UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE CIÊNCIAS ECONÔMICAS
PROGRAMA DE PÓS-GRADUAÇÃO EM ECONOMIA

MATHEUS PORTO PIMENTEL

FISCAL POLICY RULES: A NEW KEYNESIAN MODEL FOR BRAZIL WITH BAYESIAN ESTIMATION

Porto Alegre
2024

MATHEUS PORTO PIMENTEL

FISCAL POLICY RULES: A NEW KEYNESIAN MODEL FOR BRAZIL WITH BAYESIAN ESTIMATION

Dissertação de mestrado acadêmico submetida ao Programa de Pós-Graduação em Economia da Faculdade de Ciências Econômicas da UFRGS, como requisito parcial para obtenção do título de Mestre em Economia.

Orientador: Prof. Dr. Marcelo Savino Portugal

Porto Alegre
2024

CIP - Catalogação na Publicação

Porto Pimentel, Matheus
Fiscal Policy Rules: A New-Keynesian Model for Brazil / Matheus Porto Pimentel. -- 2024.
76 f.
Orientador: Marcelo Savino Portugal.

Dissertação (Mestrado) -- Universidade Federal do Rio Grande do Sul, Faculdade de Ciências Econômicas, Programa de Pós-Graduação em Economia, Porto Alegre, BR-RS, 2024.

1. Fiscal Policy Rules. 2. DSGE. 3. Model TANK. 4. New Keynesian Model. I. Savino Portugal, Marcelo, orient. II. Título.

Elaborada pelo Sistema de Geração Automática de Ficha Catalográfica da UFRGS com os dados fornecidos pelo(a) autor(a).

MATHEUS PORTO PIMENTEL

FISCAL POLICY RULES: A NEW KEYNESIAN MODEL FOR BRAZIL WITH BAYESIAN ESTIMATION

Dissertação de mestrado acadêmico submetida ao Programa de Pós-Graduação em Economia da Faculdade de Ciências Econômicas da UFRGS, como requisito parcial para obtenção do título de Mestre em Economia.

Aprovado em: Porto Alegre, 28 de junho de 2024.

BANCA EXAMIDORA:

Prof. Dr. Marcelo Savino Portugal – Orientador
UFRGS

Prof. Dr. Marcelo de Carvalho Griebeler
UFRGS

Prof. Dr. Thais Waideman Niquito
UFRGS

Dr. Filipe Stona
Bradesco Asset Management

AGRADECIMENTOS

Agradeço ao meu orientador, Professor Marcelo Savino Portugal, pela paciente orientação e as valiosas percepções dadas em nossas reuniões.

Agradeço à Rafaela, pela requerida e duradoura paciência e companheirismo nesses últimos anos. Especialmente em virtude das vicissitudes encontradas ao longo do caminho.

Agradeço a CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) pelo financiamento de parte deste processo, quado pude me dedicar exclusivamente as disciplinas e depois na escrita desta dissertação.

ABSTRACT

The study employs a New Keynesian general equilibrium model to simulate three distinct designs of fiscal rules in the Brazilian economy, assessing their impacts on consumer welfare. Specifically, it tests a rule for government fiscal deficit, a rule concerning the structural fiscal deficit, and finally, the so-called Golden Rule, which exempts public investments from the budget constraint. The DSGE (Dynamic Stochastic General Equilibrium) model used in this study features two main agents: a representative Ricardian agent and a non-Ricardian agent, which aligns well with the Brazilian economic context and falls under the classification of TANK (Two-Agent New Keynesian) models. Additionally, the model incorporates common features of other New Keynesian models, including adjustment costs on capital and frictions. Furthermore, our model includes a sector for the production of non-tradable goods and an export sector. A notable contribution of this study is the explicit modeling of the external market, represented by the commodity cycle. Additionally, entrepreneurs manage capital investment in capital goods used by both export producers and non-tradable goods producers. We estimated specific model parameters for the Brazilian economy using Bayesian methods, leveraging recent computational advancements. The data used is annual, and the sample period for this study spans from 2002 to 2023. Consumer welfare is evaluated using a welfare coefficient. Furthermore, we simulated two different shocks to the economy and analyzed the impact of these shocks on selected variables through impulse response functions and conditional moments. Our findings suggest that consumer welfare under the Structural Fiscal Deficit Rule, which constrains government investments and is conditioned on the economic cycle, provides the highest welfare to consumers, both Ricardian and non-Ricardian.

Keywords: Fiscal Policy Rules. TANK models. New-Keynesian models.

RESUMO

O trabalho simula através de um modelo de equilíbrio geral Novo-Keynesiano para a economia brasileira, três diferentes desenhos de regras fiscais, avaliando os impactos sobre o bem-estar dos consumidores. Dessa maneira, são testadas uma Regra para o Déficit Fiscal do governo, uma regra sobre o Déficit Fiscal Estrutural, e por fim, a chamada Regra de Ouro que retira da restrição orçamentária os investimentos públicos. O modelo DSGE utilizado neste trabalho, tem como características principais dois agentes, um agente representativo ricardiano e outro não-ricardiano, que ajusta-se bem a realidade brasileira, e encontra-se na classificação de modelos TANK. Adicionalmente, apresentam-se no modelo características comuns a outro modelos novo-keynesianos: custos de ajustamentamento sobre o capital e fricções. Além disso, nosso modelo conta com um setor de produção de bens *non-tradables* e outro setor exportador. Como especial contribuição deste trabalho, estão a modelagem explícita do mercado externo, representado pelo ciclo de commodities. Adicionalmente existem empresários que fazem a gestão do capital para investimento em bens de capital que são utilizados pelos produtores exportadores e *non-tradables*. Realizamos a estimação para determinados parâmetros do modelo para a economia brasileira através de métodos bayesianos, incorporando os recentes avanços computacionais. Os dados utilizados são anuais e a janela amostral deste trabalho compreende o período de 2002 a 2023. O bem-estar dos consumidores é avaliado através de um coeficiente de bem-estar. Além disso, simulamos dois diferentes choques sobre a economia e analisamos através de funções de resposta ao impulso e momentos condicionais o impacto desses choques sobre as variáveis selecionadas. Concluímos que o bem-estar dos consumidores sobre a Regra de Déficit Fiscal Estrutural, que impõe como restrição os investimentos governamentais e está condicionada ao ciclo econômico, é a que confere o maior bem-estar aos consumidores, tanto ricardianos quanto não ricardianos.

Palavras-chave: Regras de Política Fiscal. Modelos TANK. Modelos Novo-keynesianos.

LISTA DE FIGURAS

SUMÁRIO

1 INTRODUCTION

A Brief Context In recent decades, Brazil's fiscal policy has faced significant challenges due to a continuous increase in public expenditures and, more recently, the impact of the COVID-19 pandemic, which necessitated a combination of fiscal and monetary policies to address the resulting health crisis. After overcoming hyperinflation, Brazil followed at least four distinct fiscal policies. The Fiscal Responsibility Law (FRL), enacted in 2000, was Brazil's first law aimed at rationalizing federal spending. [1]

According to Barbosa e Pessoa (2014) the Brazilian macroeconomic tripod consists of three pillars: a floating exchange rate, an inflation targeting regime (monetary stability), and a primary surplus regime (fiscal stability). [2]

Indeed, for nearly two decades, the fiscal surplus strategy has shown to be an effective discretionary fiscal policy. Brazil gradually and continuously reduced nominal interest rates, which had previously reached about 20% per year in the early 2000s, as indicated in Figure 1. This reduction was partly due to a more prudent and austere budgetary policy.

According to Giambiagi (2008), fiscal policy deteriorated in the 1990s before gradually improving in the 2000s, resulting in substantial primary surpluses. Despite a significant increase in the tax burden and primary expenditure, which rose from around 24% of GDP in 1991 to 36% in 2008, and from 14% to 24%, respectively, government revenue increased from 15% to 25%.

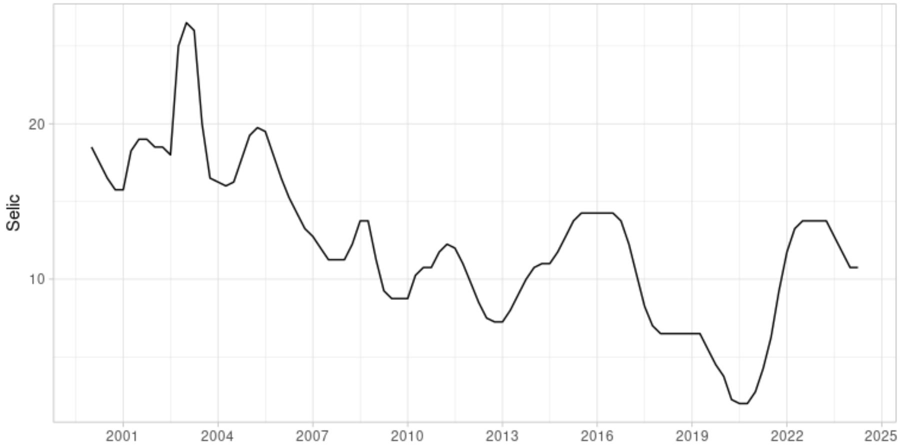
However, the global crisis of 2008 prompted countercyclical fiscal reforms, resulting in a shift in the fiscal environment. These programs intended to reduce the crisis's negative consequences while also stimulating economic growth. While countercyclical measures were deemed vital to address urgent issues, they impacted the fiscal surplus target by necessitating greater government spending and, in certain circumstances, temporary deficits. The implementation of countercyclical fiscal policies during the crisis spurred a rethinking of the prior fiscal framework, with some questioning the effectiveness and viability of the fiscal surplus strategy. The discussion turned toward a more nuanced viewpoint, acknowledging the need of fiscal policy flexibility in accommodating cyclical swings and promoting economic stability.

Following this conversation, changes in fiscal policy management occurred, together with a slew of aggravating variables, propelling the country into a two-year recession. The loss of per capita income and stagnation in Brazilian economic growth have resulted in this decade being dubbed another "lost decade"when contrasted to the 1980s.

[1] Available at LC n. 101/2000.

[2] For a full explanation of the importance of the macroeconomic tripod for the Brazilian economy and expectations, please to Barbosa e Pessoa (2014). The authors highlight the importance of the macroeconomic tripod as an effective framework for predictability.

Figura 1 – Selic - Nominal interest rate in Brazil



Source: Own elaboration, Central Bank of Brazil

According to Mesquita (2014) , the government engaged in hyper-activism during this period, which was influenced by both its management style and the global context. This trend of excessive activism reflected a prevailing line of economic policy during this time period, defined by skepticism about the market's ability to generate economic growth and development, which was replaced by a desire for government intervention.

Brazil's National Congress enacted a constitutional change in 2016 to limit expenditure growth to the previous year's inflation rate, despite the country's ongoing public accounts growth. Furthermore, the approval of new retirement rules brought some relief to the public funds. In Brazil, debates have recently centered on a new fiscal policy norm or framework. This illustrates that the debate in emerging markets, such as Brazil, is no longer about whether to have a fiscal rule that anchors and explicitly expresses the government's budget restriction, but rather, given the choices, what is the best fiscal rule to apply.

Brazil has had at least four fiscal rules. The first of these, buried in the 1988 Federal Constitution[3], is known as the "Golden Rule."This rule specifically bans the execution of credit operations that exceed the amount of capital expenditures, except for those authorized by particular supplementary or special credits for specific objectives. In effect, this regulation prohibits the government from issuing public debt to cover existing expenses.

Another key criterion is the primary surplus objective, which was legally established in 2000 by the aforementioned Fiscal Responsibility Law. The law requires that the annual budgeting process include primary surplus targets for the applicable year. Among the attributes we have discussed, the rule is transparent, as the results can be checked bimonthly via reports presenting and analyzing primary revenues and expendi-

[3] Art. 167, vol. III of the Brazilian Federal Constitution.

tures. Furthermore, the law has a normative foundation and is simple to understand: it addresses the major disparity between government expenditures and revenues. However, the lack of long-term advice undermines the rule's effectiveness as a stabilizing factor and in supporting public debt.

In 2016, a new rule known as the "Spending Ceiling"was adopted, which prevents actual growth in federal expenses (EC n. 95). In other words, the rule barred expenditures in year t+1 from surpassing those in year t, adjusting solely for nominal increments. The rule was simple, easy to apply, and understand, but it violated the principle of flexibility, resulting in non-compliance in the latter years of its implementation. [4]

Over the last four decades, Brazil has successfully fixed three of four key macroeconomic imbalances. The first was a recurring balance-of-payments crisis and a lack of foreign exchange reserves to meet international obligations. The second was a chronic and persistent acceleration of prices, known as inflation. Both issues were addressed with changes that stabilized consumer purchasing power and secured the balance of payments. During the 1980s, the exchange rate regime was also discussed. Calvo, Reinhart e Vegh (1995) popularized the term "fear of floating"to explain emerging countries' trepidation about adopting a floating exchange rate system over a fixed exchange rate regime. The new regime was formally intended as one of the pillars of the so-called Brazilian macroeconomic tripod, as previously stated. However, a fourth difficulty still exists. According to End (2023) , fiscal policy lacks credibility compared to monetary policy due to its association with political concerns.

As the fourth issue persists, it is critical that the country handle the fiscal question. *Brazil's state size may not meet the population's social and economic needs*. That is, the Brazilian budget is insufficient to cover all social needs. This study aims to contribute to this discussion by simulating three alternative fiscal rules: the benchmarking rule, which imposes no restrictions on government purchases and public investment; the second rule, which imposes restrictions on public investment and is influenced by the economic cycle; and the most expansionary rule, which involves a significant state presence in public investments.

A Brief Theory on Fiscal Rules In an interesting study, End (2023) assesses the credibility of fiscal policy across a sample of 27 eurozone nations by assessing private agents' expectations regarding the established fiscal policy goals. The author discovers that credibility acts as a "stock of trust"that is influenced by fiscal policy, historical context, and past performance. Additionally, credibility is affected by institutions such as budgetary norms and councils. In this context, the author explains how communication through budgets and fiscal regulations is critical for anchoring and building trust in fiscal policy expectations, as is the case with monetary policy. The essay finishes by recommending that governments work to protect their legitimacy.

[4] Available in EC n. 95

Following the 2008-2009 financial crisis and its aftermath, a number of studies and articles sparked debate over the limits and functions of fiscal policy in industrialized economies. According to Blanchard, Dell'Ariccia e Mauro (2013) , the global economic crisis shattered the consensus on fiscal policy management. This resulted in changes to the perception of healthy governmental debt levels. In this regard, Blanchard highlights macroprudential policies as a potential new lever for containing booms and addressing imbalances. However, he adds that the evidence for their effectiveness is ambiguous, and we are far from understanding how to utilize them reliably. As a result, our work adds to the existing debate by giving new empirical insights into the implementation of fiscal policies and their effects on the economic environment.

Notable desired properties of fiscal regulations include: i) simplicity; ii) flexibility; and iii) application. This discussion led to the formation of the "Second Generation of Fiscal Rules"[5]. Prior to the 1990s, less than 20 countries had enacted any type of fiscal rule; however, the number increased to almost 90 countries after 2008. This proliferation highlights the growing global tendency of developing fiscal frameworks that follow precise rules for conducting fiscal policy.

In a 2019 article, Brochado et al. (2019) explore the aftermath of negotiations regarding a new fiscal regulation for Brazil. The authors discuss the configurations and characteristics of a suitable design for such rules. In this sense, fiscal rules can be defined as long-term or temporary limitations on revenue, expenditure, budgetary outcomes, and public debt. Thus, fiscal rules are implemented with the goal of correcting skewed incentives and tendencies toward increased government spending.

In this way, we can identify numerous concepts that are perfect for healthy fiscal guidelines. Among these, as previously said, are: i) clearly specified rule design; ii) transparency; iii) simplicity; iv) flexibility; v) control mechanisms; and vii) consistency and efficiency. Rule design is anticipated to be well-calibrated, well aligned with goal achievement, and free of discretionary managerial interference. Ideally, the rule should be supported by strong legal structures and free of major exceptions that could jeopardize its effectiveness. (BROCHADO et al., 2019)

Transparency requires regular public disclosure and dissemination of indications and results that measure conformity with the established regulation. The regulation should be simple enough for public managers and citizens in general to understand, as well as operationally easy.

Another important trait is flexibility, which ensures that the rule does not exacerbate the macroeconomic impact associated with economic cycles. In other words, during a recession, the rule should not jeopardize the state's ability to function as a counter-cyclical agency. To do this, well-designed rules with escape clauses are required, which ensure that such exceptions do not undermine the rule's effectiveness.

5 Hodge, Kim e Lledó (2018)

Concerning control systems, it is critical to undertake regular reviews of conformity with specified goals via advisory committees. Sanctions can be triggered by thresholds tied to expenditures or earnings, without transferring responsibility to the public administrator.

Transparency requires regular public disclosure and dissemination of indications and outcomes assessing conformity with the established regulation. The regulation should be simple enough for public managers and citizens in general to understand, as well as operationally easy. Finally, for consistency and efficiency, it is critical that the goal and practicality of complying with the regulation are obvious.

The International Monetary Fund (IMF) has had significant discussions about implementing fiscal guidelines in both developing and developed countries. Beginning in 2018, the IMF published a series of discussion papers highlighting characteristics and necessary features for the formulation of efficient fiscal rules, as shown, for example, in Hodge, Kim e Lledó (2018), Lledó (2018), Eyraud et al. (2018) and Caselli et al. (2022). Davoodi et al. (2022) recently updated your database of countries with fiscal regulations based on the economic cycle.

Rules are especially important during times of economic prosperity, when government revenues rise, creating incentives for higher public spending. They are also important for anchoring expectations about the future dynamics of public debt, as well as the long-term viability of fiscal policy and the budget. It is critical to note that a framework of rules does not imply the enforcement of a single rule. In other words, when we talk about fiscal regulations, we're referring to a framework that includes several rules.

Gootjes e Hann (2022) raises questions about the sustainability of public debt in several countries. Given the fiscal stimuli triggered since the 2007-2008 financial crisis, and more recently the COVID-19 pandemic, the combination of low interest rates and significant fiscal stimuli to address situations such as health crises and financial system crises highlights the limitations of fiscal policies as output, income, and public debt stabilizers. The argument for implementing fiscal laws is based on issues of temporal inconsistency, as politicians may devalue the future more than society as a whole.

They conclude that balanced and transparent governmental budgets have a higher impact on fiscal norms. In other words, for fiscal policy principles to be effective, budgets must be transparent. Thus, numerous countries have implemented fiscal guidelines over the years to improve the sustainability of their public finances. In this approach, fiscal laws strive to put discretionary numerical and budgetary constraints on aggregate accounts.

Bhattarai e Trzeciakiewicz (2017) simulates the impacts of fiscal policy shocks using a DSGE model in the UK. Their model comes to the interesting conclusion that include non-Ricardian agents improves fiscal policy effectiveness. Furthermore, nominal rigidity increases the effectiveness of public expenditure and tax consumption, resulting in a larger drop in effective tax collections.

A important thesis Santos (2017) focuses on simulations of Brazil's fiscal rules. The author simulated three different fiscal rules: a primary surplus rule that fixes fixed primary expenditures regardless of changes in output; a rule that establishes fixed primary expenditures regardless of changes in output; and a rule that keeps a certain level of government spending (consumption, investment, and transfers) in relation to a fixed debt-to-GDP ratio. The author's model is similar to ours in that it includes Ricardian and non-Ricardian actors.

After applying impulse response functions, analyzing the simulated evaluation measure, and calculating the standard deviation for each model, the author demonstrates that under the fixed expenditure rule, most variables respond less sharply to shocks in government spending, transfers, monetary policy, risk, and productivity. This is due to the rule's restrictive nature, which results from its greater rigidity.

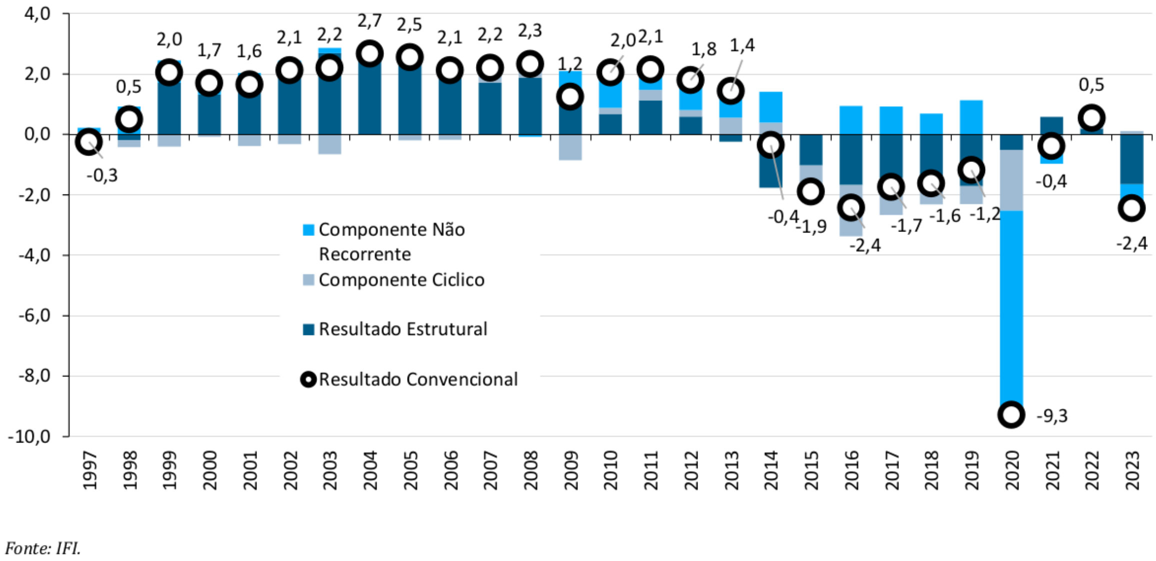
The Inter-American Development Bank (IDB) conducted studies on the fiscal aspects of Latin American countries such as Chile, Peru, and Colombia Bellido et at. (2021), García-Cicco e Kawamura (2015), Arbeláez et al. (2021), Suescún (2018) and Rodrigo, Schmidt-Hebbel e Soto (2021). The articles provide detailed modeling of fiscal rules as well as discussions about national public debt (indebtedness) and its evolution. These studies provide the framework for our research, which focuses on the Brazilian situation.

