational approach ($M = 1$)



Source: Graphs generated from the responses to structural shocks of one standard deviation in magnitude.

APPENDIX B - SMOOTHED SHOCKS FROM BA (M=0.8)

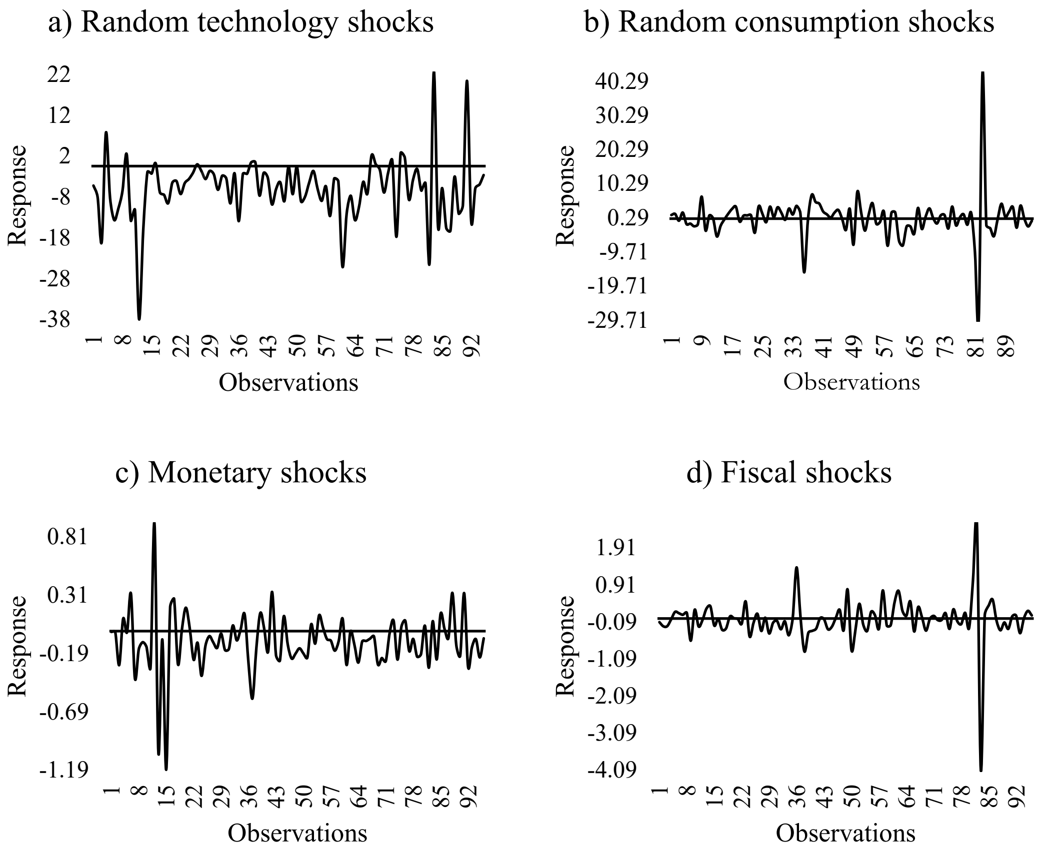
Figure 12 - Smoothed shocks from behavioral approach (M=0.8)



Source: Graphs generated from the responses to structural shocks of one standard deviation in magnitude.

APPENDIX C - SMOOTHED SHOCKS FROM BA (M=0.6)

Figure 13 - Smoothed shocks from behavioral approach (M=0.6)



Source: Graphs generated from the responses to structural shocks of one standard deviation in magnitude.

