ACTIVE AND PASSIVE FISCAL AND MONETARY POLICIES: AN ANALYSIS FOR BRAZIL AFTER THE INFLATION TARGETING REGIME

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RESUMO: Este trabalho busca identificar se a condução das políticas macroeconômicas, fiscal e monetária, no Brasil para o período pós-metas de inflação ocorreu de maneira ativa e/ou passiva. Para isso, foi estimado, pelo método Bayesiano, um modelo DSGE com rigidez de preços e concorrência monopolística, em que o superávit primário e a taxa de juros nominal são os instrumentos de política econômica disponíveis. A falta de coordenação dessas políticas no Brasil, freqüentemente, tem sido apontada como motivo para os desequilíbrios macroeconômicos, de modo que diversos autores apontaram a política fiscal ativa como fator restritivo ao desempenho eficiente da política monetária. Contudo, a análise dessas relações dentro do arcabouço dos modelos DSGE ainda é restrita, principalmente em aplicações para a economia brasileira. As estimações do modelo apontaram para um regime em que ambas as políticas foram ativas durante o período de 2000I a 2002IV, enquanto que para o período posterior, 2003I a 2008IV, a política fiscal comportou-se de maneira passiva e a política monetária foi ativa.

Palavras-chave: Política Fiscal, Política Monetária, Modelos DSGE, Métodos Bayesianos.

JEL classification: E62, E63, H62.

ABSTRACT: This paper seeks to identify whether fiscal and monetary macroeconomic policies in Brazil were active and/or passive after the inflation targeting regime. To achieve that, we used the Bayesian method to estimate a DSGE model with price rigidity and monopolistic competition, in which the primary surplus and the nominal interest rates are the available economic policy tools. The lack of coordination between these policies in Brazil usually has been identified as the reason for macroeconomic imbalance. Therefore, many authors have pointed out active fiscal policy as a limiting factor for an efficient performance of the monetary policy. However, the analysis of such relations within the framework of DSGE models is still limited, especially in applications to the Brazilian economy. The estimates demonstrated a system where both policies were active during the 2000/1Q-2002/4Q period. On the other hand, in the 2003/1Q-2008/4Q period, fiscal policy exhibited a passive behavior whereas monetary policy was active.

Keywords: Fiscal policy, monetary policy, dynamic stochastic general equilibrium (DSGE) models, Bayesian methods.

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1. Introduction

The coordination between fiscal and monetary policies has been relegated to the bottom of the macroeconomic agenda for too long. Both monetarists, who suggest minor government intervention and who are against discretionary economic policies, and Keynesians, who cling more fondly to interventions and seek to establish optimal rules for monetary and fiscal policies, have tended to dissociate the debate between fiscal and monetary policies. This way, the studies on the conduct of monetary policy were more limited to rules versus discretionary behavior, laying aside the possible influences that fiscal policy could exert on price determination.

Fiscal policy played a less significant role, the monetarist models assumed the existence of a Ricardian regime, in which the government budget was always in balance, prone only to cyclic variations. Any outstanding debt would be corrected through taxes or inflation tax with no influence whatsoever on agents' decisions. With this underlying assumption, the fiscal authority is well-behaved, and cuts in government taxes financed by rises in the level of indebtedness would be compensated for by an increase in taxation in the future in order to guarantee debt solvency. In this context, the debate over the coordination between the fiscal and monetary policies turned out to be pointless.

Sargent and Wallace (1981) blazed a trail in the modern macroeconomic theory by approaching the role of coordination between fiscal and monetary policies for price level determination. To achieve that, they explored the idea that the fiscal authority (government) must stick to an intertemporal budget constraint. In short, they establish that the value of government debt is equal to the present discounted value of future surpluses. One of the ways to produce surplus is by increasing seigniorage revenues, and for that reason fiscal deficits are related to monetary growth rate and to inflation rate. If the fiscal authority, by means of tax revenue, does not keep the intertemporal budget at a balance, the monetary authority will likely be coerced to generate enough seigniorage to meet the intertemporal budget constraint. In this situation, fiscal policy actions dominate monetary policy, leading to what Sargent and Wallace (1981) called fiscal dominance.

Later on, Leeper (1991) classified fiscal and monetary policies as active and/or passive according to their behavior. An authority that uses an active policy has autonomy to establish her policy without considering the behavior of current and past variables controlled by the passive authority. Conversely, if the authority uses a passive policy, it will be limited to optimization decisions made by consumers and by the active authority's actions.