The **structural fiscal result** is a key item to address during the investigation.Many of the comments and definitions that will be addressed hereafter are derived from the Independent Fiscal Report prepared by the Independent Fiscal Institution of the Brazilian Federal Senate Independente (2024b), Independente (2024a) e Independente (2023) which removes cyclical and non-recurring effects from government revenues, acting as a "thermometer"to assess the direction of fiscal policy. Conceptually, the structural fiscal outcome excludes discretionary and one-time occurrences from government accounts, such as exceptional revenues or increases in public spending, which occurred during the COVID-19 epidemic. The structuring of structural fiscal outcomes necessitates precise measurement because it is dependent on other unobservable factors, such as the output gap. This is in contrast to the conventional fiscal result, which is based purely on the outcome of government accounts with no additional modifications.

In addition to compensating for the revenue and expenditure cycles, the structural fiscal result considers the commodities cycle. This includes the oil price cycle and other commodity-related revenues, particularly in Brazil.

The importance of oil prices stems from the monopolistic structure of Petrobras, Brazil's main oil corporation, in which the government owns a majority stake. According to the Independent Fiscal Institution's report 2, published in March 2024, the main deficit in 2020 was 9.3%, with non-recurring variables accounting for 7.2% of GDP. The non-recurring cycle in 2017, 2018, 2021, 2022, and 2023 was significantly impacted by

Figura 2 – Structural primary surplus of the Brazilian government



Source: Independent Fiscal Institute/Senate of Brazil

the increase in non-recurring government revenue from natural resource exploitation.

In 2023, the primary deficit was -2.4% of GDP, with structural causes accounting for 1.6% and non-recurring components accounting for 0.8% [6].Brazil achieved successive primary surpluses from 1998 to 2013. Brazil did not attain a primary surplus until 2022, having started in 2014.

The model's Fiscal Rules Our model simulates three fiscal rules: the Fiscal Deficit Rule (FDR), the Structural Fiscal Deficit Rule (SFDR), and the Golden Rule (CDR). The Fiscal Deficit regulation (FDR) acts as our benchmark regulation, establishing targets for the government's current deficit on government purchases. The Structural Fiscal Deficit Rule (SFDR) is based on economic cycles, particularly those related to commodities, and establishes a consistent amount of public spending. It is more restrictive to public investment. The Golden Rule (CDR) exempts private investments from the government's budget constraints, and it follows an AR(1) approach for government investment.

The Fiscal Deficit Rule (FDR), which we use as a baseline, taxes individuals depending on their consumption and labor income. It also taxes exports, non-tradeable items, and commodity exports. The government has access to both domestic and external loans, and it makes purchases of non-tradable items while investing in the economy's productivity.

Fiscal rules may limit the government's procurement of non-tradables and investment. In the FDR, government purchases follow an autoregressive process of order 1 (AR(1)), captured by the parameter η_t^P, ensuring that government spending equals the targeted fiscal deficit η_t^I. Our experiment/simulations assumed a steady-state budgetary

[6] Independente (2024b)

surplus of 1% of GDP.[7]

The second rule, the **Structural Fiscal Deficit Rule (SFDR)**, is non-cyclical and essentially follows the concepts made in the previous paragraphs. Its key feature is that it keeps the level of government expenditure constant, even during times of economic slump and expansion. The SFDR regulation makes government spending more predictable and accounts for the effects of the economic cycle on public finances. [8] In modeling the rules within the DSGE model, the SFDR has a direct impact on public investment but not on government purchasing. As a result, the government's budget constraints are identical to those imposed by FDR, with restrictions on public investment. In the steady state, the government surplus is established at 0.5 percent of GDP.

Finally, the Current Deficit Rule (CDR), commonly known as the Golden Rule, eliminates the stochastic aspect from government purchases and imposes a stochastic process on investment η_t^I using an AR(1) process. This rule allows the government to finance its investment expenses through borrowing, which is subject to a stochastic process, while current expenses are covered through tax income. We simulate a greater fiscal deficit of -3.5% of GDP under this criterion. Despite investing, the government follows an expansionary fiscal policy under this regulation.

Given the necessity for surpluses, the first two rules take a more austere approach to state finances. Despite being more restrictive, SFDR has a higher excess effort than FDR. The government maintains an active fiscal policy by making purchases, direct investments, transfers, and subsidies that push output over the potential output under the CDR rule. This exercise is important because it models conditions for the Brazilian economy, which is under constant fiscal pressure and is influenced by interest rate cycles and global economic situations. In our model, we do not replicate monetary policy, which may be influenced by expansionary fiscal policy. In response, monetary policy may compensate by raising domestic interest rates in the long run, lowering activity and inflation.

Chapters With this in mind, the primary goal of this research is to assess the impact of fiscal policy on consumer welfare. Furthermore, this study is relevant for a variety of reasons. First, there are few empirical studies using counterfactual arguments, such as DSGE models in the Brazilian situation. Even fewer research use general equilibrium models to simulate budgetary regulations for the Brazilian instance. The literature and models for monetary policy rules are well established, whereas fiscal policy rules are less prevalent in this approach. This emphasizes that fiscal

[7] In the fiscal rule established in 2023 for the Brazilian case, known as the "New Fiscal Framework"or "Sustainable Fiscal Regime,"which is in effect until the preparation of this study, the government is gradually required to establish targets for fiscal outcomes according to Complementary Law No. 200/2023 available here. The Budgetary Guidelines Law (LDO) sets fiscal targets for the government, including a deficit of 1% of GDP in 2023, a balanced budget in 2024, a surplus of 0.5% in 2025, and a surplus of 1% in 2026. Discussions are ongoing on potential changes to the set targets.

[8] Lledó et al. (2018) provides further information on both the SFDR and CDR.

constraints, like monetary policy norms, are increasingly important for the development of macroeconomic stability.

Several studies simulate various characteristics of the Brazilian economy using DSGE models calculated with Bayesian approaches. Here are several examples: Fasolo et al. (2023), Costa (2019), Ramos e Portugal (2019), Cavalcanti e Vereda (2011), Gouvea et al. (2011), Kanczuk (2002), and with special attention to fiscal policy are: Carvalho, Valli et al. (2011) and Santos (2017).

Several popular DSGE model characteristics, such as capital adjustment costs, are included in our model. Furthermore, our model belongs to the TANK (Two Agents New-Keynesian) model class because it includes two representative agents, which is consistent with current improvements in DSGE modeling. Our model is especially novel in the Brazilian context for two reasons. First, it clearly simulates an open economy, which is typical of Brazil because it is dependent on both global economic cycles, such as commodity prices, and global growth and economic cycles. Furthermore, our model explicitly includes a sector that is gaining prominence in the Brazilian economy: **agriculture**.

We used observed variables to estimate model structural parameters as well as stochastic structural shocks. For parameter estimation and model calibration, we used an annual dataset covering the Brazilian economy from 2002 to 2023. The data set includes observable variables such as GDP, household consumption, agricultural output, investment, net public sector debt, agricultural commodity index, overall commodity index, primary surplus, and total public sector revenue. Furthermore, after estimating the model using Bayesian approaches for the Brazilian economy, we simulated two orthogonal shocks.

Building on the previous discussion about the motivation and significance of this work, the thesis is organized as follows. The second chapter presents the model, which uses a two-agent representative model established by García-Cicco and Kawamura (2015) and Bellido et al (2021). This is the standard Dynamic Stochastic General Equilibrium (DSGE) model, [9] with two heterogeneous agents: a Ricardian agent with saving capacity and capital stock ownership, and a contingent of non-saving consumers, sometimes known as Non-Ricardians.

Furthermore, the model includes three productive sectors: an export market, a non-traded goods market, and a market for agricultural commodities exports. The model also contains a sector for capital goods production and physical capital investment. We also model entrepreneurs who own capital goods and physical assets. Finally, we

[9] According to Galí e Gertler (2007), two complementary approaches to New Keynesian models emerged in the 1980s and 1990s. On the one hand, there were quantitative Real Business Cycle (RBC) models that brought numerical methodologies and optimizers to the agents being modeled. New Keynesian models were qualitative and incorporated monetary and financial ideas into RBC models.

introduce fiscal authority, which is represented in the model by government purchases and public investment. The approach was created for a small open economy, like Peru's. However, the Brazilian economy shares similarities with its neighboring economy, such as being an agro-exporting economy with low savings, a large number of unskilled workers, and a sizable amount of tax income earned from commodity exports. Furthermore, the Peruvian economy, like the Brazilian economy, ran deficits in its public accounts for years, with a rising debt-to-GDP ratio that was reversed upon the establishment of a fiscal law.

After estimating the model and simulating theoretical moments for the specified variables, we conclude that the Structural Fiscal Deficit Rule provides consumers with the greatest welfare increases. These findings suggest that, in addition to the importance of well-defined fiscal rules, as highlighted in the literature, a deficit rule conditioned on the economic cycle improves consumer welfare. Despite the stricter nature of this fiscal rule, the government is unable to act countercyclically, particularly during times of crisis.

2 A DSGE MODEL

The purpose of this section, which mostly follows the research development by Bellido et al. (2021) and Gacía-Cicco e Kawamura (2015), , is to present the model employed in this paper. The model utilized is a conventional DSGE (Dynamic Stochastic General Equilibrium) for a small open economy, based on the framework described by Bellido et al. (2021). In summary, this model shares some properties with other New Keynesian models. The optimality conditions are in **Appendix A**.

In our model, there are two representative agents: a Ricardian agent with access to financial markets and capital, and a non-Ricardian agent known as "rule of thumb"households, as discussed for the Brazilian case by Gouvea et al. (2011). The economy consists of a large number of identical Ricardian households, whose mass is 1-κ. Ricardian agents have access to both national and international capital markets, where they provide loans to entrepreneurs. They purchase debt securities and receive contracted interest payments from the previous period $t-1$. They pay taxes derived from consumption τ^c and labor supply τ^w. Additionally, these agents receive a share of income from commodities they export at prices p_t^{Co}, which are determine by a stochastic endowment y_t^{Co}. Furthemore, they receive profits Ω_t^R from various firms they own.

These agents have a utility function of the form as CRRA[1] where $\beta \in (0,1)$ is the discount factor, c_t is the consume of the agent, and h_t is the hours of work. $U(c_t, h_t)$ is twice continuously differentiable, increasing, strictly concave utility function, and E_0 denotes a mathematical expectation conditioned on time 0 information.[2] The parameters that constitute consumer preferences are: θ is the coefficient of risk aversion and υ is the elasticity of labour supply know as Frisch elasticity.[3] The consumer seeks to maximize inter-temporal consumption, balancing both present and future consumption. [4] The parameter β captures the degree of preference and importance the consumer places on the future, ς captures the habit formation of these consumers and is a function of tax rates and relative prices. Both β and ς are endogenously calibrated in the steady state.

[1] Constant Relative Risk Aversion.

[2] The macroeconomic dynamic models, whose turning point is marked by the publication of the classic work by Kydland e Prescott (1982), operate on a microeconomic foundation where individuals seek to maximize their utilities. These models are standard in New Keynesian and Real Business Cycle (RBC) models. For a detailed understanding of consumer behavior in dynamic systems, please refer to the following resources: Sargent (2009), DeJong e Dave (2011), Ljungqvist e Sargent (2018) and Stokey (1989).

[3] The Frisch elasticity captures the elasticity of labor supply in response to changes in the wage rate, given a constant marginal utility of wealth. See more in Galí (2015) and Walsh (2017) for a comprehensive view of New Keynesian models.

[4] Building upon the critiques put forth by Lucas in 1976, as famously articulated in Lucas (1976), Lucas e Prescott (1971), and Prescott (1986), regarding the utilization of statistical models devoid of the inclusion of structural models capable of effectively observing the direction of economic policies, economic models grounded in a framework and economic foundation gained prominence. It is essential to emphasize that Lucas's most substantial contribution lies in the examination of how agents' behavior influences the formation of key macroeconomic aggregates and price-setting mechanisms.

The working hours of individuals in this economy are divided between labor hours h and leisure hours l. Additionally, workers can create a portfolio of debt securities by allocating investments into both domestic and foreign bonds. The Ricardian agents can work in either the export markets or in non-tradable sectors. The labor factor is perfectly mobile between these two sectors. This mobility allows workers to shift between sectors based on economic conditions and relative wages, facilitating efficient allocation of labor resources across different sectors of the economy. On the other hand, non-Ricardian agents do not have access to financial markets. They supply labor, consume their entire wage, and pay taxes τ^C and τ^w. In steady state, the functional forms are the same as those for Ricardian agents.

Total consumption is the sum of consumption of non-tradable and tradable goods. The optimality condition requires that the expenditure minimization subject to a given budget constraint satisfies the consumer's utility requirement. Regardless of the level of c_t the consumer's problem consists of deciding the optimal combination of the two different goods, tradables and non-tradables, while minimizing costs. The parameter $\varphi \in (0, 1)$ represents the share of non-tradables and tradables. While ϵ is the elasticity of substitution between the goods.

The portion of goods and services suppliers is divided into three sectors: a producer of final non-tradable goods, an exporter of commodities, and firms producing capital goods for both sectors. Additionally, there are entrepreneurs who own capital and invest in the exporting firms and producers of final goods. They receive returns from their profits and loans to these firms. The exporting firms solve a classic profit maximization problem subject to a given technology. In our economy, the technology follows an autorregresive process of order 1 $AR(1)$ for sectors $a_t^j, j = X, N$. The shares of labor are given by α_X for the exporting sector and by $1 - \alpha_X - \theta_X$ for the private capital, where θ_X represents the government's share of capital in firms producing exportable and non-tradable goods. The cost component consists of wages paid to workers $w_t h_w^j, j = X, N$ and rental payments u_t^j on capital k_{t-1}^j paid to entrepreneurs.

The entrepreneurs in this economy invest in capital for both the tradable and non-tradable sectors and oversee the management of this capital.[5] Each period, these entrepreneurs receive an initial capital stock k_{t-1} and borrow from Ricardian agents l_{t-1}^j where $j = X, N$ In each new period, entrepreneurs purchase capital from capital producers at prices q_t^j and lease it to firms producing tradable and non-tradable goods at prices u_t^j. After one period and accounting for depreciation δ, entrepreneurs sell the remaining invested capital and repay their loans. However, entrepreneurs cannot freely

[5] Lucas e Prescott (1971) introduced another factor into the dynamics: rational expectations. Agents do not form their expectations solely by looking at past events. They shape their expectations using the framework of available information. In this manner, behavioral equations describing macroeconomic aggregates give way to first-order solutions of intertemporal problems for firms and households. The DSGE approach also allows for the specification, estimation, calibration, simulation, and evaluation of the impacts of behavior on the well-being of agents and firms.

borrow from Ricardian agents without restrictions. Loans are conditioned by a risk factor, denoted as rp_t^j, which discounts the expected asset value at present value by a risk premium rate r_t^L. The risk premium is determined by leverage parameters *lev* and the elasticity of the premium relative to leverage in each sector ξ^j. After loan repayments, a fraction $1 - \vartheta$ of entrepreneurs exit the market and transfer the remaining profits to the Ricardian agents. The same fraction enters the market each period, receiving a new injection of capital denoted by ι^j.

In each sector, there are firms that purchase old capital $(1 - \delta)k_{t-1}^j$ and combine it with capital goods to produce new capital and technology. These capital-buying firms face capital adjustment costs specified by a function S_j and a parameter ϕ_j. Consequently, firms choose the optimal level of investment by maximizing the present value of profits, which is subject to a stochastic factor Γ. Additionally, there are firms that combine imported and non-tradable goods to produce capital goods that they sell to capital goods firms.

In fiscal policy, our focus is on simulating three scenarios, as we discussed earlier. Our benchmark rule involves government spending following an AR(1) process η_t^P, with restrictions imposed on investment by an adjustment factor η^r. In this economy, the government also participates in investments in capital goods, following the same specifications as discussed for the investment market above. Capital takes into account adjustment costs, and there are firms that combine non-tradable capital x_t^{NG} with imported capital x_t^{MG}.

For the SFDR rule, the impact is directly on investments, while government purchases remain unaffected. Under this rule, adjustments are made to government revenue based on the difference between current revenues and revenues in the steady state. This is because revenues cannot be contingent on the economic cycle. Finally, the CDR removes investments from the government's intertemporal budget constraint and follows an AR(1) process.

Another important aspect of our model concerns consumer welfare, given by a welfare coefficient as a function of a penalization factor λ applied to individual consumption. A lower penalization factor λ corresponds to higher consumer welfare. We will calculate this parameter using second-order Taylor approximations computed by Dynare software. In this case, the higher the consumer welfare, the greater the intertemporal welfare gain for these agents, allowing us to evaluate the three fiscal rules under these parameters.

Next, we specify the equations governing this economy, as well as the functional forms used. Again, the optimality conditions and equilibrium in the steady state can be found in the appendices.

2.1 HOUSEHOLDS

We start this section looking for the households behaviour.

2.1.1 Ricardian Households

The representative infinitely-lived Ricardian consumer wants to maxime:

$$\max \left\{c_t^R, h_t^R, l_t^R, d_t^{R*}, d_t^G\right\}_{t=0}^{\infty} V_t = E_0 \left\{\sum_{t=0}^{\infty} \beta^t U(c_t^R, h_t^R)\right\} \tag{1}$$

The consumer faces a sequence of budget constraints:

$$\begin{gathered}(1+\tau^c)p_t c_t^R + d_{t-1}^{R*}(1+r*_{t-1}) + p_t l_t^R + p_t d_t^G = \\ (1-\tau^w)w_t h_t^R + (1-\tau^{Co})p_t^{Co} y_t^{Co} + d_r^{R*} + p_t lt - 1(1+r_{t-1}^L) + p_t d_{t-1}^G(1+r_{t-1}^D) + \Omega_t^R\end{gathered} \tag{2}$$

where V_t is the lifetime utility and the instantaneous utility has the follwing form:

$$U(c_t^R, h_t^R) = \left[\frac{c_t^R - \varsigma \frac{(h_t^R)^{1+\upsilon}}{1+\upsilon}}{1-\theta} - 1\right]^{1-\theta} \tag{3}$$

In this economic context: h_t^r represents total hours worked. c_t^R is the consumption of final goods. p_t is the price of final goods (where $1/p_t$ is the real exchange rate). d_t^{R*} is the stock of international debt. l_t^R refers to loans from entrepreneurs. d_t^G is the stock of government debt (both denominated in units of consumption). w_t denotes real wages received by workers. r_t^* represents the international interest rate. r_t^L is the loan interest rate. r_t^D indicates the domestic public debt interest rate. Ω_t^R signifies profits received from firms, of which households are owners. Additionally, there is an exogenous and stochastic endowment of commodities y_t^{Co} that is entirely exported at international relative prices of p_t^{Co}. The total hours worked is given by:

$$h_t^R = h_t^{R,X} + h_t^{R,N} \tag{4}$$

Additionally, households pay three types of taxes. Labor income tax (τ^w): This tax is levied on earnings from labor income. Consumption tax (τ^c): This tax is imposed on consumption expenditure. (τ^{Co}): This tax is applied to the revenue generated from commodities.

The international interest rates are defined as follows:

$$r_t^* = r_t^w + exp\left\{\phi_{d*}\left(\frac{\bar{d}_t^* - \bar{d}^*}{\bar{d}^*}\right)\right\} - 1 \tag{5}$$

And the interest rate on domestic public debt is:

$$r_t^D = r_t^L + exp\left\{\phi_{dG}\left(\frac{\bar{d}_t^G - \bar{d}^G}{\bar{d}^G}\right)\right\} - 1 \tag{6}$$

In which d_t^* represents the size of international debt exposure, [6] $\bar{d}t^G$ denotes the government's domestic debt position, $\bar{d}^*$, $\bar{d}^G$, ϕ_{d*}, and ϕ_{dG} are positive parameters, and r_t^w is an exogenous variable following an AR(1) process.

Also note that the country's risk premium is defined as $(cp_t \equiv r_t^* - r_t^w)$, serving as a closing mechanism as in García-Cicco e Kawamura (2015) and Schmitt-Grohé e Uribe (2003).

2.1.2 Non-Ricardian Households

There is a continuum of non-Ricardian households that do not have access to financial markets and do not receive income from profits. A proportion κ of agents exhibit these characteristics. The optimization problem that these consumers seek to maximize is given by:

$$\max\left\{c_t^{RN}, h_t^{RN}, I_t^R, d_t^{R*}, d_g^R\right\}_{t=0}^{\infty} V_t = E_0\left\{\sum_{t=0}^{\infty}\beta^t U(c_t^{RN}, h_t^{RN})\right\} \tag{7}$$

subject to:

$$(1+\tau^c)p_t c_t^{NR} = (1+\tau^w)w_t h_t^{NR} \tag{8}$$

and the instantaneous utility is:

$$U(c_t^{RN}, h_t^{RN}) = \left[\frac{c_t^{RN} - \varsigma\frac{(h_t^{RN})^{1+\upsilon}}{1+\upsilon}}{1-\theta} - 1\right] \tag{9}$$

Also, labor is perfectly mobile between sectors for these households.

$$h_t^N R = h_t^{NR,X} + h_t^{NR,N} \tag{10}$$

Non-Ricardian consumers therefore seek to maximize their utilities, which follow the same functional form as Ricardian consumers. However, their consumption and intertemporal budget constraint are restricted to the income derived from wages earned $w_t h_t^{NR}$, net of the tax rate τ_w levied on wages.

[6] Such that$d_t^* = (1-\kappa)d_t^{R*} + d_t^{G*}$ is the stock of international debt from households and the government.

2.2 AGGREGATE CONSUMPTION

Aggregate consumption is composed of a combination of tradable goods consumption (c_t^T) and non-tradable goods consumption (c_t^N). Here, ϵ represents the elasticity of substitution between the goods, and $0 < \varphi < 1$ is the share of non-tradable goods in aggregate consumption.

The aggregate consumption good is formed by combining tradable (c_t^T), and non-tradable (c_t^N) goods in the following sense:

$$c_t = \left[\varphi^{1/\epsilon}(c_t^N)^{1-1/\epsilon} + (1-\varphi)(c_t^T)^{1-1/\epsilon}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{11}$$

Tradable consumption is a Cobb-Douglas aggregation of exportable (c_t^X) and importable (c_t^M) goods:

$$c_t^T = \left(\frac{c_t^X}{\chi}\right)^{\chi}\left(\frac{c_t^M}{1-\chi}\right)^{1-\chi} \tag{12}$$

with χ is the share of exportable in total expenditure in tradable goods. The optimal choice of c_t^N, c_t^X, c_t^M is determined as follows:

$$\min_{\{c_t^N, c_t^T, c_t^X, c_t^M\}_{t=0}^{\infty}} c_t = \left[\varphi^{1/\epsilon}(c_t^N)^{1-1/\epsilon} + (1-\varphi)(c_t^T)^{1-1/\epsilon}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{13}$$

subject to:

$$p_t c_t = p_t^T c_t^T + p_t^N c_t^N \tag{14}$$

$$c_t^T = \left(\frac{c_t^X}{\chi}\right)\left(\frac{c_t^M}{1-\chi}\right)^{1-\chi} \tag{15}$$

$$p_t^T c_t^T = p_t^X c_t^X + c_t^M \tag{16}$$

where p_t^T, p_t^X and p_t^N are the relative prices of tradables, exportables and non-tradables. Note that the importable good is the numeraire.