APPENDIX D - EQUATIONS OF THE PROPOSED MODEL

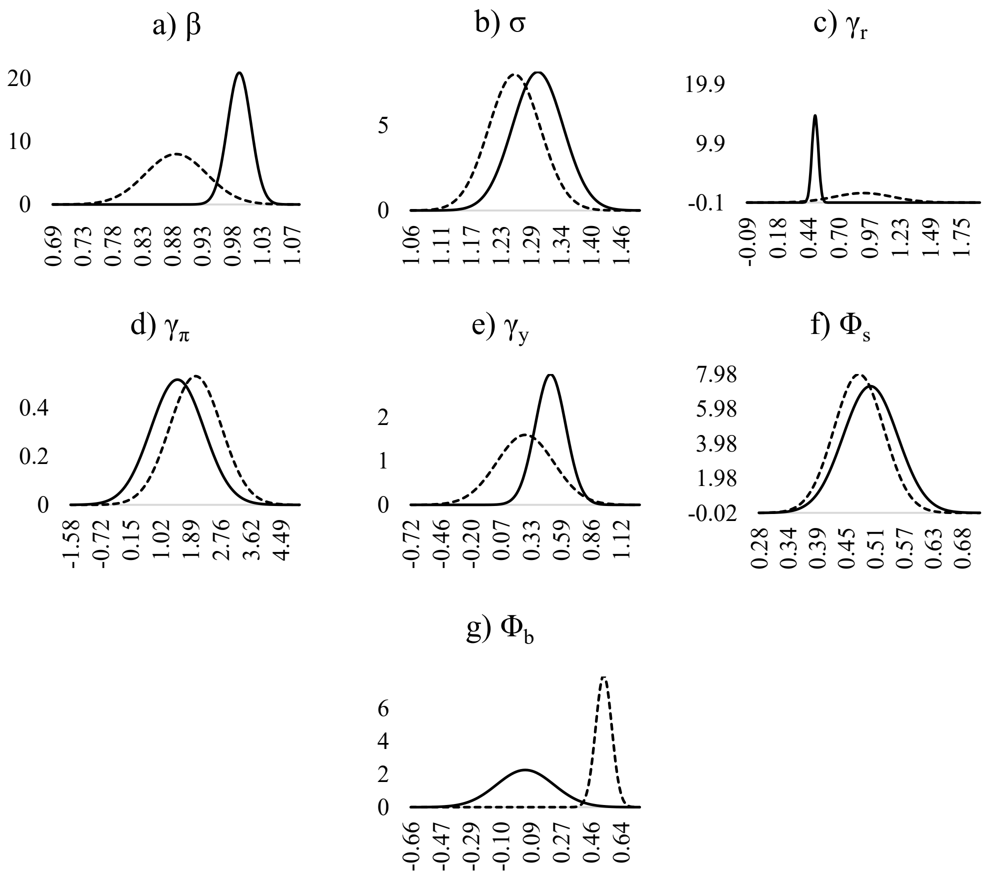
Table 6 - Equations of the proposed model

$y_t = s_c c_t + s_g g_t$	(Aggregate demand)
$y_t^n = \left[\frac{s_c(1+\phi)}{\sigma(1-\alpha)+s_c(\phi+\alpha)}\right](\epsilon_t^a + 1) + m_c + \log(1-\alpha) - \epsilon_t^c$	(GDP Natural)
$m_c = \left(\frac{\sigma}{s_c} + \frac{1+\phi}{1-\alpha} - 1\right)(y_t^n)$	(Marginal cost firms)
$r_t = (r_{t-1})^{\gamma_r}\left[\left(r_t^n \frac{\pi_t}{\pi_t^*}\right)^{\gamma_\pi}(y_t - y_t^n)^{\gamma_y}\right]^{1-\gamma_r} + \epsilon_t^r$	(Taylor rule)
$g_t = \gamma_g g_{t-1} + (1-\gamma_g)(\phi_s s_{t-1}^*) - \phi_b b_{t-1}^\gamma + \epsilon_t^g$	(Gov't consumption)
$c_t = ME_t[c_{t+1}] - \frac{1}{\sigma}(r_t - E_t[\pi_{t+1}]) + \frac{1}{\sigma}(\epsilon_t^c - \epsilon_{t+1}^c)$	(Euler equation)
$\pi_t = M\beta E_t[\pi_{t+1}] + \lambda_t + \left(\frac{\sigma}{s_c} + \frac{1+\phi}{1-\alpha} - 1\right)(y_t - y_t^n) + \epsilon_t^\pi$	(New Keynesian Phillips curve)

Sources: Gabaix (2020) and Fasolo *et al*. (2024).

APPENDIX E - PARAMETERS FROM RATIONAL APPROACH (M=1)

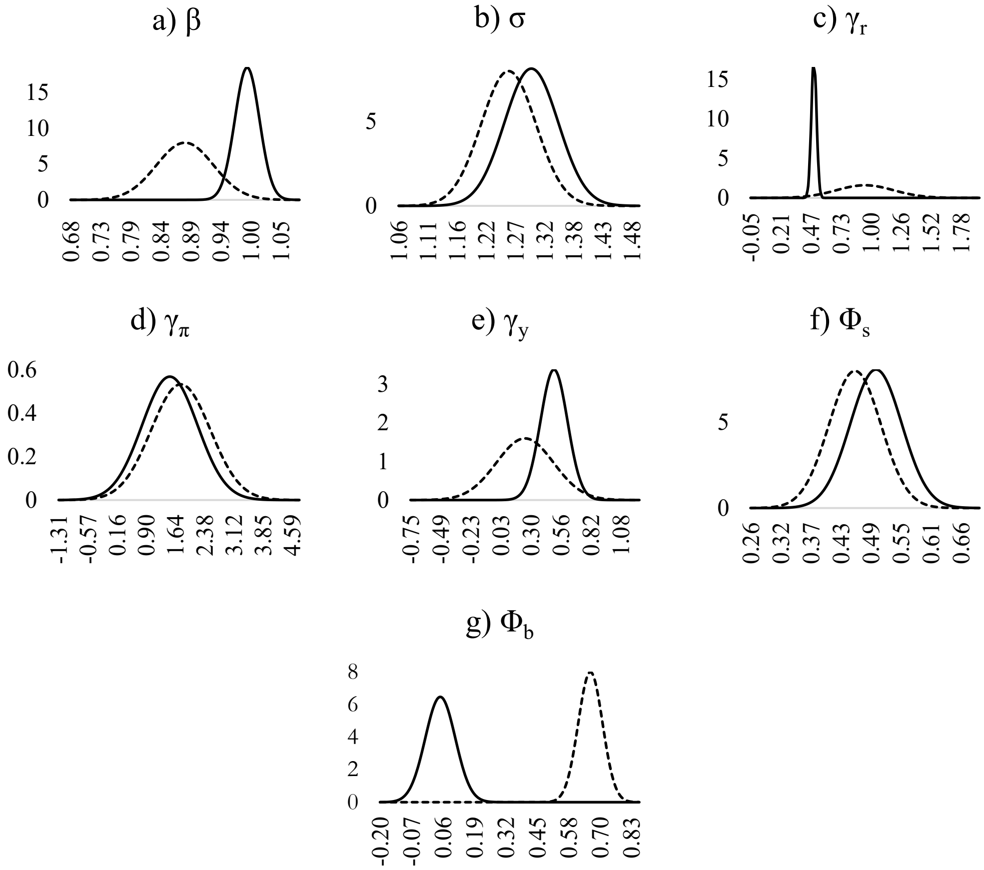
Figure 14 - Priors and posteriors of the parameters from rational approach (M=1)



Notes: The solid line refers to the priors, while the dashed line refers to the posteriors. Probability distribution functions based on 100 points.
Source: Graphs generated from the conducted estimates.