2.3 PRODUCTION

In this section, we will begin to discuss the model's productive sector.

2.3.1 Exportable Goods

In our economy, there are three types of firms: exporters, producers of non-tradable final goods, and producers of capital goods. The firms producing exportable goods typically seek to maximize profits. Therefore, the firm follows this optimization problem:

$$\max_{\{h_t^X, k_{t-1}^X\}_{t=0}^{\infty}} \prod_T^X = (1-\tau^X)p_t^X y_t^X - w_t h_t^X - u_t^X k_{t-1}^X \tag{17}$$

Subject to technology:

$$y_t^X = a_t^X (h_t^X)^{\alpha_X} (k_{t-1}^X)^{1-\alpha_X-\theta_X} (k_{t-1}^G)^{\theta_X} \tag{18}$$

where τ^X is an income tax, a_t^X is an exogenous productivity shock, k_t^X is the stock of capital in this sector and u_t^X is the rental rate of capital in the non-tradabels.

Producers of exportable goods export at the commodity price p_t^X, and the total net revenue is calculated by multiplying the total quantity of goods produced y_t^X by the commodity price, discounted by the tax rate.

2.3.2 Non-Tradable Goods

The final non-tradable goods-producing firms seek to maximize the following profit maximization problem:

$$\max_{\{h_t^N, k_{t-1}^N\}_{t=0}^{\infty}} \prod_T^N = (1-\tau^N)p_t^N y_t^N - w_t h_t^N - u_t^N k_{t-1}^N \tag{19}$$

Subject to:

$$y_t^N = a_t^N (h_t^N)^{\alpha_N} (k_{t-1}^N)^{1-\alpha_N-\theta_N} (k_{t-1}^G)^{\theta_N} \tag{20}$$

The firm also faces a technological constraint similar to that encountered by the exporting firm. In this case, τ^N is the tax rate for the non-tradable sector, a_t^N is an exogenous productivity shock, k_t^N is the capital stock of this sector, and u_t^N represents the rental rates from the use of capital stocks in the non-tradable firms.

The parameter α_t^N corresponds to the labor share in the production function, while $1-\alpha_t^N$ represents the capital share in the production function, adjusted for the share of public capital denoted by the parameter θ_N.

2.3.3 Entrepreneurs

In our economy, there are entrepreneurs who manage the capital stock in the exporting sector and the non-tradable goods sector. Each entrepreneur begins each period with a capital stock k^j_{t-1} and maintains a portion of outstanding loans l^j_{t-1}, where $j = X, N$.

In each sector, entrepreneurs purchase new capital goods at the price q^j_t and receive rents from firms in each sector at the price u^j_t.

After depreciation (at rates δ), entrepreneurs sell the remaining capital to capital producers and repay their loans. Entrepreneurs use loans provided by households and their own wealth stocks represented by (n^j_t).

Therefore, their balance sheet is given by:

$$q^j_t k^j_t = n^j_t + p_t l^j_t \tag{21}$$

for $j = X, N$. Entrepreneurs face constraints on borrowing. There is a portion of loans that households are willing to lend, which are functions of the expected price of rental returns u^j_{t+1}, the price of capital q^j_{t+1} discounted by the capital depreciation rate δ:

$$E_t \left\{ \frac{u^j_{t+1} + (1+\delta)q^j_{t+1}}{q^j_t} \right\} = (1 + r^L_t) rp^j_t \tag{22}$$

so that $rp^j_t \equiv rp \left(\frac{q^j_t k^j_t}{n^j_t} \frac{1}{lev} \right)^{\xi_j}$ for $j = X, N$. The parameter *lev* represents the leverage of the entrepreneurs, [7] while *rp* is the steady-state risk premium, both assumed to be equal across sectors. Thus, $\xi_j > 0$ captures the elasticity of the premium with respect to leverage in each sector.

After loan repayment, a fraction of entrepreneurs $1-\vartheta$ exit the market and transfer the remaining profits to Ricardian households. A fraction of ϑ now enters the market each period, each receiving an initial capital injection from Ricardian households given by $\frac{i^j}{1-\vartheta}$.

The aggregate net worth in each sector is given by:

$$n^t_t = \vartheta \left\{ \left[u^j_t + (1-\delta)q^j_t \right] k^j_{t-1} - p_t l^j_{t-1}(1 + r^L_{t-1}) \right\} + i^j \tag{23}$$

for j = X, N.

[7] The leverage is defined as $lev^j_t = \frac{q^j_t k^j_t}{n^j_t}$

2.3.4 Capital and Investment Goods

In each sector, there are firms that purchase old capital, $(1-\delta)k^j_{t-1}$, and combine it with capital goods investment to produce new capital k^j_t, using the following technology:

$$k^j_t = (1-\delta)k^j_{t-1} + \left[1 - S_j\left(\frac{i^j_t}{i^j_{t-1}}\right)\right] i^j_t \tag{24}$$

8

for j = X,N. Where $S_k(.)$ is an adjustment costs function with the following form:

$$S_j\left(\frac{i^j_t}{i^j_{t-1}}\right) = \frac{\phi_j}{2}\left(\frac{i^j_t}{i^j_{t-1}} - 1\right)^2 \tag{25}$$

For $j = X, N$.

These firms choose the optimal amount of investment maximizing its total discounted profits:

$$\max_{i^j_t} E_0 \left\{\sum_{t=0}^{\infty} \Gamma_t \left\{ q^j_t \left[1 - S_j\left(\frac{i^j_t}{i^j_{t-1}}\right)\right] i^j_t - p^I_t i^j_t \right\}\right\} \tag{26}$$

where p^I_t is the relative price of investment goods, q^j_t is the relative price of capital and Γ_t is the stochastic discount factor. Additionally, there are firms that combine imported and non-traded goods to produce investment goods. Later, they sell these goods to capital firms and the government. Their technology is:

$$i_t = \left(\frac{x^N_t}{\gamma}\right)^{\gamma} \left(\frac{x^M_t}{1-\gamma}\right)^{1-\gamma} \tag{27}$$

where $i_t = i^N_t + i^X_t$. The optimal choice between non-traded and importable inputs is given by the following program:

$$\max_{\{x^N_t, x^M_t\}_{t=0}^{\infty}} p^I_t i_t - p^N_t x^N_t - x^M_t \tag{28}$$

subject to:

$$i_t = \left(\frac{x^N_t}{\gamma}\right)^{\gamma} \left(\frac{x^M_t}{1-\gamma}\right)^{1-\gamma} \tag{29}$$

Where x^j_t are the inputs for investment production, with imported inputs x^M_t and domestically produced inputs x^N_t.

8 It's worth noting here that i^j_t refers to the **investment** variable, not the nominal interest rate.

2.4 FISCAL POLICY

In this small open economy, the government generates revenue by taxing its agents through the following taxes: $(\tau^c, \tau^w, \tau^X, \tau^N, \tau^{Co})$. Therefore, the government's total revenue T comes from taxes on consumption, wages, exports, non-tradable goods, and taxation of exportable commodities. The government also has access to debt markets in domestic and international markets (d_t^G and d_t^{G*}).

The government conducts government purchases (g_t) of non-tradables and invests in the economy (i_t^G). Its budget constraint is imposed by a process:

$$p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*}(1 + r_{t-1}^*) + p_t d_{t-1}^G (1 + r_{t-1}^D) - rev_t = \tilde{d}_t^G \tag{30}$$

where rev_t denotes total revenues, which is equal to the following equation:

$$rev_t = \tau^c p_t c_t + \tau^w w_t h_t + \tau^X p_t^X y_t^X + \tau^N p_t^N y_t^N + \tau^{Co} p_t^{Co} y_t^{Co} \tag{31}$$

and $\tilde{d}_t^G$ is the total debt. We assume that a portion of the total public debt is given by a parameter ϖ is obtained from the domestic debt market, like as Suescún (2018) and Bellido et al. (2021). Therefore, a share $1 - \varpi$ is obtained from the foreign debt market:

$$p_t d_t^G = \varpi \tilde{d}_t^G \tag{32}$$

$$d_t^{G*} = (1 - \varpi)\tilde{d}_t^G \tag{33}$$

Regarding expenditure policy, the government is subject to **fiscal rules on government purchases and public investment**. On the current expenditure side, we have the following specification.

$$\frac{p_t^N g_t}{p \times gdp} = \eta_t^P \tag{34}$$

where $p \times gdp$ is the GDP in steady state terms of consumption units. Therefore, government purchases of non-tradables are a fraction (η_t^P) of GDP per consumption unit. Note that η_t^P is an **exogenous variable** following an AR(1) process. [9] Additionally, we specify a **Fiscal Deficit Rule** which operates as a **constraint on public investment**:

$$p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*} r_{t-1}^* + p_t d_{t-1}^G r_{t-1}^D + \eta^r \tilde{d}_t^G - rev_t = \eta_t^I \times p_t \times gdp_t \tag{35}$$

[9] The complete specification is detailed in **appendix A.**

where η_t^I determines the **numerical target** of the Fiscal Deficit Rule [10] and η^r is an adjustment factor.[11]

Moreover, public capital (k_t^G) follows the next equation:

$$k_t^G = (1-\delta^G)k_{t-1}^G + \left[1 - S_g\left(\frac{i_t^G}{i_{t-1}^G}\right)\right] i_t^G \tag{36}$$

where δ^G is the depreciation rate of public capital and $S_g(.)$ is its adjustment cost with the following functional form:

$$S_G\left(\frac{i_t^G}{i_{t-1}^G}\right) = \frac{\phi_G}{2}\left(\frac{i_t^G}{i_{t-1}^G} - 1\right)^2 \tag{37}$$

Finally, we assume public investment is a composite of non-tradable and importable goods, through the following technology:

$$i_t^G = \left(\frac{x_t^{NG}}{\gamma^g}\right)^{\gamma^g}\left(\frac{x_t^{MG}}{1-\gamma^g}\right)^{1-\gamma^g} \tag{38}$$

such that the government chooses optimally between these two inputs by the following program:

$$\max_{\{x_t^{NG}, x_t^{MG}\}_{t=0}^{\infty}} p_t^{IG} i_t^G + p_t^N x_t^{NG} + x_t^{MG} \tag{39}$$

subject to:

$$i_t^G = \left(\frac{x_t^{NG}}{\gamma^g}\right)^{\gamma^g}\left(\frac{x_t^{MG}}{1-\gamma^g}\right)^{1-\gamma^g} \tag{40}$$

2.4.1 Alternative Fiscal Rules

In this work, we employ two distinct designs of fiscal policy rules. The first one refers to the Structural Fiscal Deficit Rule (SFDR), which directly impacts public

---

[10] It follows an AR(1) process for trying to capture deviations from the Fiscal Deficit Rule and can be interpreted as public investment shocks.

[11] Following García-Cicco e Kawamura (2015) we combine the government budget constrait and the fiscal deficit rule, such that we obtain: $\tilde{d}_t^G - \tilde{d}_{t-1}^{G*}(1+r_{t-1}^*) - p_t d_{t-1}^G(1+r_{t-1}^D) + rev_t + d_{t-1}^{G*} r_{t-1}^* + p_t d_{t-1}^G r_{t-1}^D + \eta^r \tilde{d}_t^G - rev_t = \eta_t^I \times p_t \times gdp_t$ Notice that total public debt is defined as $\tilde{d}_t^G = d_t^G + p_t d_t^G$ Hence:

$$\tilde{d}_t^G - (1-\eta^r)\tilde{d}_{t-1}^G = \eta_t^I \times p_t \times gdp_t$$

Then, if $\eta_t^I \times p_t \times gdp_t$ is stationary, $\eta^r = 0$ implies that the total public debt, $\tilde{d_t^G}$, contains a unit root. In that sense, we interpreted η^r as an adjustment factor which assures a non-explosive path for total public debt. If $\tilde{d}_t^G$ is stationary, then d_t^{G*} and d_t^G also are. We calibrate eta^r such that the previous equation holds in steady state $\eta^r = \frac{\eta^I \times p \times \times gdp_t}{\tilde{d}^G}$.

investment, while the fiscal rule for government purchases of non-tradables remains unchanged. In this sense, we replace the rule for public investment with the following:

$$p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*} r_{t-1}^* + p_t d_{t-1}^G r_{t-1}^D + \eta^r \tilde{d}_t^G - rev = \eta_t^I \times p \times dgp \tag{41}$$

where *rev* is the steady-state level of fiscal revenues.

The third design is the Current Deficit Rule (CDR), also known as the golden rule. In this case we drop out the purchases of non-traded goods and replace the original by the next one:

$$p_t^N g_t + d_{t-1}^{G*} r_{t-1}^* + p_t d_{t-1}^G r_{t-1}^D + \eta^r \tilde{d}_t^G - rev_t = \eta_t^P \times p \times dgp_t \tag{42}$$

where η_t^P is the numerical target. In this case, the public investment is modeled as follows:

$$\frac{p_t^{IG} i_t^G}{p \times gdp} = \eta_t^I \tag{43}$$

where η_t^I is an AR(1) process with Gaussian innovations.

2.5 AGGREGATION AND MARKET CLEARING

Next, we present the market equilibrium conditions for the various markets:

Labor:

$$(1-\kappa) h_t^R + \kappa h_t^R = h_t^X + h_t^N \tag{44}$$

Consumption:

$$(1-\kappa) c_t^R + \kappa c_t^{NR} = c_t \tag{45}$$

Foreign debt:

$$(1-\kappa) d_t^{R*} + d_t^{G*} = d_t \tag{46}$$

Total debt:

$$d_t^* + d_t^G = \bar{d}_t \tag{47}$$

Loans:

$$(1-\kappa) l_t^R = l_t^X + l_t^N \tag{48}$$

Private investment:

$$i_t = i_t^N + i_t^X \tag{49}$$

Non-tradables:

$$y_t^N = c_t^N + x_t^N + g_t + x_t^{NG} \tag{50}$$

Imports:

$$imp_t = c_t^M + x_t^M + x_t^{MG} \tag{51}$$

Exports:

$$exp_t = p_t^X(y_t^X - c_t^X) + p_t^{Co}y_t^{Co} \tag{52}$$

Trade balance:

$$tb_t = exp_t - imp_t \tag{53}$$

Net foreign lending position:

$$d_{t-1}^*(1 + r_{t-1}^*) = d_t^* + tb_t \tag{54}$$

GDP in consumption units:

$$p_t gdp_t = p_t^X y_t^X + p_t^N y_t^N + p_t^{Co} y_t^{Co} \tag{55}$$

GDP - expenditures side:

$$p_t gdp_t = p_t c_t + p_t^i i_t + p_t^{IG} i_t^G + p_t^N g_t + tb_t \tag{56}$$

Finally, notice there are eight driving forces in the model $(a_t^X, a_t^N, p_t^{Co}, y_t^{Co}, r_t^W, p_t^X, \eta_t^P$ and $\eta_t^I)$ that follow an AR(1) processes with Gaussian innovations.

2.6 WELFARE INDICATORS

Consumer welfare will play a central role in our model. In this sense, the welfare of Ricardian and non-Ricardian consumers is defined as follows:

$$V_t^j = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t^j, h_t^j) \right\} \tag{57}$$

for $j = R, NR$. We can rewrite this equation recursively as follows:

$$V_t^j = U(c_t^j, h_t^j) + \beta E_t V_{t+1}^j \tag{58}$$

where $U(c_t^j, h^j) = \left[\frac{c_t^j - \varsigma \frac{(h_t^R)^{1+\upsilon}}{1+\upsilon}}{1-\theta} - 1 \right]$ for j = R,RN. Finally, the welfare gain, λ_W, is obtained from:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t^a, h_t^a) \right\} = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U((1 - \lambda_w) c_t^r h_t^r) \right\} \tag{59}$$

As pointed out by García-Cicco e Kawamura (2015), λ_w represents the percentage of consumption sequences in equilibrium under the reference policy *r* and the alternative policy *a*. A lower value of λ_w implies a greater welfare gain.[12] The objective

[12] See the **appendix A** for the functional form in the steady state.

is to calculate the percentage of consumption in equilibrium r that the consumer is willing to sacrifice to be indifferent between the r and a equilibria, denoted by λ, where indifference is measured in terms of unconditionally expected utility.

As point ou for García-Cicco e Kawamura (2015) in some cases, the utility is such that we can solve for λ explicitly, but in general this may not be the case. We will then show how to aproximate λ using a **second order Taylor expansion** around the steady state in the general case.

The derivations that follow closely follow the exposition given by García-Cicco e Kawamura (2015):

Let σ^2 denote the perturbation parameter that scales the variance of all shocks in the model. It can be shown that up to second order the unconditional of a generic variable X_t is approximated by

$$EX_t = X^{ss} + X_{\sigma^2}\frac{\sigma^2}{2} \tag{60}$$

Where X_{σ^2} reflects how the unconditional expectation depends on σ^2.[13] Thus, we redefine the left-hand side of **2.58** as $V^a(\sigma^2)$ to reflect the fact that it will depend on the perturbation parameter, and its approximation is then $V^a(\sigma^2) \approx V^{a,ss} + V^a_{\sigma^2}\frac{\sigma^2}{2}$ with can be easily computed with most computational packages such as Dynare as it is use here. [14]. Similarly, for a given value of λ, is the right-hand side of **2.58**, defines as $V^r(\lambda, \sigma^2)$, can also be approximated as a function of σ^2 (i.e. $V^r(\lambda, \sigma^2) \approx V^{r,ss}(\lambda) + V^r_{\sigma_2}(\lambda)\frac{\sigma^2}{2}$) for all λ).

Therefore, given that λ is implicitly defined as $V^a(\sigma^2) = V^r(\lambda, \sigma^2)$, it is then clear that it will be a function of σ^2 that can be approximated up to second order as:

$$\lambda(\sigma^2) \approx \lambda^{ss} + \lambda_{\sigma^2}\frac{\sigma^2}{2} \tag{61}$$

To compute λ^{ss}, notice the because in steady state $\sigma = 0$ **2.58** yields:

$$V^a(0) = V^r(\lambda^{ss}, 0) \tag{62}$$

In many cases λ^{ss} can be solved for algebraically from that equation, and if not it can be found with a numerical solver. To obtain λ_{σ_2}, differentiate $V^a(\sigma^2) = V^r(\lambda, \sigma^2)$ with respect to σ^2 and evaluate at the steady state, which yields

$$\lambda_{\sigma^2} = \frac{V^a_{\sigma^2} - V^r_{\sigma^2}(\lambda^{ss})}{V^r_{\lambda}(\lambda^{ss})} \tag{63}$$

where $V^r_{\lambda}(\lambda^{ss})$ denotes the second-order accurate approximation of the derivative of $V^r(\lambda, \sigma^2)$ with respect to λ evaluated at the state λ^{ss}. This is the second-order

[13] For instance see Andreasen, Fernández-Villaverde e Rubio-Ramírez (2018).
[14] Adjemian et al. (2024)

accurate approximation of $-E\left\{\sum_{t=0}^{\infty} U_c((1-\lambda^{ss})c_t^r, h_t^r)c_t\right\}$, which can also be computed using Dynare or similar as it is use here to calculate the consumer welfare.

3 DATA AND ESTIMATION

A crucial component of DSGE [1] model work involves accurately calibrating and estimating model parameters. Different structural parameters may produce different outcomes for the same economic policy simulation [2] In this chapter, we will calibrate a subset of the parameters before estimating the rest using Bayesian methods. The Metropolis-Hastings approach was used to generate posterior distributions for the parameters, which uses recursion via the Markov Chain Monte Carlo (MCMC) process.

For nonlinear structural models like ours, we can summarize the set of equations and variables into three groups. [3] The first group characterizes the evolution of state variables included in the model:

$$s_t = f(s_{t-1}, v_t) \tag{1}$$

In which s_t are the state variables and v_t is a collection of structural shocks. The second set of equations is known as policy functions, representing the optimal specification of control variables as a function of state variables:

$$c_t = c(s_t) \tag{2}$$

Finally, the set of equations that map the model variables to the observations:

$$X_t = \tilde{g}(s_t, c_t, v_t, u_t) \equiv g(s_t, u_t) \tag{3}$$

In wich u_t are the error terms. In our model, there are 86 variables, with 9 structural shocks and 23 state variables. The parameters associated with $s_t = f(s_{t-1}, v_t)$, $c_t = c(s_t)$ and $g(s_t, u_t)$ are obtained by mapping the parameter vector μ, through the likelihood function associated with $L(X|\mu)$. The estimation and calibration of parameters can be found in 1. A total of 22 parameters were estimated for the Brazilian economy using Bayesian methods, among which 18 are related to shocks and 4 are structural parameters. Additionally, 31 parameters were calibrated based on references in the literature. The remaining targets were proposed in the paper for steady-state values as specified in the previous chapter and can also be referenced in **Appendix A**.

The model is then put into state-space form for parameter estimation, in the form of[4]:

---

1 Following the seminal essay by Kydland e Prescott (1982), a new approach to analyzing genuine business cycles arose. Economics, considered as a dynamic and stochastic organism, crystallized into macroeconomics, giving rise to Dynamic Stochastic General Equilibrium (DSGE) models. Their work had a dual impact on macroeconomics, both methodologically and philosophically.

2 Consider the findings of Cavalcanti e Vereda (2011).

3 See DeJong e Dave (2011) and Canova (2007) for applied research in macroeconomics.

4 We use the notation of DeJong e Dave (2011)

$$x_{t+1} = F(\mu)x_t + G(\mu)v_{t+1}$$
$$X_t = H(\mu)'x_t \tag{4}$$

And by definition:

$$E(e_t e_t') = G(\mu)$$
$$E(v_t v_t') \tag{5}$$
$$G(\mu)' \equiv \Xi(\mu)$$

Bayesian estimation[5] allows for the incorporation of beliefs and information into the formation of prior distributions. These beliefs are updated when generating posterior distributions. In this text, we follow the methodology proposed by An e Schorfheide (2007) and Fernandéz-Villaverde (2010).[6] [7] A significant portion of the parameters in our model were calibrated based on what much of the literature already deems as appropriate calibrations for certain parameters. We largely use the calibrations employed in Bellido et al. (2021), García-Cicco e Kawamura (2015) and Suescún (2018), for the consumer preference parameters in the Brazilian economy, we use the calibrations and initial values suggested by Gouvea et al. (2011), Carvalho, Valli et al. (2011) and Cavalcanti e Vereda (2011).

The parameters θ, ϵ, ξ^X, and ξ^N are estimated along with the structural shocks and autoregressive coefficients. The steady-state calibrations for the Fiscal Deficit Rule (FDR) include a surplus of 1% of GDP, 0.5% surplus for the Structural Fiscal Deficit Rule (SFDR), and a primary deficit of -3.5% for the Current Deficit Rule (CDR). In steady state, investment is calibrated at 1% of GDP for both CDR and SFDR, while in the more expansionary CDR, investment is calibrated at 4.5% of GDP. The results can be found in the following chapter.

---

5 For a rigorous introduction to Bayesian estimation, refer to Chapter 13 of Hamilton (1994).

6 For parameter estimation and steady-state calculations, we utilized the **Dynare** software, for which extensive documentation on its usage can be found in Adjemian et al (2024).

7 Here, we opted for model estimation using the RW-Metropolis-Hastings algorithm, as employed for the SAMBA model in the Brazilian case, as well as in the general literature, as detailed in the original article by Gouvea et al. (2011). However, recent advancements in DSGE model estimation have explored alternative algorithms, as can be seen in the SAMBA model update by Fasolo et al. (2023), following the methodology suggested by Cai et al (2021).

Tabela 1 – Calibrated Parameters

Names	Description	Value	Source
θ	Risk aversion	1.3000	Gouvea et al. (2011) and own estimation
υ	Frish elasticity	2.0000	Carvalho, Valli et al. (2011)
χ	Share of exportable goods in tradable consumption composite	0.5000	Bellido et al. (2021)
α_X	Importance of labor in the exportable production	0.5500	Bellido et al. (2021)
α_N	Importance of labor in the non-tradable production	0.7500	Bellido et al. (2021)
δ	Depreciation rate of private capital	0.1000	Cavalcanti e Vereda (2011)
δ_G	Depreciation rate of public capital	0.0350	Bellido et al. (2021)
γ	Share of non-tradables in private investment	0.4000	Bellido et al. (2021)
γ_G	Share of non-tradables in public investment	0.8000	Bellido et al. (2021)
ϕ_{d*}	Elasticity of country premium - foreign debt	0.0010	Bellido et al. (2021)
ϕ_d	Elasticity of country premium - domestic debt	0.0010	Bellido et al. (2021)
κ	Share of Non-Ricardian households	0.6500	Bellido et al. (2021)
ν	Entrepreneurs survival rate	0.9700	Bellido et al. (2021)
ϵ	Elasticity of substitution between tradable and non-tradable sectors	0.7500	Own Estimation
ξ^X	Elasticity of the risk premium in the tradable sector	1.5000	Own Estimation
ξ^N	Elasticity of the risk premium in the non-tradable sector	1.5000	Own Estimation
θ^X	Importance of public capital in the exportable production	0.1000	Bellido et al. (2021)
θ^N	Importance of public capital in the tradable production	0.1000	Bellido et al. (2021)
ϕ^X	Capital adjustment cost in the tradable sector	0.1000	Bellido et al. (2021)
ϕ^N	Capital adjustment cost in the non-tradable sector	0.1000	Bellido et al. (2021)
ϕ^{IG}	Capital adjustment cost in the public sector	0.1000	Bellido et al. (2021)

Continued on next page

Tabela 1 – continued from previous page

Names	Description	Value	Source
ϕ^G	Share of internal public debt	0.4800	Bellido et al. (2021)
ρ_{aX}	Tradable sector productivity	0.5000	Own Estimation
ρ_{aN}	Non-tradable sector productivity	0.5000	Own Estimation
ρ_{pX}	Tradable sector price	0.5000	Own Estimation
ρ_{yCo}	Commodity sector production	0.5000	Own Estimation
ρ_{pCo}	Commodity sector prices	0.5000	Own Estimation
ρ_{rW}	Foreign interest rate	0.5000	Own Estimation
ρ_{sf^A}	Stock-flow adjustment	0.5000	Own Estimation
ρ_g	Current expenditures	0.5000	Own Estimation
ρ_{ig}	Public investment	0.5000	Own Estimation
tb_{ss}	Trade balance	0.0200	Bellido et al. (2021)
ig_{ss}	Government investment	0.0450	Bellido et al. (2021)
g_{ss}	Government spending	0.1100	Bellido et al. (2021)
d^G_{ss}	Government debt	0.3000	Bellido et al. (2021)
lev	Entrepreneurs leverage	2.0500	Bellido et al. (2021)
η_0	Target in the fiscal rule	0.0100/0.005/-0.0350	Own Calibration
$gdp_{m,ss}$	GDP	0.6250	Bellido et al. (2021)
RP_{ss}	Risk Premium	1.0330	Bellido et al. (2021)
r^W_{ss}	International interest rate	1.0124	Bellido et al. (2021)
$p^{Co}_s s$	Commodities prices	1.0000	Bellido et al. (2021)
$p^X_s s$	Tradable exportable prices	1.0000	Bellido et al. (2021)
$a^N_s s$	Productivity technology of the non-tradable sector	1.0000	Bellido et al. (2021)
			Continued on next page

Tabela 1 – continued from previous page

Names	Description	Value	Source
$p_s^N s$	Non-tradable exportable prices	1.0000	Bellido et al. (2021)
$p_s^{Ig} s$	Investment government prices	1.0000	Bellido et al. (2021)
$sfA_s^{ss} s$	Stock-flow at steady-state	1.0000	Bellido et al. (2021)
$g_s s$	Government spending	1.0000	Bellido et al. (2021)
h_{ss}	Steady-state labour hours	0.3000	Bellido et al. (2021)
τ^C	Consumption tax rate	0.1483	Bellido et al. (2021)
τ^W	Labor income tax rate	0.0230	Bellido et al. (2021)
τ^X	Exportable income tax rate	0.0015	Bellido et al. (2021)
τ^N	Non-tradable income tax rate	0.0005	Bellido et al. (2021)
τ^{Co}	Commodity income tax rate	0.1500	Bellido et al. (2021)

Source: Own Elaboration.

3.1 BRAZILIAN ECONOMIC DATA

We used annual Brazilian data[8] from 2002 to 2023 from the Brazilian National Accounts. Details regarding the data used, their sources, and their treatment can be found in 2 below. For the vast majority of the series used here, we applied several treatments such as taking the first difference and applying the natural logarithm to make them stationary. We then conducted three stationarity tests using the following statistical tests: ADF, KPSS and PP[9] which confirm the stationary of the Brazilian series used in the model estimation. Additionally, we employed the Kalman Filter to assist in forming the likelihood function[10] for model estimation.

Tabela 2 – Domestic Observable Variables

Description	Source	Treatment
Gross Domestic Product (GDP) vol (s.a.)	IBGE	First log difference
Households consumption vol (s.a.)	IBGE	First log difference
Product of Agriculture vol (s.a.)	IBGE	First log difference
Investment: Gross formation of fixed capital - vol (s.a.)	IBGE	First log difference
Net Debt of the Consolidated Public Sector	Central Bank of Brazil	First log difference
Agricultural commodity index	Central Bank of Brazil	First log difference
Commodity index	Central Bank of Brazil	First log difference
Primary Surplus - public sector - 12 months	National Treasury	difference YoY
Total Revenue - public sector - 12 months	National Treasury	difference YoY

Source: Own Elaboration.

[8] Following the annual calibration strategy of the model.
[9] Refer to the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, named after the authors Kwiatkowski, Phillips, Schmidt, and Shin, for more information Bueno (2008).
[10] We utilized the Kalman Filter in the DSGE model as suggested by Smets e Wouters (2003). For more rigorous information on the Kalman Filter, refer to Harvey (1990) and DeJong e Dave (2011).

4 RESULTS

After specifying, calibrating, and estimating the three different fiscal rules, we obtained results that will now be discussed. We used the Metropolis-Hastings Random Walk algorithm with two parallel chains of Markov Chain Monte Carlo (MCMC) simulations, each with 100,000 iterations [1], to find the distributions *à posteriori* [2] with an acceptance rate in each chain close to 33%.

The Brazilian economic data used for estimation were generally relevant for estimating a significant portion of the parameters. However, for the parameter of relative risk aversion, or the inverse of the inter-temporal elasticity of substitution θ, although the model was unable to gain additional information, it maintained the mean at the same point as the prior distribution.

We draw attention to some parameters of greater interest. The first parameter of interest is the coefficient of relative risk aversion, or the inverse of individuals' inter-temporal elasticity of substitution, represented in our model as θ. Gouvea et al. (2011) already warns at the beginning of the discussion in their chapter about the difficulty encountered in correctly identifying this parameter in DSGE-type macroeconomic models. In our estimation, the parameter θ remained unchanged after simulations, indicating that the model was unable to estimate it. Therefore, we adopted the same value found in Gouvea et al. (2011) of 1.30 for this parameter.

Similar findings were reported by Gouvea et al. (2011) in the estimation of the SAMBA model. In their words:

> We can observe these patterns in most of the parameters related to rigidity and indexation of price and wages, real frictions, and monetary policy. The same occurs for parameters of the AR(1) process and innovations.The main exceptions are the inverse of intertemporal elasticity of substitution, σ - usually of difficult identification - the elasticity of substitution between imported and domestic inputs in some sectors, and the administered price rule parameters. Gouvea et al., 2011, p. 52

Ramos e Portugal (2019) also discuss difficulties in finding the parameter under discussion, noting that in the distribution the parameter mean was "pushed"more than two standard deviations below the prior during estimation. The authors also use a median of 1.30, and after estimation, they converge to the same posterior in order to not affect the final parameter result.

For the parameter ν, we used the value of 2.00 as used in Carvalho, Valli et al. (2011), who also employed a DSGE model to assess the impacts of fiscal policy. This differs from the model used in Cavalcanti e Vereda (2011), where values close to unity were used. Similarly, Smets e Wouters (2003) also used values around a mean of 2.00

[1] The number of simulations follows the same approach used in Costa (2019).

[2] The convergence tests for the first three moments of the distribution can be checked in the **Appendix B** and follow the convergence tests discussed and proposed by Brooks e German (1998).

for the prior distribution, with a standard deviation of 0.75, indicating a 95% probability of this parameter lying within the range of $0.5, 3.5$. Christoffel, Coenen e Warne (2008) also used these values for the euro area.

For the parameter ϵ, which represents the elasticity of substitution between tradables and non-tradables, we found a value of 0.7552, suggesting that the elasticity between imported and domestic goods is inelastic. This means that consumers in our economy substitute domestic consumption for imports in a more rigid manner. One reason for this is the significant share of services consumed in the country, as well as the high degree of administered goods in the Brazilian economy, which are essentially basic goods such as electricity and water. This leads to a high degree of inelasticity in the substitution between tradables and non-tradables. Cavalcanti e Vereda (2011) mention that these substitution parameters are scarce in the national literature and, as they are not relevant in international literature, there are few references regarding this parameter.

For the parameters ξ^X and ξ^N, which represent the elasticities of risk premiums for the tradable and non-tradable sectors, we found values of 1.4981 and 1.4846, respectively. These values suggest that there is elasticity capturing the risk premium with respect to the leverage of the business sectors. There are no estimations for such parameters in the Brazilian economy, which constitutes a contribution of this work for future discussions. The parameters discussed above pertain to the SFDR. The remaining parameters relate to the estimated shocks and can be consulted in **Appendix A**.

4.1 WELFARE

For our variable of interest, consumer welfare, evaluated in the model by the recursion presented in the previous chapter, as a function of the parameter λ, the following results were obtained. We simulate the model to generate second order moments. The results suggest that under the Structural Fiscal Deficit Rule, the welfare of consumers, both Ricardian and Non-Ricardian, is the highest. This implies that, from the perspective of this welfare indicator, the rule that best confers welfare to the analyzed consumers is the Structural Fiscal Deficit Rule.

These results suggest that under a rule for public investment, both Ricardian and non-Ricardian consumers experience the greatest welfare gains. Despite SFDR being the most restrictive in terms of public investment and unable to act countercyclically, the gains derived are greater compared to other rules. Additionally, the imposition of primary surpluses close to equilibrium also suggests that balanced public accounts in the long run confer greater gains to society.

One of the reasons for higher consumer welfare under the SFDR is the high share

Tabela 3 – Theorical Moments based on State Space

Variable	Fiscal Deficit Rule	Structural FDR	Current Deficit Rule
WelfareR	76.8461	107.4381	66.7684
WelfareNR	-209.6371	-132.1629	-191.2337
ConsumeR	0.8490	1.2110	0.7529
ConsumeNR	-1.4661	-0.9201	-1.3583
HoursR	-1.2095	-1.0275	-1.1736
HoursNR	-1.2095	-1.0275	-1.1736
investment	-3.2762	-2.6750	-3.1261

Source: Own Elaboration.

of non-Ricardian actors in our simulations. Non-Ricardian agents are more vulnerable to consumption variations because they smooth their consumption and have access to financial markets, whereas Ricardian agents modify their consumption more slowly during periods of growth or recession. The SFDR smoothes out this usage as well. The retention of a part of consumers, in the Brazilian scenario, who rely on income transfers, which is not discussed here, can be a method for stabilizing consumption. This is because the SFDR smoothes both spending and revenues over the economic cycle, ensuring that direct transfers continue in both phases of the economy.

Although the SFDR rule maximizes consumer welfare, it is also the most difficult to implement. This is owing to the difficulties of estimating unobservable variables in short time frames, such as the output gap, making the rule the most difficult in practice. For the Brazilian situation, among the three rules described here, attempts were made to adopt the fiscal deficit rule and the Golden Rule, with the SFDR remaining active.

4.2 BAYESIAN IMPULSE RESPONSE FUNCTIONS

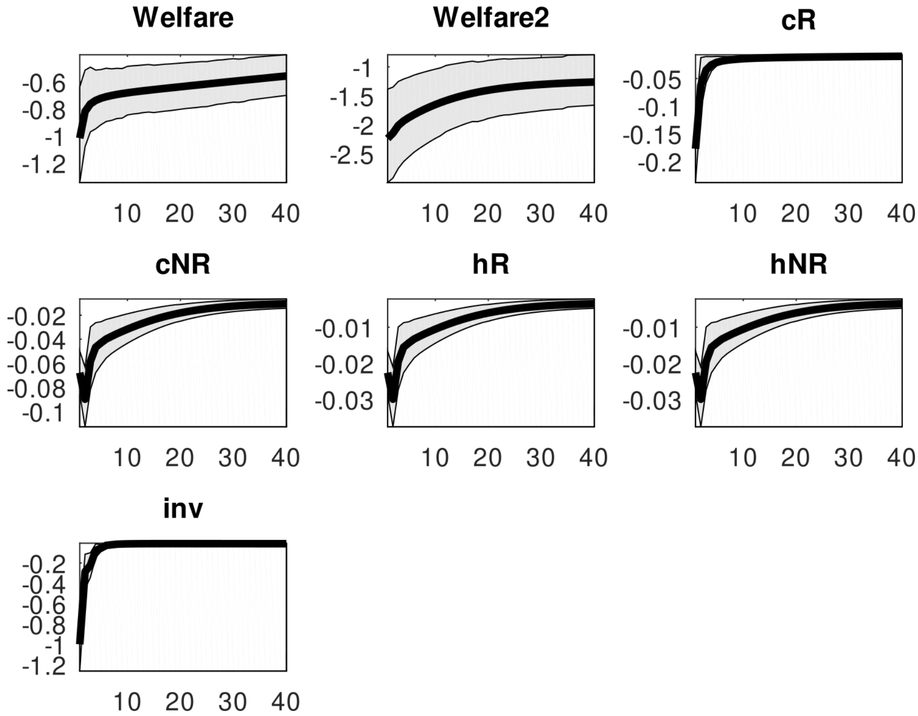
Let's assess two orthogonal shocks on the variables: international interest rates and government investment, and their impact on Ricardian and non-Ricardian consumption, hours worked, investment, and consumer welfare. The shocks under the Structural Fiscal Deficit Rule (SFDR) were conducted using Bayesian impulse response functions, and the confidence interval was estimated using Bayesian techniques. All responses presented align with expectations for variables in New Keynesian models. Since welfare is not an economic variable, agents' welfare may exhibit different components than expected in the relationships after the shocks.

4.2.1 Shock to international interest rates

After a shock to international interest rates under the Structural Fiscal Deficit Rule (SFDR), the impulse response functions can be observed in Figure 3. As expected, an increase in international interest rates decreases the welfare of both Ricardian and non-Ricardian consumers, as well as negatively impacting the consumption of both. However, the impact on the consumption of Ricardian consumers is greater than the effect on non-Ricardian consumers.

Regarding hours worked, the impulse response functions suggest a reduction in labor supply as well as a decrease in total investment.

Figura 3 – Impact of an increase in international interest rate

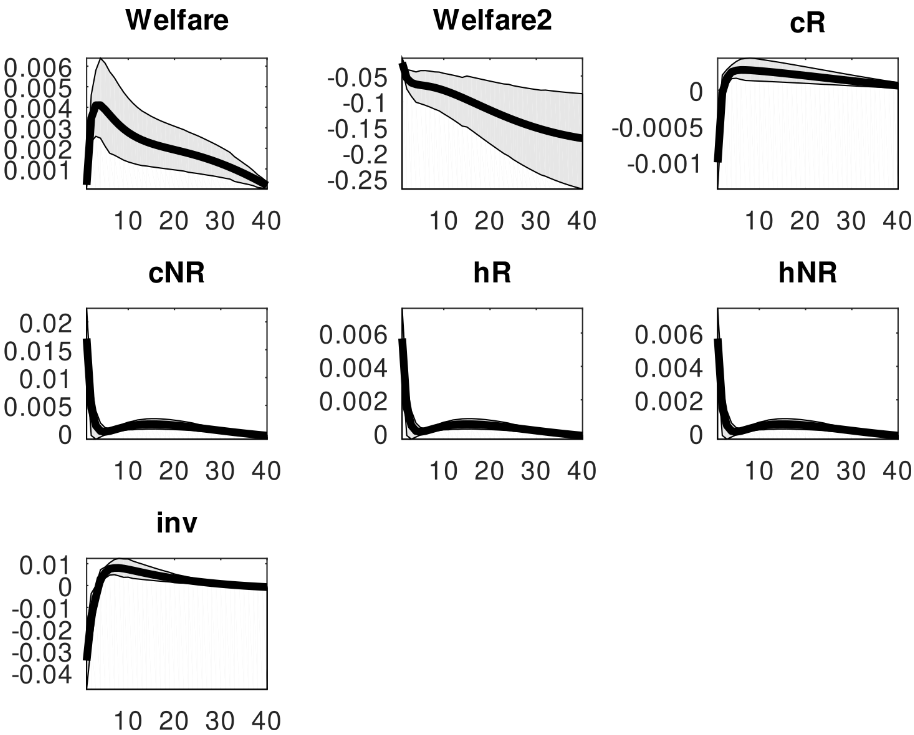


Source: Own Elaboration.

4.2.2 Shock to government investment

After a positive shock of one standard deviation in government investment under the SFDR rule, the response variables behave as expected, as shown in the figure 4. The consumption of Ricardian agents experiences a slight decrease, while the consumption of non-Ricardian agents marginally increases. Both Ricardian and non-Ricardian agents' hours worked also increase due to a demand effect stemming from higher activity levels. In contrast, **total investment** decreases, suggesting a *crowding-out* effect on investments, where private investment reduces in response to increased public investment, which decreases over the long term. In terms of comparative statics, the SFDR imposes a more restrictive rule on public investments, so in the event of a shock, total investment tends to retract.

Figura 4 – Impact of an increase in Government Investment



Source: Own Elaboration.

5 CONCLUSION

Brazil has achieved gradual progress in macroeconomic reforms over the last 40 years, tackling critical issues such as productivity increase and economic growth. The prolonged balance of payments crisis of the 1980s, caused by an unsustainable era of expansion fuelled by external debt and consecutive governmental deficits, was overcome following a decade of deep social disparity.

Price stability was implemented through the Real Plan in the 1990s, kicking off a process of state reform that included privatizations, institutional consolidation, and strengthening, as well as the beginning of a steady reduction in poverty. In the 2000s, the country had an economic boom fueled by the commodities cycle, political stability, and economic expansion. Following the 2008 crisis, interventionist economic discourse returned, resulting in a two-year economic slowdown. Subsequent years were spent restoring lost productivity gains and per capita GDP, which prompted a series of state reforms including as labor reform, pension reform, and, more recently, tax reform.

As the fourth issue persists, it is critical that the country handle the fiscal question. In Brazil, it appears that the size of the Brazilian state is incompatible with the population's social and economic needs. That is, the Brazilian budget is insufficient to cover all social needs. This study aims to contribute to this discussion by simulating three alternative fiscal rules: the benchmarking rule, which imposes no restrictions on government purchases and public investment; the second rule, which imposes restrictions on public investment and is influenced by the economic cycle; and the most expansionary rule, which involves a significant state presence in public investments.

Indeed, Brazil still faces a major fiscal imbalance. The society has yet to discover a long-term solution to managing public debt and fiscal policies that are consistent with the budgets of the federal government, states, and municipalities. In tackling this issue, fiscal regulations are critical because they provide greater certainty and consistency in fiscal concerns. As a result, using models capable of recreating the economic environment and capturing key aspects of the Brazilian economy is critical for understanding and forecasting economic outcomes in this context.

This study aims to replicate three unique fiscal rules for the Brazilian economy using the model proposed by Mendoza (2021). After accurately specifying the parameter estimation model using Bayesian methods, we evaluate the effects of these three rules on consumer welfare. In addition, we assess the impulse response functions for various shocks within this framework.

Several popular DSGE model characteristics, such as capital adjustment costs, are included in our model. Furthermore, our model belongs to the TANK (Two Agents New-Keynesian) model class because it includes two representative agents, which is consistent with current improvements in DSGE modeling. Our model is especially novel in the Brazilian context for two reasons. First, it clearly simulates an open economy, which is typical of Brazil because it is dependent on both global economic cycles, such as commodity prices, and global growth and economic cycles. Furthermore, our model explicitly includes a sector that is gaining prominence in the Brazilian economy: **agriculture**.