APPENDIX F - PARAMETERS FROM BA (M=0.8)

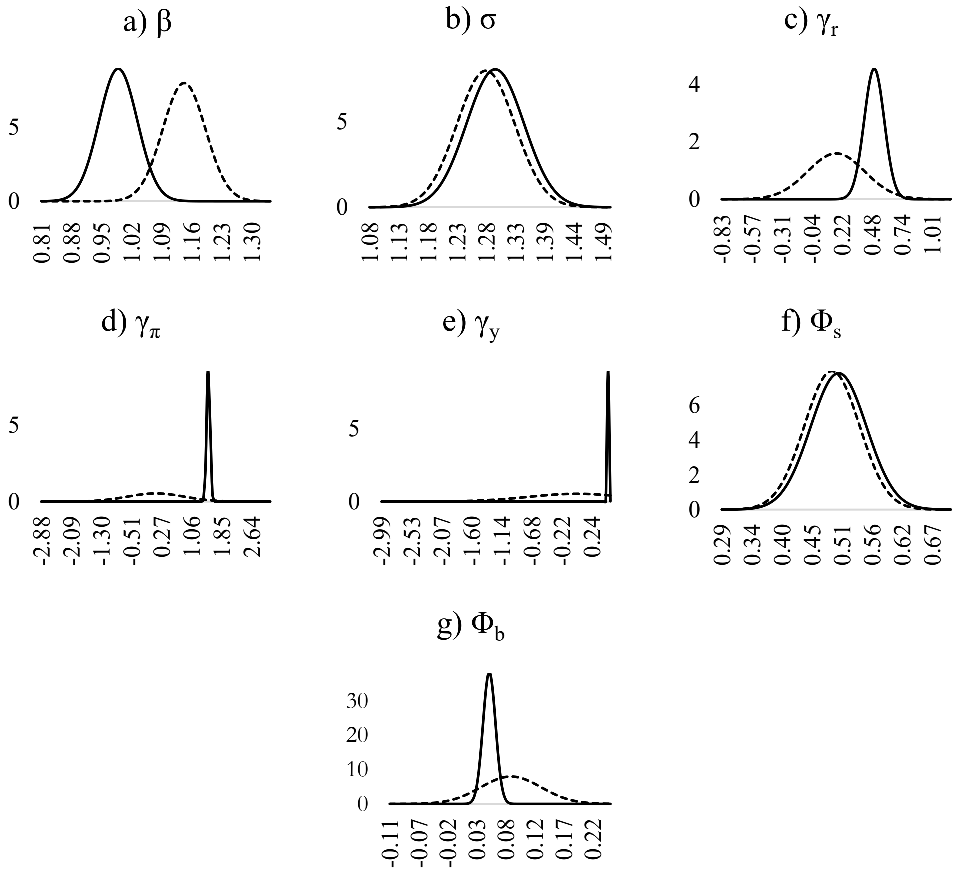
Figure 15 - Priors and posteriors of the parameters from behavioral approach (M=0.8)



Notes: The solid line refers to the priors, while the dashed line refers to the posteriors. Probability distribution functions based on 100 points.
Source: Graphs generated from the conducted estimates.

APPENDIX G - PARAMETERS FROM BA (M=0.6)