We used observed variables to estimate model structural parameters as well as stochastic structural shocks. For parameter estimation and model calibration, we used an annual dataset covering the Brazilian economy from 2002 to 2023. The data set includes observable variables such as GDP, household consumption, agricultural output, investment, net public sector debt, agricultural commodity index, overall commodity index, primary surplus, and total public sector revenue. Furthermore, after estimating the model using Bayesian approaches for the Brazilian economy, we simulated two orthogonal shocks. The results showed that, under this specification for the Brazilian economy, and after assessing the impact of the three simulated rules, the model suggests a higher welfare gain with a Structural Fiscal Deficit Rule, which is a rule conditioned on the economy's business cycle, with a focus on the commodity cycle. These findings underline the importance of fiscal laws for the welfare of economic agents, which has been noted in various research and literature.

For future research, we propose estimating broader parameters for the Brazilian economy and evaluating their effects on macroeconomic aggregates. Furthermore, improvements in the estimation of various model parameters may produce additional intriguing results.

The contribution of this work is the inclusion of elements in the estimated DSGE models for Brazil, adding previously unstudied characteristics such as the modeling of sectors linked to the commodity cycle (which is critical to the Brazilian economy) and the inclusion of fiscal rules in DSGE modeling, which is still being discussed in Brazil.

REFERENCE

ADJEMIAN, Stéphane; JUILLARD, Michel; KANKANAMGE, Sumudu; KARAMÉ, Frédéric; MAIH, Junior; MUTSCHLER, Willi; PFEIFER, Johannes; RATTO, Marco; RION, Normann; VILLEMOT, Sébastien. **Dynare**: **reference manual**, version 6. Reference Manual, Version 6. 2024. Available at: https://www.dynare.org/manual. Accessed on: 02 fev. 2024.

AN, Sungbae; SCHORFHEIDE, Frank. Bayesian Analysis of DSGE Models. **Econometric Reviews**, [S.L.], v. 26, n. 2-4, p. 113-172, 12 abr. 2007. Informa UK Limited. http://dx.doi.org/10.1080/07474930701220071.

ANDREASEN, Martin M; FERNÁNDEZ-VILLAVERDE, Jesús; RUBIO-RAMÍREZ, Juan F. The Pruned State-Space System for Non-Linear DSGE Models: theory and empirical applications. **The Review Of Economic Studies**, [S.L.], v. 85, n. 1, p. 1-49, 28 jun. 2017. Oxford University Press (OUP). http://dx.doi.org/10.1093/restud/rdx037.

ARBELÁEZ, María Angélica; BENÍTEZ, Miguel; STEINER, Roberto; VALENCIA, Oscar. **A Fiscal Rule to Achieve Debt Sustainability in Colombia**. 2021. Disponível em: https://publications.iadb.org/en/fiscal-rule-achieve-debt-sustainability-colombia. Accessed on: 10 out. 2023.

BARBOSA, Fernando de Honorato; PESSOA, Samuel. Desaceleração recente da economia. In: PðBLICAS, Insper/Centro de Debate de Políticas (comp.). **Coletânea de capítulos da agenda "Sob a Luz do Sol"**. São Paulo: Insper, 2014. p. 15-30.

BHATTARAI, Keshab; TRZECIAKIEWICZ, Dawid. Macroeconomic impacts of fiscal policy shocks in the UK: a dsge analysis. **Economic Modelling**, [S.L.], v. 61, p. 321-338, fev. 2017. Elsevier BV. http://dx.doi.org/10.1016/j.econmod.2016.10.012.

BLANCHARD, Olivier Jean; DELL'ARICCIA, Giovanni; MAURO, Paolo. **Rethinking Macro Policy II: Getting Granular**. Washington: International Monetary Fund, 2013.

BROCHADO, Acuã; BARBOSA, Flávia Fernandes Rodrigues; LEISTER, Maurício Dias; MARCOS, Rafael Perez; MOTA, Tatiana de Oliveira; SBARDELOTTO, Tiago; ARAÚJO, Vinícius Luiz Antunes. **Regras Fiscais**: uma proposta de arcabouço sistêmico para o caso brasileiro. Brasília: Secretaria do Tesouro Nacional, 2019.

BROOKS, Stephen P.; GELMAN, Andrew. General Methods for Monitoring Convergence of Iterative Simulations. **Journal Of Computational And Graphical Statistics**, [S.L.], v. 7, n. 4, p. 434-455, dez. 1998. Informa UK Limited. http://dx.doi.org/10.1080/10618600.1998.10474787.

BUENO, Rodrigo de Losso da Silveira. **Econometria de séries temporais**. 2. ed. São Paulo: Cengage Learning, 2018.

CAI, Michael; DEL NEGRO, Marco; HERBST, Edward; MATLIN, Ethan; SARFATI, Reca; SCHORFHEIDE, Frank. Online estimation of DSGE models. **The Econometrics**

Journal, [S.L.], v. 24, n. 1, p. 33-58, 21 set. 2020. Oxford University Press (OUP). http://dx.doi.org/10.1093/ectj/utaa029.

CALVO, Guillermo A.; REINHART, Carmen M.; VÉGH, Carlos A.. Targeting the real exchange rate: theory and evidence. **Journal Of Development Economics**, [S.L.], v. 47, n. 1, p. 97-133, jun. 1995. Elsevier BV. http://dx.doi.org/10.1016/0304-3878(95)00006-2.

CANOVA, Fabio. **Methods for Applied Macroeconomic Research**. [S.l.]: Princeton University Press, 2007. V.13.

CARVALHO, Fabia A. de; VALLI, Marcos. **Fiscal Policy in Brazil through the Lens of an Estimated DSGE Model**. Brasília: Bcb, 2011. Available at: https://www.bcb.gov.br/pec/wps/ingl/wps240.pdf. Available at: 13 dez. 2023

CASELLI, Francesca; DAVOODIA, Hamid; GONCALVES, Carlos; HONG, Gee Hee; LGERBORG, Andresa; MEDAS, Paulo; NGUYEN, Anh Dinh Minh; YOO, Jiae. **The Return to Fiscal Rules**. Washington: Imf, 2022. Available at: https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2022/10/11/The-Return-to-Fiscal-Rules-523709. Accessed on: 13 nov. 2023.

CASTRO, Marcos R. de; GOUVEA, Solange N.; MINELLA, André; SANTOS, Rafael C.; SOUZA-SOBRINHO, Nelson F.. **SAMBA:**: stochastic analytical model with a bayesian approach. 239. ed. Brasília: Banco Central do Brasil, 2011. (Working Paper Series).

CAVALCANTI, Marco Antônio Freitas de Hollanda; VEREDA, Luciano. **Propriedades dinâmicas de um modelo DSGE com parametrizações alternativas para o Brasil**. Brasília: Instituto de Pesquisa Econômica Aplicada (Ipea), 2011. Available at: https://repositorio.ipea.gov.br/bitstream/11058/1425/1/TD_1588.pdf. Accessed on: 11 fev. 2024.

CHRISTOFFEL, Kai; COENEN, Günter; WARNE, Anders. **The New Area-Wide Model of the euro area**: a micro-founded open-economy model for forecasting and policy analysis. [Frankfurt]: European Central Bank, 2008.

COSTA, Celso J.. Preferred habitat and the term structure of interest rates in DSGE models. **Journal Of Applied Economics**, [S.L.], v. 22, n. 1, p. 581-601, 1 jan. 2019. Informa UK Limited. http://dx.doi.org/10.1080/15140326.2019.1680124.

DAVOODI, Hamid R; ELGER, Paul; FOTIOU, Alexandra; GARCIA-MACIA, Daniel; HAN, Xuehui; LAGERBORG, Andresa; LAM, Waikei R; A MEDAS, Paulo. **Fiscal Rules and Fiscal Councils:**: recent trends and performance during the covid-19 pandemic. [Washington]: International Monetary Fund, 2014. (Working Paper No. 2022/011).

DEJONG, David N.; DAVE, Chetan. **Structural Macroeconometrics**. 2. ed. [S.L.]: Princeton University Press, 2011.

END, Nicolas. Big Brother is also being watched: measuring fiscal credibility. **Journal Of Macroeconomics**, [S.L.], v. 77, p. 103548, set. 2023. Elsevier BV. http://dx.doi.org/10.1016/j.jmacro.2023.103548.

EYRAUD, Luc; BAUM, Anja; HODGE, Andrew; JARMUZEK, Mariusz; TURE, H. Elif; MBAYE, Samba; KIM, Young-Bae. **How to Calibrate Fiscal Rules:**: a r. [Washington]: International Monetary Fund, 2018. (How-To Note No 2018/002).

EYRAUD, Luc; DEBRUN, Xavier; HODGE, Andrew; LLEDÓ, Victor; PATTILLO, Catherine. **Second-Generation Fiscal Rules:**: balancing simplicity, flexibility, and enforceability. Washington: Imf Staff Discussion Note, 2018. Available at: https://www.imf.org/external/datamapper/fiscalrules/sdn1804-on-second-generation-fiscal-rules.pdf. Accessed on: 02 set. 2022.

FASOLO, Angelo Marsiglia; ARAðJO, Eurilton; JORGE, Marcos Valli; KORNELIUS, Alexandre; MARINHO, Leonardo Sousa Gomes. **Brazilian Macroeconomic Dynamics Redux:**: shocks, frictions, and unemployment in samba model. Brasília: Banco Central do Brasil, 2023. (Working Paper Series). N. 578.

FERNÁNDEZ-VILLAVERDE, Jesús. The econometrics of DSGE models. **Series**, [S.L.], v. 1, n. 1-2, p. 3-49, 19 fev. 2010. Springer Science and Business Media LLC. http://dx.doi.org/10.1007/s13209-009-0014-7.

GALÍ, J. **Monetary policy, inflation, and the business cycle:** an introduction to the new Keynesian framework and its applications. [S.l.]: Princeton University Press, 2015.

GALÍ, Jordi; GERTLER, Mark. Macroeconomic Modeling for Monetary Policy Evaluation. **Journal Of Economic Perspectives**, [S.L.], v. 21, n. 4, p. 25-45, 1 nov. 2007. American Economic Association. http://dx.doi.org/10.1257/jep.21.4.25.

GARCÍA-CICCO, Javier; KAWAMURA, Enrique. Dealing with the Dutch disease:: fiscal rules and macro-prudential policies. **Journal Of International Money And Finance**, [S.L.], v. 1, n. 55, p. 205-239, 2005.

GIAMBIAGI, Fabio. 18 anos de política fiscal no Brasil: 1991/2008. **Economia Aplicada**, [S.L.], v. 12, n. 4, p. 535-580, dez. 2008. FapUNIFESP (SciELO). http://dx.doi.org/10.1590/s1413-80502008000400002.

GOOTJES, Bram; HAAN, Jakob de. Do fiscal rules need budget transparency to be effective? **European Journal Of Political Economy**, [S.L.], v. 75, p. 102210, dez. 2022. Elsevier BV. http://dx.doi.org/10.1016/j.ejpoleco.2022.102210.

HAMILTON, J. D. **Time series analysis**. [S.l.]: Princeton university press, 2020.

HARVEY, A. C. **Forecasting, structural time series models and the Kalman Filter**.Cambridge university press, New York: 1990.

INSTITUIÇÃO FISCAL INDEPENDENTE. Relatório de acompanhamento fiscal: junho de 2023. Brasília: Senado Federal, 2023. Available at: https://www2.senado.leg.br/bdsf/bitstream/handle/id/611252/RAF77_JUN2023.pdf Accessed on: 25 mar. 2024.

INSTITUIÇÃO FISCAL INDEPENDENTE. Relatório de acompanhamento fiscal: janeiro de 2024. Brasília: Senado Federal, 2024a. Available at: https://www2.senado.leg.br/bdsf/bitstream/handle/id/645989/RAF84_JAN2024.pdf Accessed on: 15 mar. 2024

INSTITUIÇÃO FISCAL INDEPENDENTE. Relatório de acompanhamento fiscal: março de 2024. Brasília: Senado Federal, 2024b. Available at: https://www2.senado.leg.br/bdsf/bitstream/handle/id/648335/RAF86_MAR2024.pdf Accessed on: 10 abr. 2024

KANCZUK, Fabio. Juros reais e ciclos reais brasileiros. **Revista Brasileira de Economia**, [S.L.], v. 56, n. 2, p. 249-267, abr. 2002. FapUNIFESP (SciELO). http://dx.doi.org/10.1590/s0034-71402002000200003

KYDLAND, Finn E.; PRESCOTT, Edward C.. Time to Build and Aggregate Fluctuations. **Econometrica**, [S.L.], v. 50, n. 6, p. 1345, nov. 1982. JSTOR. http://dx.doi.org/10.2307/1913386.

LJUNGQVIST, L.; SARGENT, T. J. **Recursive macroeconomic theory**. [S.l.]: MIT Press, 2018.

LLEDÓ, Victor Duarte; DUDINE, Paolo; EYRAUD, Luc; ALVA, Adrian Peralta. **How to Select Fiscal Rules:**: a primer. Washington, Dc: International Monetary Fund, 2018. (How-To Note No 2018/003). Avaible at: https://www.imf.org/en/Publications/Fiscal-Affairs-Department-How-To-Notes/Issues/2018/03/15/How-to-Select-Fiscal-Rules-A-Primer-45552. Accessed on: 1 set. 2023.

LUCAS, Robert E.. Econometric policy evaluation: a critique. **Carnegie-Rochester Conference Series On Public Policy**, [S.L.], v. 1, p. 19-46, jan. 1976. Elsevier BV. http://dx.doi.org/10.1016/s0167-2231(76)80003-6.

LUCAS, Robert E.; PRESCOTT, Edward C.. Investment Under Uncertainty. **Econometrica**, [S.L.], v. 39, n. 5, p. 659, set. 1971. JSTOR. http://dx.doi.org/10.2307/1909571.

MESQUITA, Mário. A política econômica do governo Dilma: a volta ao experimentalismo.. In: MESQUITA, Mário. **Centro de Debates de Políticas Públicas. Sob a Luz do Sol, uma agenda para o Brasil**. São Paulo: CDPP, 2014. p. 3-15.

MENDOZA, Waldo; VEGA, Marco; ROJAS, Carlos; ANASTACIO, Yuliño. Fiscal Rules and Public Investment: the case of peru, 2000-2019. **Inter-American Development Bank**, [S.L.], v. -, n. -, p. 1-89, jan. 2021. Inter-American Development Bank. http://dx.doi.org/10.18235/0003018. Accessed on: https://publications.iadb.org/en/fiscal-rules-and-public-investment-case-peru-2000-2019. Available at: 10 out. 2022.

PRESCOTT, Edward C.. Theory ahead of business-cycle measurement. **Carnegie-Rochester Conference Series On Public Policy**, [S.L.], v. 25, p. 11-44, set. 1986. Elsevier BV. http://dx.doi.org/10.1016/0167-2231(86)90035-7.

RAMOS, Pedro Lutz; PORTUGAL, Marcelo Savino. Choques Antecipados de Política Monetária, Forward Guidance e Políticas Macroeconômicas de Estabilização. **Revista Brasileira de Economia**, [S.L.], v. 73, n. 2, p. 253-280, abr. 2019. GN1 Sistemas e Publicacoes Ltd.. http://dx.doi.org/10.5935/0034-7140.20190012.

RODRIGO, J.; SCHMIDT-HEBBEL, K.; SOTO, R. **Fiscal rule and public investment in Chile**. [S.l.], 2021. IDB Working Paper Series, No. IDB-WP-1189 Available at: https://www.econstor.eu/bitstream/10419/237477/1/IDB-WP-1189.pdf

SANTOS, A. S. dos. **Regras de política fiscal em um Modelo DSGE uma análise a partir da regra de gastos fixos e de superávit primário**. 2017. 71 f. Tese (Doutorado em Economia) — Universidade de Brasília, Brasília, 2017. Available at: http://repositorio2.unb.br/jspui/handle/10482/31044. Accessed on: 10 dez. 2022

SARGENT, T. J. **Dynamic macroeconomic theory**. [S.l.]: Harvard University Press, 2009.

SCHMITT-GROHÉ, Stephanie; URIBE, Martín. Closing small open economy models. **Journal Of International Economics**, [S.L.], v. 61, n. 1, p. 163-185, out. 2003. Elsevier BV. http://dx.doi.org/10.1016/s0022-1996(02)00056-9.

SMETS,F.; WOUTERS,R. An estimated dynamic stochastic general equilibrium model of the euro area. **Journal of the European economic association**, Oxford University Press, v. 1, n.5, p.1123-1175, 2003.

STOKEY, N. L. **Recursive methods in economic dynamics**. [S.l.]: Harvard University Press, 1989.

SUESCÚN, Rodrigo. **A Tool for Fiscal Policy Planning in a Medium-Term Fiscal Framework**: the fmm-mtff model. [S.L.]: Inter-American Development Bank, 2018. Inter-American Development Bank. http://dx.doi.org/10.18235/0001372. Available at: https://publications.iadb.org/en/publications/english/viewer/A-Tool-for-Fiscal-Policy-Planning-in-a-Medium-Term-Fiscal-Framework-The-FMM-MTFF-Model.pdf. Accessed on: 13 dez. 2023.

WALSH, C. E. **Monetary theory and policy**. [S.l.]: MIT Press, 2017.

APÊNDICE A – EQUILIBRIUM CONDITIONS

FIRST ORDER CONDITIONS

A.0.1 Households

The first-order conditions presented here closely follows García-Cicco e Kawamura (2015).

A.0.2 Ricardian Households

:

$$U^R_{c,t} = \lambda_t(1+\tau_c)$$

$$-U^R_{h,t} = \frac{\lambda_t}{p_t}(1-\tau_w)w_t$$

$$c^R_t - \varsigma\frac{(h^R_t)^{1+\upsilon}}{1+\upsilon}^{-\theta} = \lambda(1+\tau_c)$$

$$\frac{\lambda_t}{p_t} = \beta(1+r^*_t)E_t\left\{\frac{\lambda_{t+1}}{p_{t+1}}\right\}$$

$$\frac{\lambda_t}{p_t} = \beta(1+r^L_t)E_t\left\{\lambda_t\right\}$$

A.0.3 Non-Ricardian Households

:

$$-U^{NR}_{h,t} = \frac{U^{NR}_{c,t}}{p_t}(1-\tau_c)w_t$$

$$p_t c^{NR}_t = (1-\tau_w)w_t h^{NR}_t$$

A.0.4 Aggregate consumption

$$c_t = \left[\varphi^{1/\epsilon}(c^N_t)^{1-1/\epsilon} + (1-\varphi)^{1/\epsilon}(c^T_t)^{1-1/\epsilon}\right]^{\frac{\epsilon}{\epsilon-1}}$$

$$c^T_t = \left(\frac{c^X_t}{\chi}\right)^{\chi}\left(\frac{c^M_t}{1-\chi}\right)^{1-\chi}$$

$$c_t^N = \varphi \left(\frac{p_t}{p_t^N} \right)^{\epsilon} c_t$$

$$c_t^T = (1-\varphi) \left(\frac{p_t}{p_t^T} \right)^{\epsilon} c_t$$

$$c_t^X = \chi \left(\frac{p_t^T}{p_t^X} \right)^{\epsilon} c_t^T$$

$$c_t^M = (1-\chi) \left(p_t^T \right) c_t^T$$

A.0.5 Production of tradables

$$y_t^X = a_t^X (h_t^X)^{\alpha_X} (k_{t-1}^X)^{1-\alpha_X-\theta_X} (k_{t-1}^G)^{\theta_X}$$

$$w_t = \alpha_X (1-\tau_X) p_X \frac{y_t^X}{h_t^X}$$

$$u_t^X = (1-\tau_X) p_t^X (1-\alpha_X-\theta_X) \frac{y_t^X}{k_{t-1}^X}$$

A.0.6 Production of non-tradables

$$y_t^N = a_t^X (h_t^N)^{\alpha_N} (k_{t-1}^N)^{1-\alpha_N-\theta_N} (k_{t-1}^G)^{\theta_N}$$

$$w_t = \alpha_N (1-\tau_N) p_N \frac{y_t^N}{h_t^N}$$

$$u_t^N = (1-\tau_N) p_t^N (1-\alpha_N-\theta_N) \frac{y_t^N}{k_{t-1}^N}$$

A.0.7 Entrepreneurs

A.0.7.1 Exportable entrepreneurs

$$q_t^X k_t^X = n_t^X + p_t l_t^X$$

$$E_t\left\{\frac{u^X_{t+1}+(1+\delta)q^X_{t+1}}{q^X_t}\right\}=(1+r^L_t)rp\left(\frac{q^X_t k^X_t}{n^X_t lev}\right)^{\xi_X}$$

$$n^X_t=\vartheta\left\{\left[u^X_t+(1-\delta)q^X_t\right]k^X_{t-1}-p_t l^X_{t-1}(1+r^L_{t-1})\right\}+i^X$$

A.0.7.2 Non-tradable entrepreneurs

$$q^N_t k^N_t=n^N_t+p_t l^N_t$$

$$E_t\left\{\frac{u^N_{t+1}+(1+\delta)q^N_{t+1}}{q^N_t}\right\}=(1+r^L_t)rp\left(\frac{q^N_t k^N_t}{n^N_t lev}\right)^{\xi_N}$$

$$n^N_t=\vartheta\left\{\left[u^N_t+(1-\delta)q^N_t\right]k^N_{t-1}-p_t l^N_{t-1}(1+r^L_{t-1})\right\}+i^N$$

A.0.7.3 Capital and Investment

$$k^X_t=(1-\delta)k^X_{t-1}+\left[1-S_j\left(\frac{i^X_t}{i^X_{t-1}}\right)\right]i^X_t$$

$$p^I_t=q^X_t\left[1-S_X\left(\frac{i^X_t}{i^X_{t-1}}\right)-S'_X\left(\frac{i^X_t}{i^X_{t-1}}\right)\frac{i^X_t}{i^X_{t-1}}\right]+E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}q^X_{t+1}S'_X\left(\frac{i^X_{t+1}}{i^X_t}\right)\left(\frac{i^X_{t+1}}{i^X_t}\right)^2\right\}$$

$$k^N_t=(1-\delta)k^N_{t-1}+\left[1-S_j\left(\frac{i^N_t}{i^N_{t-1}}\right)\right]i^N_t$$

$$p^I_t=q^N_t\left[1-S_N\left(\frac{i^N_t}{i^N_{t-1}}\right)-S'_N\left(\frac{i^N_t}{i^N_{t-1}}\right)\frac{i^N_t}{i^N_{t-1}}\right]+E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}q^N_{t+1}S'_N\left(\frac{i^N_{t+1}}{i^N_t}\right)\left(\frac{i^N_{t+1}}{i^N_t}\right)^2\right\}$$

$$i_t=\left(\frac{x^N_t}{\gamma}\right)^{\gamma}\left(\frac{x^M_t}{1-\gamma}\right)^{1-\gamma}$$

$$x^N_t=\gamma\left(\frac{p^I_t}{p^N_t}\right)i_t$$

$$x^M_t=(1-\gamma)\left(p^I_t\right)i_t$$

A.0.8 Fiscal Policy

A.0.8.1 Fiscal Deficit Rule

$$fn = p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*} r_{t-1}^* + p_t d_{t-1}^G r_{t-1}^D - rev_t + \eta^r$$

$$d_t^{G*} = (1 - \phi^G) fn$$

$$p_t d_t^G = \phi_G fn$$

$$rev_t = \tau^c p_t c_t + \tau^w w_t \left((1-\kappa) h^R + \kappa h^{NR} \right) + \tau^X p_t^X y_t^X + \tau^N p_t^N y_t^N + \tau^{Co} p_t^{Co} y_t^{Co}$$

$$p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*} \left(r_{t-1}^* - 1 + \eta^R \right) + p_t d_{t-1}^G (r_{t-1}^D - 1 + \eta^R) = i_{ss}^{IG} gdp_m + rev_{ss} + (rev - rev_{ss})$$

$$k_t^G = (1 - \delta_G) k_{t-1}^G \left[\frac{\phi^G}{2} \left(\frac{i_t^G}{i_{t-1}^G} - 1 \right)^2 \right] i_t^G$$

$$x^{NG} = \gamma^g \left(\frac{p_{ig}}{p_t^N} \right) i_t^G$$

$$x^{MG} = (1 - \gamma^g) p_{ig} i_t^G$$

$$\frac{p_t^N g_t}{gdpm_{ss}} = i_{t,ss}^G$$

A.0.8.2 Structural Fiscal Deficit Rule

$$fn = p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*} r_{t-1}^* + p_t d_{t-1}^G r_{t-1}^D - rev_t + \eta^r$$

$$d_t^{G*} = (1 - \phi^G) fn$$

$$p_t d_t^G = \phi_G fn$$

$$rev_t = \tau^c p_t c_t + \tau^w w_t \left((1-\kappa) h^R + \kappa h^{NR} \right) + \tau^X p_t^X y_t^X + \tau^N p_t^N y_t^N + \tau^{Co} p_t^{Co} y_t^{Co}$$

$$p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*} \left(r_{t-1}^* - 1 + \eta^R \right) + p_t d_{t-1}^G (r_{t-1}^D - 1 + \eta^R) = i_{ss}^{IG} gdp_m + rev_{ss}$$

$$k_t^G = (1 - \delta_G) k_{t-1}^G \left[\frac{\phi^G}{2} \left(\frac{i_t^G}{i_{t-1}^G} - 1 \right)^2 \right] i_t^G$$

$$x^{NG} = \gamma^g \left(\frac{p_{ig}}{p_t^N} \right) i_t^G$$

$$x^{MG} = (1 - \gamma^g) p_{ig} i_t^G$$

$$\frac{p_t^N g_t}{gdpm_{ss}} = i_{t,ss}^G$$

A.0.8.3 **Current Deficit Rule**

$$fn = p_t^N g_t + p_t^{IG} i_t^G + d_{t-1}^{G*} r_{t-1}^* + p_t d_{t-1}^G r_{t-1}^D - rev_t + \eta_0^r$$

$$d_t^{G*} = (1 - \phi^G) fn$$

$$p_t d_t^G = \phi_G fn$$

$$rev_t = \tau^c p_t c_t + \tau^w w_t \left((1-\kappa) h^R + \kappa h^{NR} \right) + \tau^X p_t^X y_t^X + \tau^N p_t^N y_t^N + \tau^{Co} p_t^{Co} y_t^{Co}$$

$$rev_t - (p_t^N g_t d_{t-1}^{G*})(r_{t-1}^* - 1 + \eta^r) + (p_t d_{t-1}^G)(r_{t-1}^D - 1 + \eta^r) = g_t gdp_m$$

$$k_t^G = (1 - \delta_G) k_{t-1}^G \left[\frac{\phi^G}{2} \left(\frac{i_t^G}{i_{t-1}^G} - 1 \right)^2 \right] i_t^G$$

$$x^{NG} = \gamma^g \left(\frac{p_{ig}}{p_t^N} \right) i_t^G$$

$$x^{MG} = (1 - \gamma^g) p_{ig} i_t^G$$

$$\frac{p_t^N g_t}{gdpm_{ss}} = i_{t,ss}^G$$

A.0.9 Market clearing

$$h_t^X + h_t^N = (1-\kappa) h_t^R + \kappa h_t^R \tag{A.1}$$

$$c_t = (1-\kappa) c_t^R + \kappa c_t^{NR} \tag{A.2}$$

$$d_t^* = (1-\kappa) d_t^{R*} + d_t^{G*} \tag{A.3}$$

$$(1-\kappa) l_t^R = l_t^X + l_t^N \tag{A.4}$$

$$i_t = i_N + i_X \tag{A.5}$$

$$y_t^N = c_t^N + x_t^N + g_t + x_t^{NG} \tag{A.6}$$

$$imp_t = c_t^M + x_t^M + x_t^{MG} \tag{A.7}$$

$$exp_t = p_t^X (y_t^X - c_t^X) + p_t^{Co} y_t^{Co} \tag{A.8}$$

$$tb_t = exp_t - imp_t \tag{A.9}$$

$$p_t gdp_t = p_t^X y_t^X + p_t^N y_t^N + p_t^{Co} y_t^{Co} \tag{A.10}$$

$$rer_t = 1/p_t \tag{A.11}$$

$$d_{t-1}^* (1 + r_{t-1}^*) = d_t^* + tb_t \tag{A.12}$$

$$r_t^* = r_t^w + exp\left\{ \phi_W \left(\frac{\bar{d}_t^* - \bar{d}^*}{\bar{d}^*} \right) \right\} - 1 \tag{A.13}$$

$$r_t^D = r_t^L + exp\left\{\phi_W \left(\frac{\bar{d}_t^G - \bar{d}^G}{\bar{d}^G}\right)\right\} - 1 \tag{A.14}$$

$$gdp_t^m = p_t gdp_t \tag{A.15}$$

A.0.10 Exogenous process

Productivity of exportable sector:

$$a_t^X = (1 - \rho_a^X) log(a_{ss}^X) + \rho_a^X a_{t-1} + \varepsilon_{at}^X$$

Productivity of non-tradable sector:

$$a_t^N = (1 - \rho_a^N) log(a_{ss}^N) + \rho_a^N a_{t-1} + \varepsilon_{at}^N$$

Prices of exportable goods:

$$p_t^X = (1 - \rho_p^X) log(p_{ss}^X) + \rho_p^X p_{t-1} + \varepsilon_{pt}^X$$

Commodities production:

$$y_t^{Co} = (1 - \rho_y^{Co}) log(y_{ss}^{Co}) + \rho_y^{Co} y_{t-1} + \varepsilon_{yt}^{Co}$$

Commodities price:

$$p_t^C o = (1 - \rho_p^{Co}) log(p_{ss}^{Co}) + \rho_p^{Co} y_{t-1} + \varepsilon_{pt}^{Co}$$

Foreign interest rate:

$$r_t^W = (1 - \rho_r^W) log(r_{ss}^W) + \rho_r^W r_{t-1} + \varepsilon_{rt}^W$$

Public expenditures:

$$sh_t^G = (1 - \rho_{sh}^G) log(sh_{ss}^G) + \rho_{sh}^G sh_{t-1} + \varepsilon_{sh}^G$$

Stock-flow adjustments:

$$sf_t^A = (1 - \rho_{sf}^A) log(sf_{ss}^A) + \rho_{sf}^A sf_{t-1} + \varepsilon_{sf}^A$$

Public investment:

$$sh_t^{IG} = (1 - \rho_{sh}^{IG}) log(sh_{ss}^{IG}) + \rho_{sh}^{IG} sh_{t-1} + \varepsilon_{sh}^{IG}$$

A.1 PARAMETERS IN THE STEADY STATE

Let's demonstrate here the steady state of exogenously given parameters in the model to match: $s^{tb} = \frac{tb}{gdp^m}$, $s^{Co} = \frac{p^{Co}y^{Co}}{gdp^m}$, r^W, h^X, h^N and p^N. Since we do not exclude government purchases from the fiscal rules, we calibrate them as follows: $s^G = \frac{p^N g}{gdp^m}$.

$$p^I = (p^N)^\gamma, p^T = (p^x)^\chi, q^X = p^I, q^X = p^N$$

$$u^X = q^X\left[(1+r^L)rp - 1 + \delta\right], u^N = q^N\left[(1+r^L)rp - 1 + \delta\right]$$

$$k^N = \left[\frac{u^N}{p^N(1-\tau^N)}\right]h^N$$

$$y^N = a^N(h^N)^{\alpha_N}(k^N)^{1-\alpha_N}, w = p^N\alpha_N\frac{y^N}{h^N}$$

$$k^X = \left[\frac{w(1-\alpha_X-\theta_X)}{u^X\alpha^X}\right]h^N$$

$$a^X = \left(\frac{w}{p^X\alpha_X}\right)^{1-\theta_X}\left(\frac{h^X}{k^X}\right)^{1-\alpha_X}$$

$$y^X = (a^X)^{\frac{1}{1-\theta^X}}(h^X)^{\frac{\alpha_X}{1-\theta^X}}(k^X)^{1-\frac{\alpha_N}{\theta^X}}$$

$$i^X = \delta k^X, i^N = \delta k^N, i = i^X + i^N, x^N = \gamma\left(\frac{p^I}{p^N}\right)i, x^M = (1-\gamma)(p^I)i$$

$$c^N = y^N - x^N - g - x^{NG}$$

$$c^M = (1-\chi)(p^X y^X + p^{Co}y^{Co} - x^M - tb), c^X = \frac{\chi}{(1-\chi)}\frac{c^M}{p^X}, p = p^N\left(\frac{c^N}{\varphi^c}\right)^{\frac{1}{\epsilon}}$$

$$\varphi = \left[1 + \left(\frac{p^T}{p^N}\right)^\epsilon\frac{c^T}{c^N}\right]^{-1},$$

$$c = \left[\varphi^{1/\epsilon}(c^N)^{1-1/\epsilon} + (1-\varphi)(c^T)^{1-1/\epsilon}\right]^{\frac{\epsilon}{\epsilon-1}}$$

$$p = p^N\left(\frac{c^N}{\varphi^c}\right)^{1/\epsilon}$$

$$gdp = \frac{gdp_m}{p}, \bar{d} = \frac{tb}{r^* - 1}$$

$$n^X = \frac{q^X k^X}{lev}, n^N = \frac{q^N k^N}{lev}, l^X = \frac{q^X k^X - n^X}{p}, l^N = \frac{q^N k^N - n^N}{p}$$

$$\iota^X = n^X - \vartheta\left\{\left[u^X + (1-\delta)q^X\right]k^X - pl^X(1+r^L)\right\}$$

$$\iota^N = n^N - \vartheta\left\{\left[u^N + (1-\delta)q^N\right]k^N - pl^N(1+r^L)\right\}$$

For the following parameters determined endogenously in the model $\beta, \varsigma, \varphi$ and λ.

$$\beta = (1 + r^{W})^{-1}, r^{*} = r^{W}, r^{L} = r^{*}$$

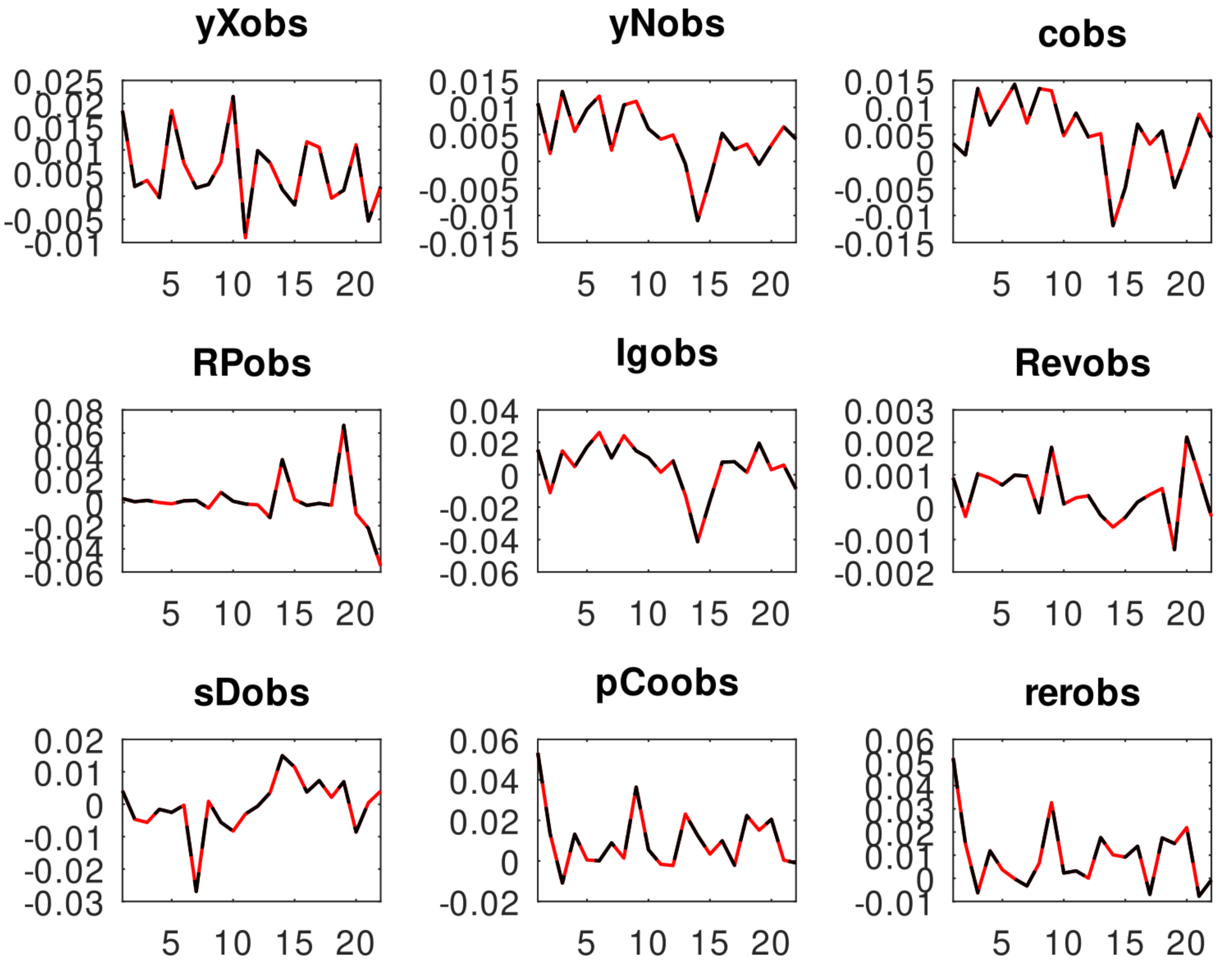
$$\varsigma = \frac{(1-\tau^{W})}{(1-\tau^{c})} \frac{w}{p} \frac{1}{(h^{NR})^{\upsilon}}$$

$$\varphi = 1 + \left[\left(\frac{p^{T}}{p^{N}} \right)^{\epsilon} \frac{c^{T}}{c^{N}} \right]^{-1}$$

$$\lambda_{ss} = \left(c^{R} - \varsigma (h^{R})^{\frac{(1+\upsilon)}{(1+\upsilon)}} \right)^{\frac{-\theta}{1+\tau^{C}}}$$

APÊNDICE B – OBSERVABLE DATA, *PRIORIES*, *POSTERIORS* AND CONVERGENCE DIAGNOSTICS

Figura 5 – Observable data series - after transformation, Source: BCB, National Treasurie and IBGE. Data prepared by the author



Source: Own Elaboration.

Tabela 4 – Estimated parameters for *Fiscal Deficit Rule*

Parameter	Description	Distribution	Mean *à priori*	SD *à priori*	Mean *à posteriori*	90 % Conf. Interval
θ	Risk aversion	Normal	1.3000	0.0500	1.3000	1.3000
ϵ	Elasticity of substitution between tradable and non-tradable sectors	Beta	0.7500	0.0500	0.7314	0.6459-0.8202
ξ^X	Elasticity of the risk premium in the tradable sector	Gamma	1.5000	0.0250	1.4869	1.4472-1.5273
ξ^N	Elasticity of the risk premium in the non-tradable sector	Gamma	1.5000	0.0250	1.4906	1.4510-1.5327
ρ_{aX}	Tradable sector productivity	Beta	0.5000	0.2000	0.6786	0.3837-0.8989
ρ_{aN}	Non-tradable sector productivity	Beta	0.5000	0.2000	0.3813	0.0973-0.6529
ρ_{pX}	Tradable sector price	Beta	0.5000	0.2000	0.4576	0.1501-07393
ρ_{yCo}	Commodity sector production	Beta	0.5000	0.2000	0.4688	0.1307-0.7663
ρ_{pCo}	Commodity sector prices	Beta	0.5000	0.2000	0.4766	0.1487-0.7930
ρ_{rW}	Foreign interest rate	Beta	0.5000	0.2000	0.1790	0.0373-0.3100
ρ_{sf^A}	Stock-flow adjustment	Beta	0.5000	0.2000	0.3452	0.0873-0.5901
ρ_g	Current expenditures	Beta	0.5000	0.2000	0.2634	0.0470-0.4602
ρ_{ig}	Public investment	Beta	0.5000	0.2000	0.3853	0.1491-0.6296
ε_{aX}	Tradable sector productivity	Inv-gamma	1.0000	inf	0.1694	0.1287-0.2072
ε_{aN}	Non-tradable sector productivity	Inv-gamma	1.0000	inf	0.1831	0.1379-0.2243
ε_{pX}	Commodity sector production	Inv-gamma	1.0000	inf	0.1717	0.1304-0.2088
$\varepsilon_{y_{co}}$	Commodity sector production	Inv-gamma	1.0000	inf	0.1789	0.1371-0.2221
$\varepsilon_{p_{Co}}$	Commodity sector prices	Inv-gamma	1.0000	inf	0.1685	0.1282-0.2060

Continued on next page

Tabela 4 – continued from previous page

Parameter	Description	Distribution	Mean *à priori*	SD *à priori*	Mean *à posteriori*	90 % Conf. Interval
ε_{r_W}	Foreign interest rate	Inv-gamma	1.0000	inf	0.1708	0.1310-0.2094
ε_{sf_A}	Stock-flow adjustments	Inv-gamma	1.0000	inf	0.1685	0.1284-0.2057
ε_{g}	Current Expenditures	Inv-gamma	1.0000	inf	0.3137	0.2335-0.3875
ε_{ig}	Public investment	Inv-gamma	1.0000	inf	2.8539	2.0838-3.6192

Source: Own Elaboration.

Tabela 5 – Estimated parameters for ***Structural Deficit Rule***

Parameter	Description	Distribution	Mean *à priori*	SD *à priori*	Mean *à posteriori*	90 % Conf. Interval
θ	Risk aversion	Normal	1.3000	0.0500	1.3000	1.3000
ϵ	Elasticity of substitution between tradable and non-tradable sectors	Beta	0.7500	0.0500	0.7552	0.6750-0.8329
ξ^X	Elasticity of the risk premium in the tradable sector	Gamma	1.5000	0.0250	1.4981	1.4586-1.5321
ξ^N	Elasticity of the risk premium in the non-tradable sector	Gamma	1.5000	0.0250	1.4846	1.4550-1.5190
ρ_{aX}	Tradable sector productivity	Beta	0.5000	0.2000	0.5239	0.1359-0.8619
ρ_{aN}	Non-tradable sector productivity	Beta	0.5000	0.2000	0.5864	0.2585-0.8723
ρ_{pX}	Tradable sector price	Beta	0.5000	0.2000	0.4221	0.1077-0.7348
ρ_{yCo}	Commodity sector production	Beta	0.5000	0.2000	0.6260	0.3310-0.9987
ρ_{pCo}	Commodity sector prices	Beta	0.5000	0.2000	0.4320	0.1607-0.7082
ρ_{rW}	Foreign interest rate	Beta	0.5000	0.2000	0.2589	0.0361-0.4546
ρ_{sf^A}	Stock-flow adjustment	Beta	0.5000	0.2000	0.3020	0.0606-0.5417
ρ_g	Current expenditures	Beta	0.5000	0.2000	0.3193	0.0708-0.5516
ρ_{ig}	Public investment	Beta	0.5000	0.2000	0.3504	0.0961-0.5778
ε_{aX}	Tradable sector productivity	Inv-gamma	1.0000	inf	0.1718	0.1292-0.2104
ε_{aN}	Non-tradable sector productivity	Inv-gamma	1.0000	inf	0.1909	0.1428-0.2355
ε_{pX}	Commodity sector production	Inv-gamma	1.0000	inf	0.1718	0.1322-0.2123
ε_{yCo}	Commodity sector production	Inv-gamma	1.0000	inf	0.1837	0.1389-0.2262
$\varepsilon_{p_{Co}}$	Commodity sector prices	Inv-gamma	1.0000	inf	0.1694	0.1263-0.2059

Continued on next page

Tabela 5 – continued from previous page

Parameter	Description	Distribution	Mean *à priori*	SD *à priori*	Mean *à posteriori*	90 % Conf. Interval
ε_{r_W}	Foreign interest rate	Inv-gamma	1.0000	inf	0.1713	0.1307-0.2102
ε_{sf_A}	Stock-flow adjustments	Inv-gamma	1.0000	inf	0.1700	0.1294-0.2102
ε_{g}	Current Expenditures	Inv-gamma	1.0000	inf	0.3144	0.2318-0.3880
ε_{ig}	Public investment	Inv-gamma	1.0000	inf	4.3253	2.9588-5.8601

Source: Own Elaboration.