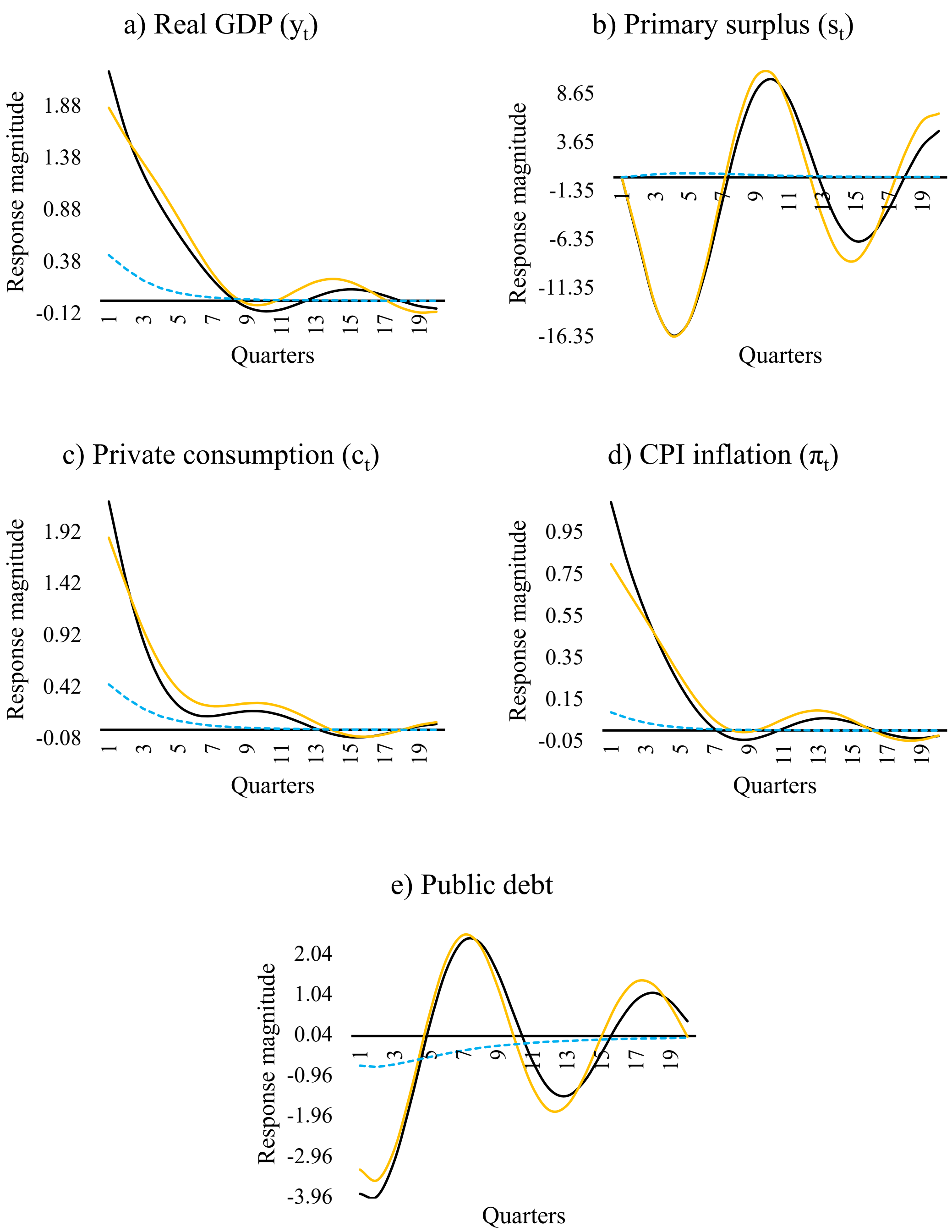
Figure 16 - Priors and posteriors of the parameters from behavioral approach (M=0.6)



Notes: The solid line refers to the priors, while the dashed line refers to the posteriors. Probability distribution functions based on 100 points.
Source: Graphs generated from the conducted estimates.

APPENDIX H - INTEREST RATE NEGATIVE SHOCKS

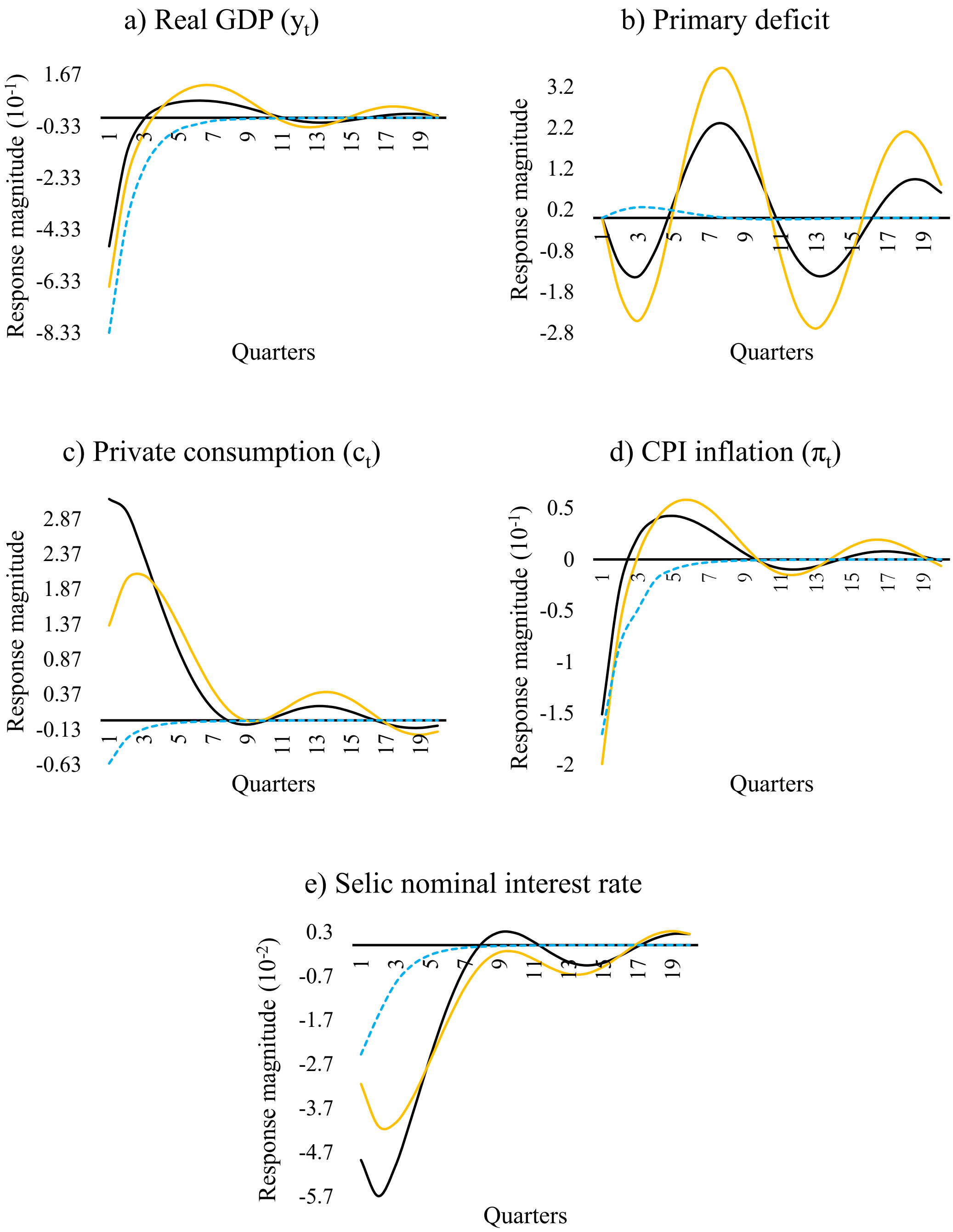
Figure 17 - IRFs: Interest rate negative shocks (expansionary monetary policy)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$.
Source: Graphs generated from the conducted estimates.

APPENDIX I – GOVERNMENT CONSUMPTION NEGATIVE SHOCKS

Figure 18 - IRFs: Gov't consumption negative shocks (contractionary fiscal policy)



Notes: 95% confidence interval. The smooth black line represents the IRFs of the rational approach. The horizontal lines indicate the transition from positive to negative territory or vice versa. The orange line corresponds to the IRFs of the behavioral approach with $M = 0.8$. Finally, the blue dashed line corresponds to the IRFs of the behavioral approach with $M = 0.6$.
Source: Graphs generated from the conducted estimates.