Tabela 6 – Estimated parameters for *Current Deficit Rule*

Parameter	Description	Distribution	Mean *à priori*	SD *à priori*	Mean *à posteriori*	90 % Conf. Interval
θ	Risk aversion	Normal	1.3000	0.0500	1.3000	1.3000
ϵ	Elasticity of substitution between tradable and non-tradable sectors	Beta	0.7500	0.0500	0.7555	0.6948-0.8183
ξ^X	Elasticity of the risk premium in the tradable sector	Gamma	1.5000	0.0250	1.4882	1.4483-1.5225
ξ^N	Elasticity of the risk premium in the non-tradable sector	Gamma	1.5000	0.0250	1.4966	1.4555-1.5382
ρ_{aX}	Tradable sector productivity	Beta	0.5000	0.2000	0.5526	0.1586-0.8359
ρ_{aN}	Non-tradable sector productivity	Beta	0.5000	0.2000	0.3793	0.1140-0.6354
ρ_{pX}	Tradable sector price	Beta	0.5000	0.2000	0.4559	0.1542-0.7349
ρ_{yCo}	Commodity sector production	Beta	0.5000	0.2000	0.3936	0.1019-0.7248
ρ_{pCo}	Commodity sector prices	Beta	0.5000	0.2000	0.4841	0.1910-0.7402
ρ_{rW}	Foreign interest rate	Beta	0.5000	0.2000	0.1540	0.0327-0.2788
ρ_{sf^A}	Stock-flow adjustment	Beta	0.5000	0.2000	0.2804	0.0537-0.5400
ρ_g	Current expenditures	Beta	0.5000	0.2000	0.3372	0.0974-0.5655
ρ_{ig}	Public investment	Beta	0.5000	0.2000	0.4657	0.2173-0.7261
ε_{aX}	Tradable sector productivity	Inv-gamma	1.0000	inf	0.1960	0.1288-0.2065
ε_{aN}	Non-tradable sector productivity	Inv-gamma	1.0000	inf	0.1833	0.1402-0.2270
ε_{pX}	Tradable sector prices	Inv-gamma	1.0000	inf	0.1730	0.1306-0.2107
$\varepsilon_{y_{Co}}$	Commodity sector production	Inv-gamma	1.0000	inf	0.1797	0.1365-0.2217
$\varepsilon_{p_{Co}}$	Commodity sector prices	Inv-gamma	1.0000	inf	0.1688	0.1303-0.2083

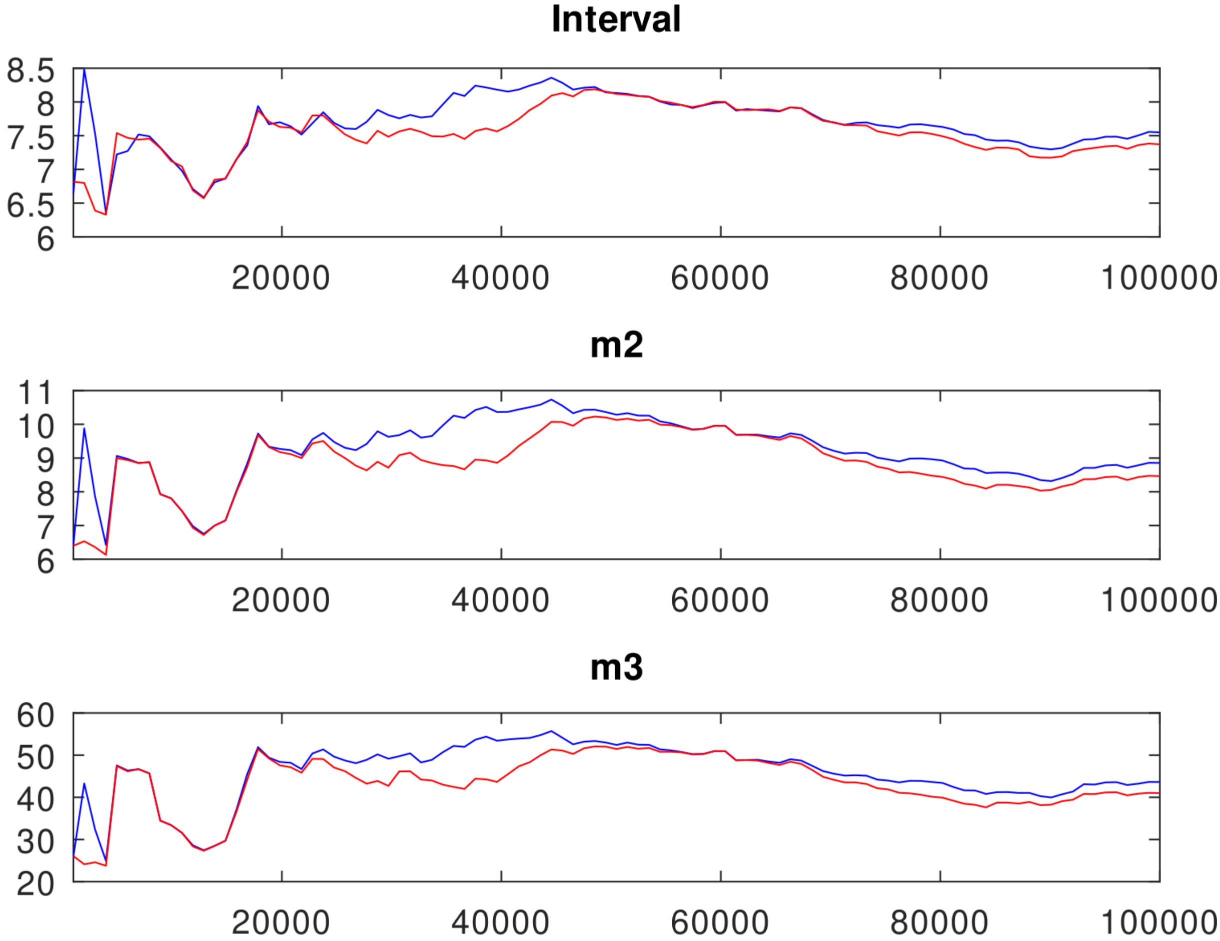
Continued on next page

Tabela 6 – continued from previous page

Parameter	Description	Distribution	Mean *à priori*	SD *à priori*	Mean *à posteriori*	90 % Conf. Interval
ε_{r_W}	Foreign interest rate	Inv-gamma	1.0000	inf	0.1737	0.1318-0.2127
ε_{sf_A}	Stock-flow adjustments	Inv-gamma	1.0000	inf	0.1691	0.1288-0.2070
ε_{g}	Current Expenditures	Inv-gamma	1.0000	inf	0.9000	0.6495-1.1438
ε_{ig}	Public investment	Inv-gamma	1.0000	inf	0.3509	0.2629-0.4320

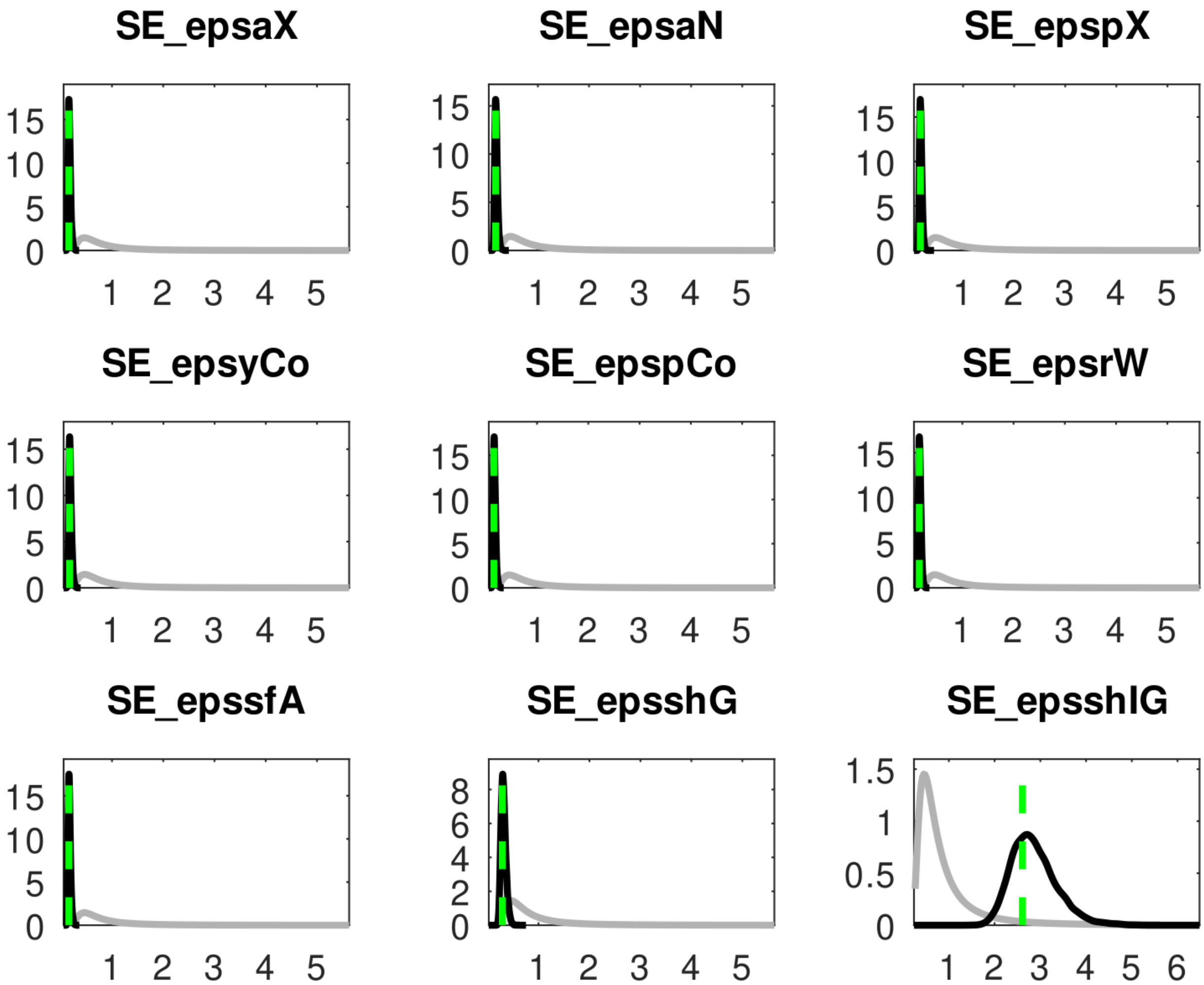
Source: Own Elaboration.

Figura 6 – FDR - Convergence diagnostics



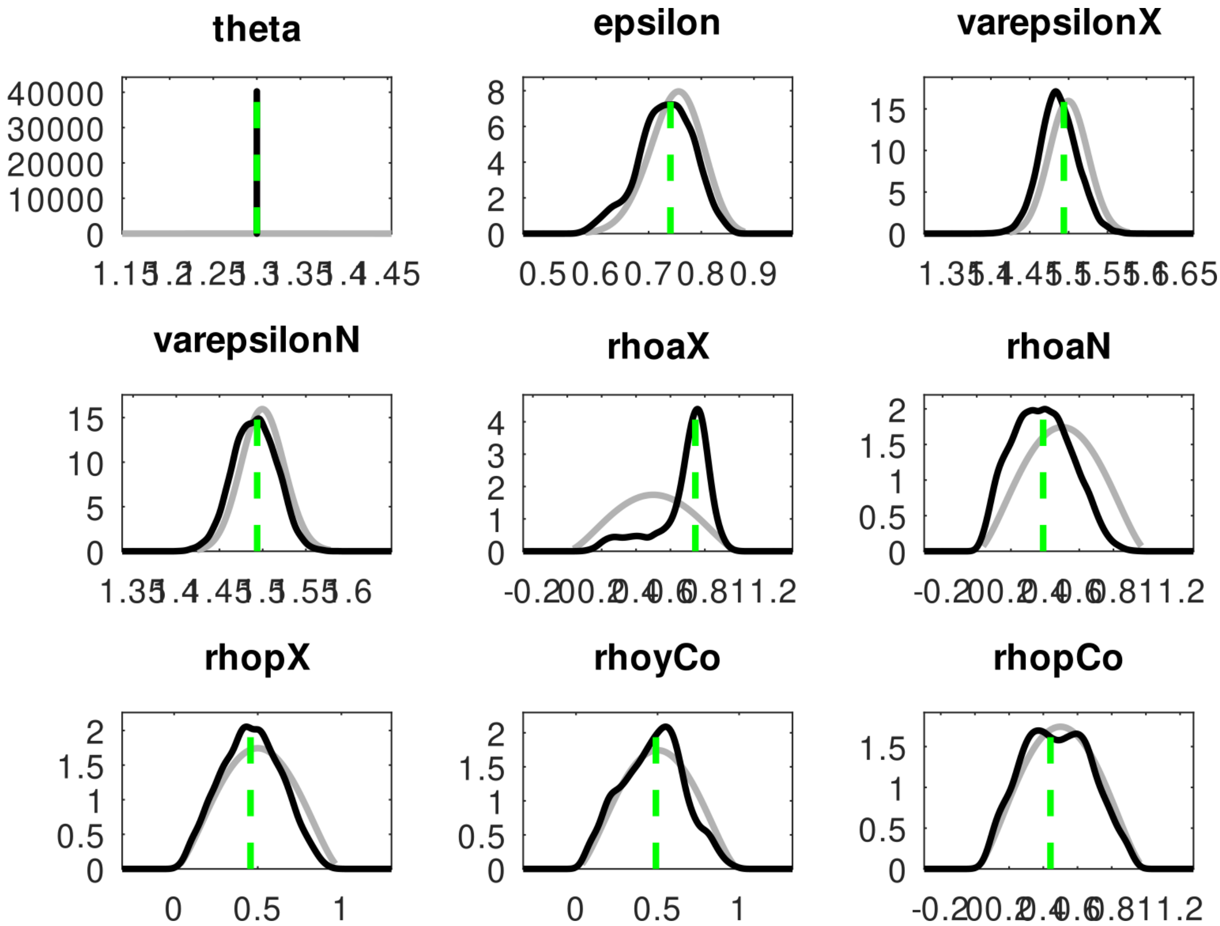
Source: Own Elaboration

Figura 7 – FDR - Priors and posteriors of the parameters



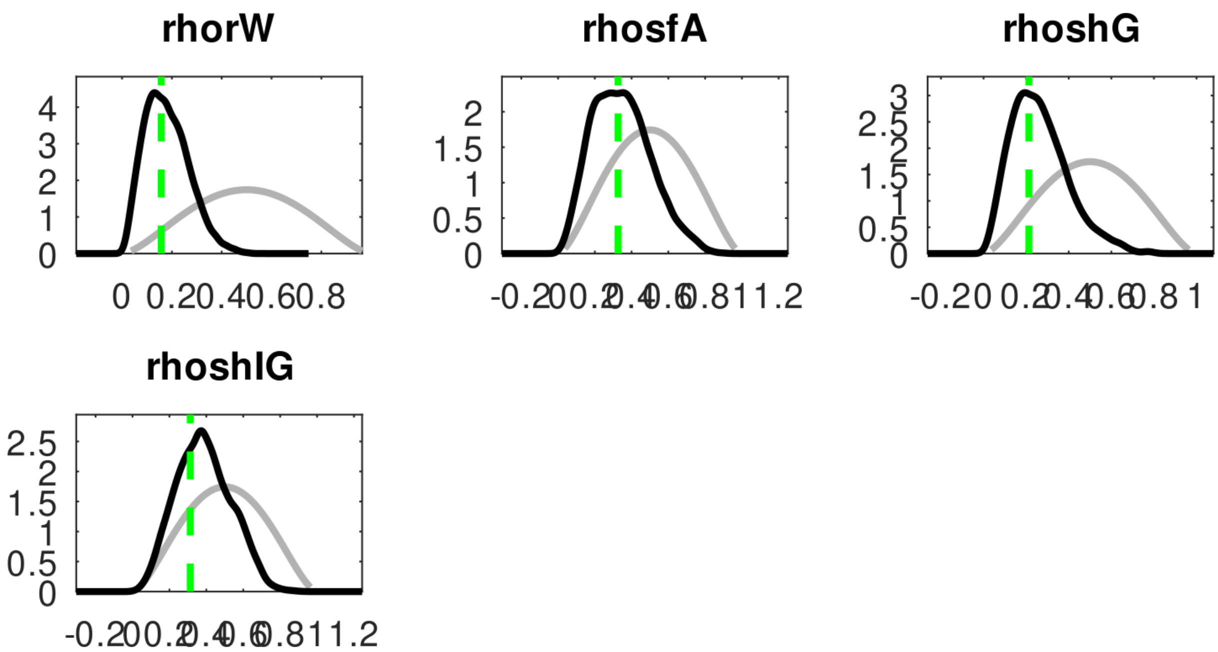
Source: Own Elaboration

Figura 8 – FDR - Priors and posteriors of the parameters (continued)



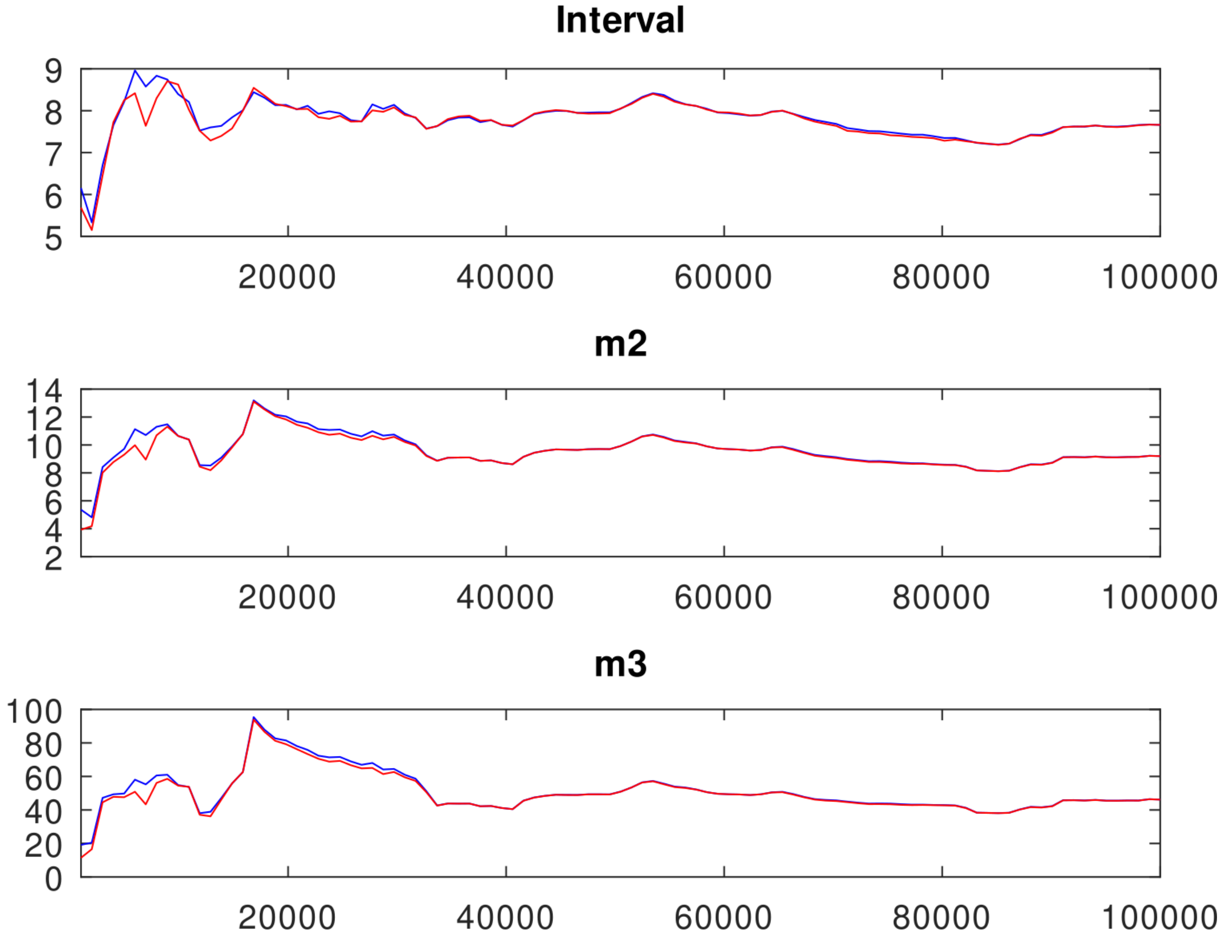
Source: Own Elaboration

Figura 9 – FDR - Priors and posteriors of the parameters (continued)



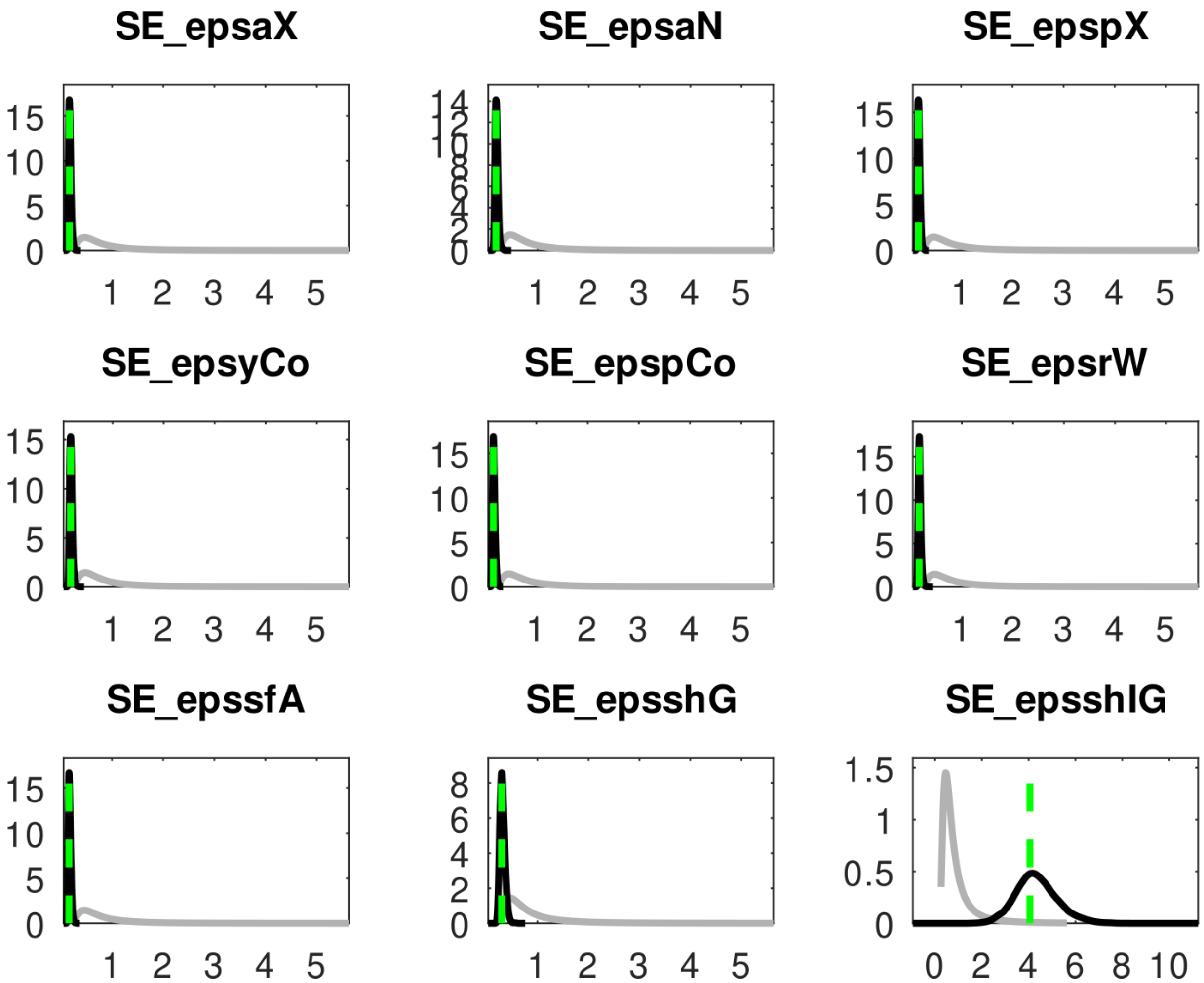
Source: Own Elaboration

Figura 10 – SFDR - Convergence diagnostics



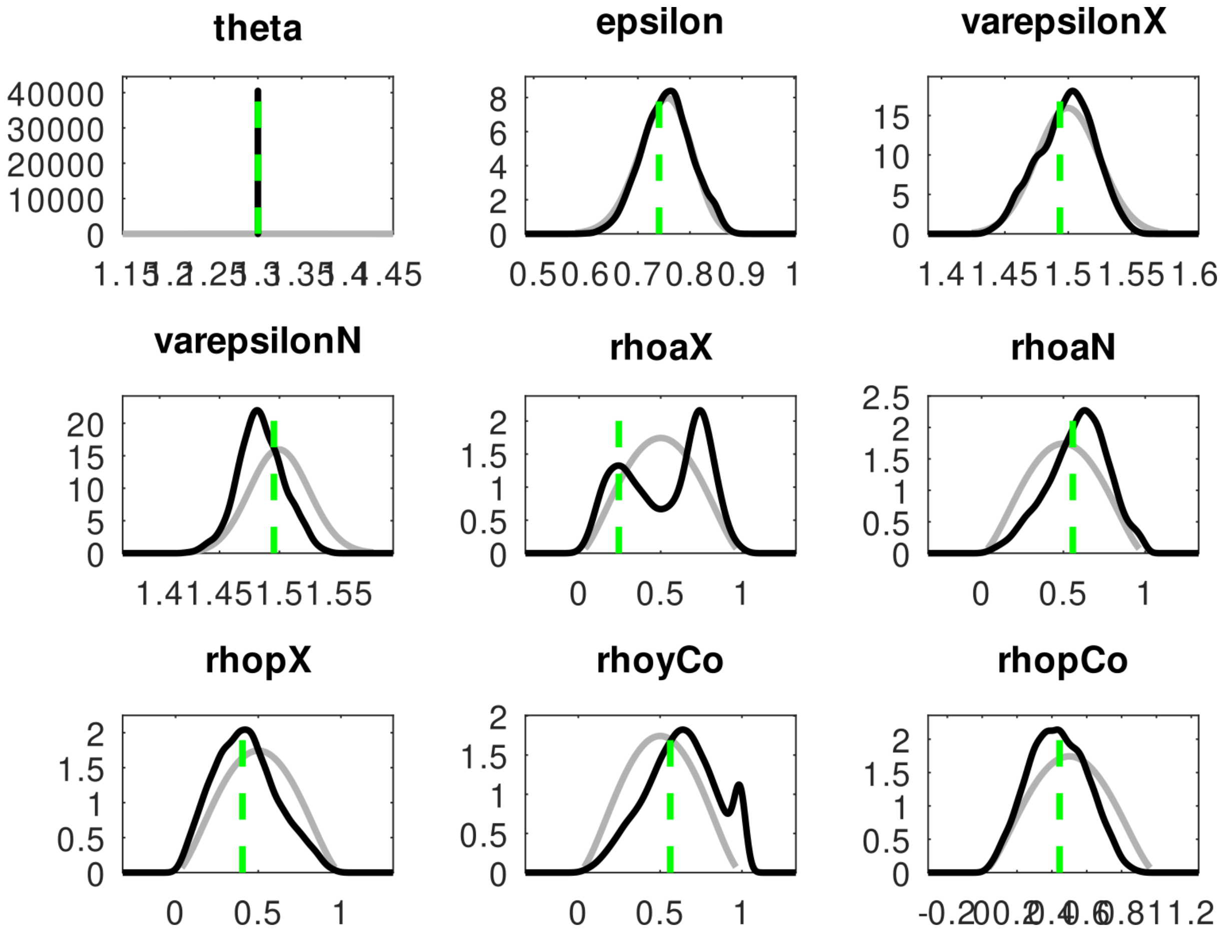
Source: Own Elaboration

Figura 11 – SFDR - Priors and posteriors of the parameters



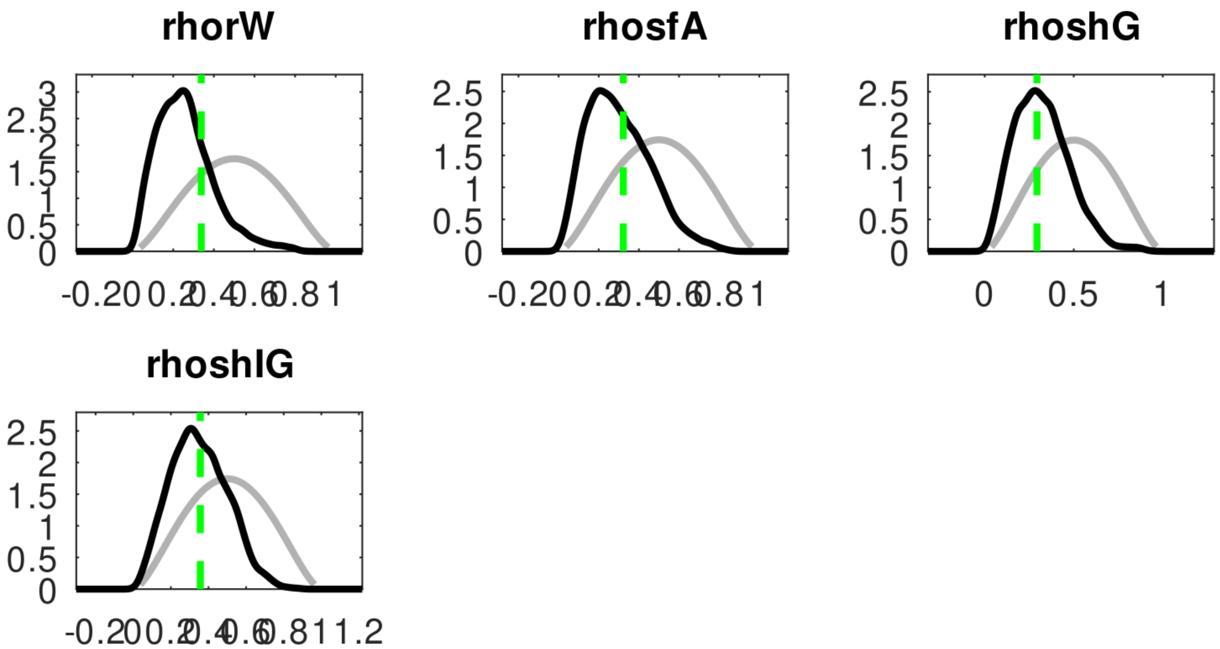
Source: Own Elaboration

Figura 12 – SFDR - Priors and posteriors of the parameters (continued)



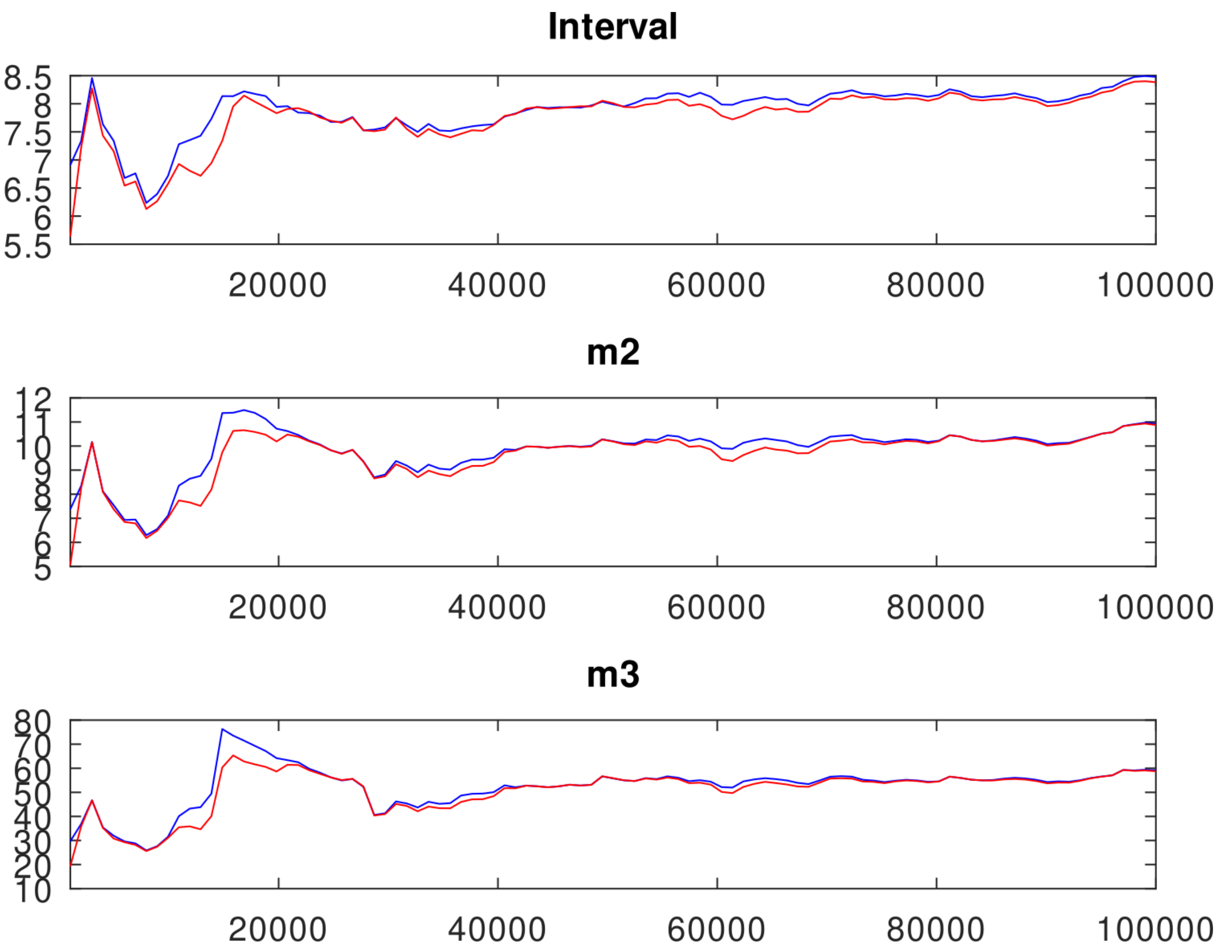
Source: Own Elaboration

Figura 13 – SFDR - Priors and posteriors of the parameters (continued)



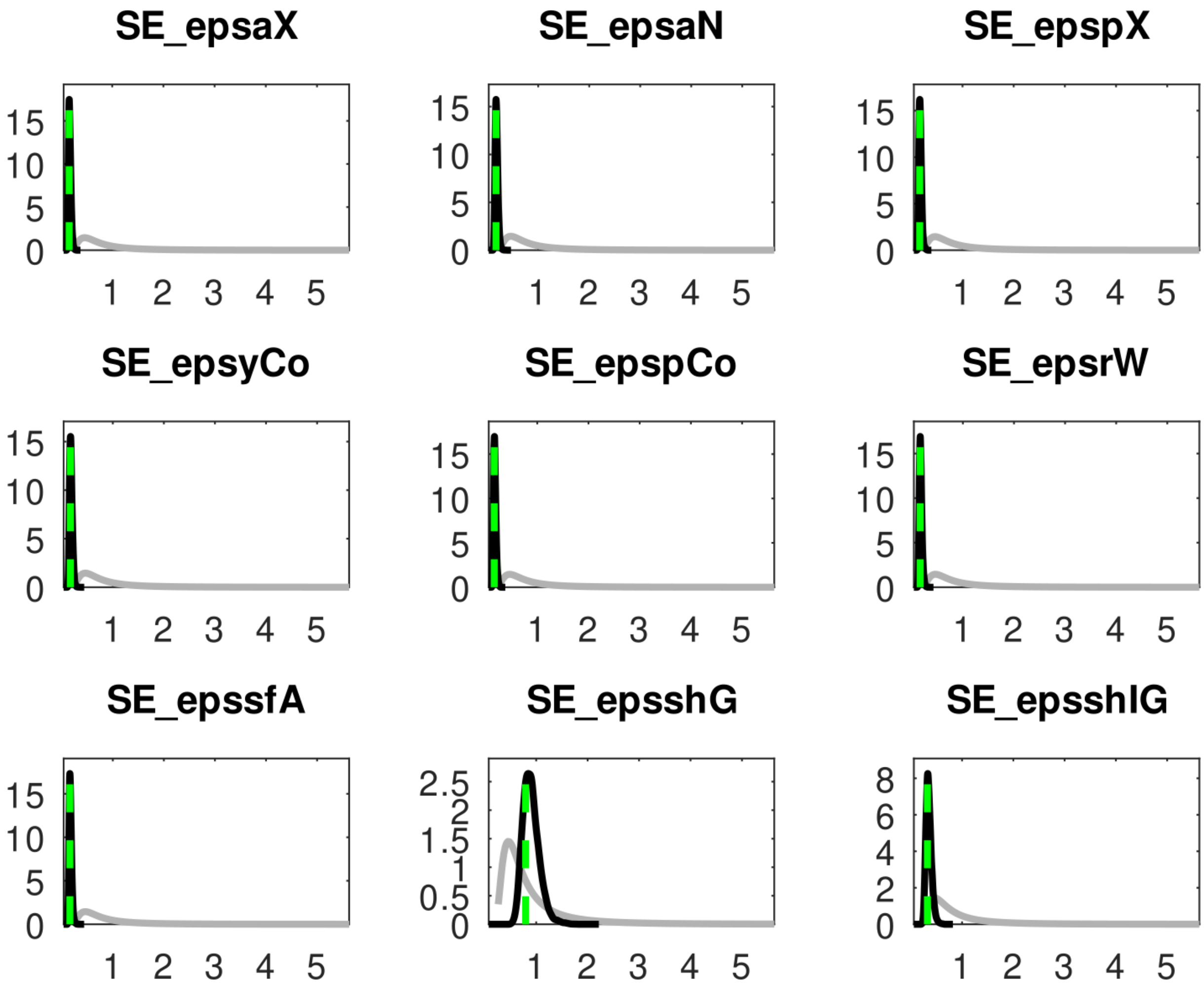
Source: Own Elaboration

Figura 14 – CDR - Convergence diagnostics



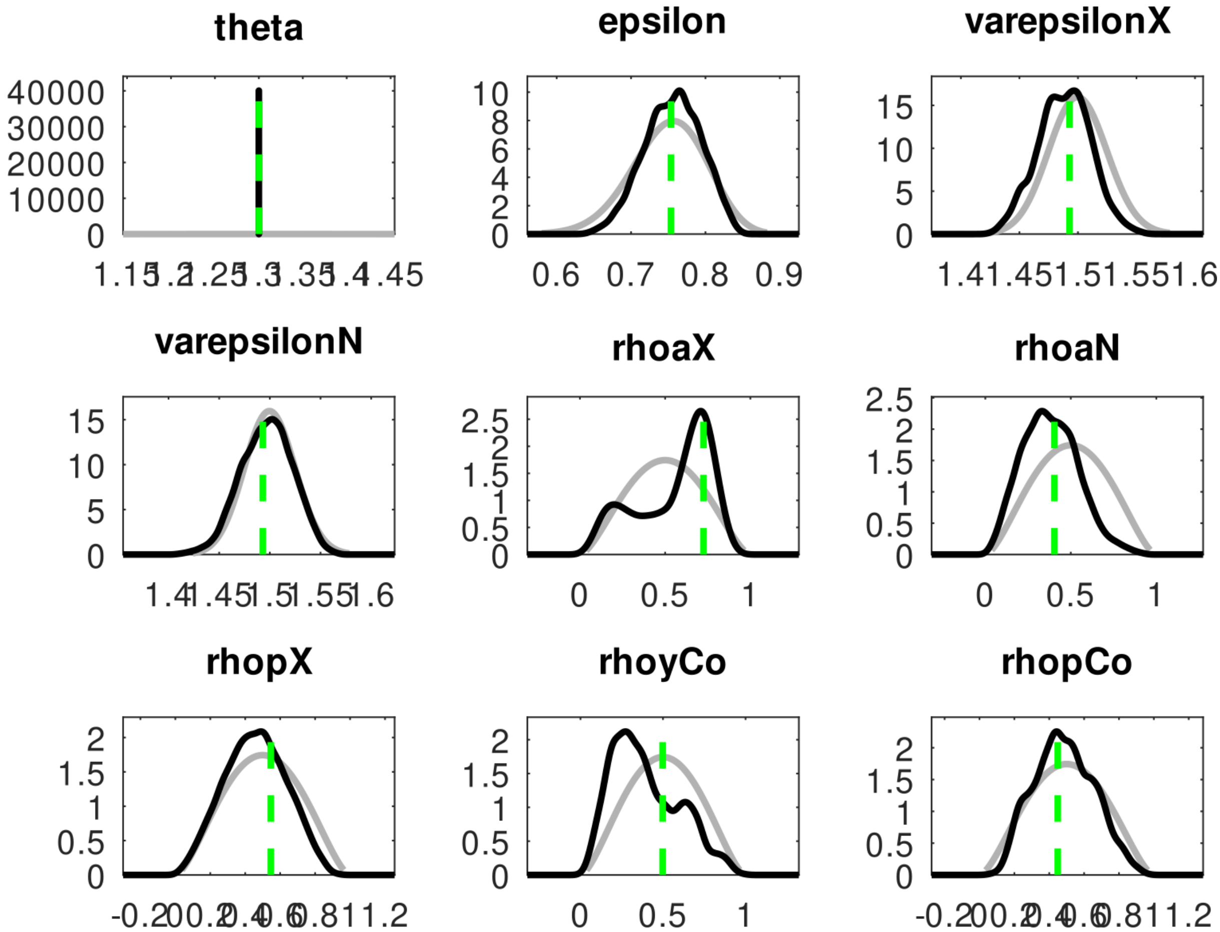
Source: Own Elaboration

Figura 15 – CDR - Priors and posteriors of the parameters



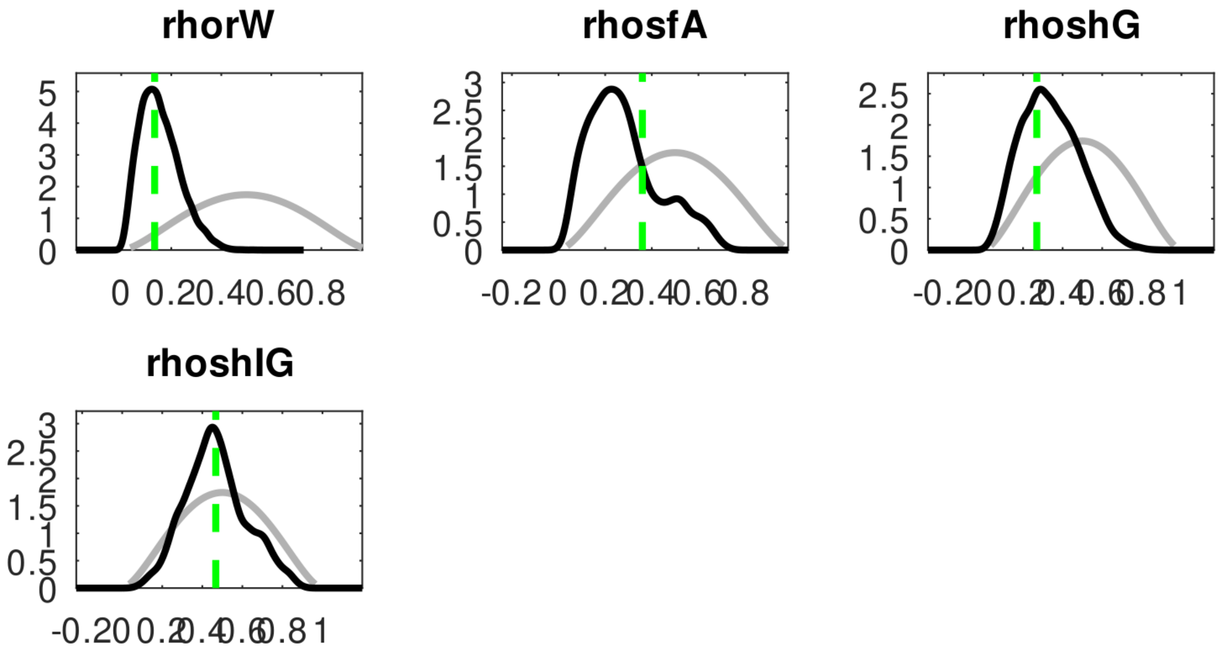
Source: Own Elaboration

Figura 16 – CDR - Priors and posteriors of the parameters (continued)



Source: Own Elaboration

Figura 17 – CDR - Priors and posteriors of the parameters (continued)



Source: Own Elaboration