More recently, Woodford (1995) proposed another way whereby fiscal policy can interfere with price level determination, known as the Fiscal Theory of the Price Level (FTPL). The FTPL adds to the theory developed by Leeper (1991) and differs from the theory put forward by Sargent and Wallace (1981) by assuming that the government budget constraint equation represents an equilibrium condition. If the constraint is violated for a given price level, then such level is not consistent with an equilibrium. As a result, Woodford (1995) classified fiscal policy as Ricardian when the fiscal authority acts judiciously and the debt does not prevent the conduct of monetary policy from attaining the inflation target. On the other hand, a non-Ricardian regime occurs when the risk of fiscal insolvency requires that the monetary authority cause inflationary "surprise" to deflate the nominal value of the government debt. This strand of literature includes the models developed by Leeper (2002 and 2005), Sims (1994), Woodford (1996, 2001 e 2003) and Bohn (1998), in addition to the works by Christiano and Fitzgerald (2000) and Calrstorm and Fuerst (1999), who presented a summary of theoretical models.

In fact, one should note that in countries which use the inflation targeting regime and which do not have serious fiscal problems, such as the United Kingdom, Canada and New Zealand, monetary policy can be conducted by using only one rule, as the Taylor (1993) rule, without taking into account the performance of any fiscal variable. Therefore, the conduct of fiscal policy does not have a remarkable impact on the results of monetary policy since economic agents believe, with a high degree of certainty, in debt solvency.

Nevertheless, this does not seem to be the case in some emerging countries, particularly in Brazil. In the Brazilian case, the interest rate at levels that far exceed economic growth rates brought about successive nominal deficits, rising the debt/GDP ratio. As a matter of fact, in different moments in history, even debt solvency has been questioned. This way, the lack of coordination between monetary and fiscal policies should be regarded as a factor that can trigger or aggravate economic instability.

In this scenario, inconsistency between fiscal and monetary policies may be one of the possible explanations to the systematic domestic and/or foreign macroeconomic disequilibria Brazilian economy has been put through in the last 30 years, especially after the oil price shock in the 1970s. The price and output stabilization policies often caused imbalance in domestic and foreign debts. More recently, after the implementation of the Real Plan, both monetary policy and the increase in Brazilian public debts have been hotly debated in the academic milieu and by policymakers. Monetary policy was successful in curbing inflation, despite some shortcomings, whereas Brazilian public debts sharply increased, chiefly in 1998/1999 and 2002/2003, when their sustainability was called into question.

The purpose of this paper is to check whether Brazil was under fiscal or monetary dominance in the period that followed the inflation targeting regime, given the framework of dynamic stochastic general equilibrium (DSGE) models, thus contributing towards the discussion about the need of coordination between monetary and fiscal policies. This is a timely topic, as in the analyzed period, issues such as public debt sustainability, high interest rates and inflation control were the subject of debate about macroeconomic policy.

To do that, we estimate a DSGE model based on Woodford (2003), with two market imperfections – price rigidity and monopolistic competition, for the Brazilian economy. The model consists of an aggregate demand block represented by a dynamic IS curve and the government budget constraint, the aggregate demand block with a new Keynesian Phillips curve, and a block with the reaction functions of fiscal and monetary authorities.

Based on the analysis of the reaction function parameters of the fiscal and monetary authorities, we will determine in which period the policies were active or passive. If the fiscal authority generates a more than proportionate increase in the primary surplus to GDP ratio in relation to the increase in the debt to GDP ratio, fiscal policy is regarded as passive, otherwise, it is considered to be active. In the case of monetary policy, it is classified as active when there is an increase in the nominal interest rate that is more than proportionate to the rise in above-target inflation rate. To implement this exercise, the DSGE model was estimated for six different periods: 2000I-2003IV, 2001I-2004IV, 2002I-2005IV, 2003I-2006IV, 2004I-2007IV and 2005I-2008IV.

A Bayesian estimation method was used. This method seems to be the most suitable because it allows estimating the whole DSGE system. In addition, the inclusion of priors aids in the identification of parameters, avoiding the use of parameters whose values differ from those suggested by the theory, as likelihood function maximization is restricted to only a subspace of the parametric space.

The paper is organized as follows. Section 1 presents a literature review on the coordination between fiscal and monetary policies, as well as on the results outlined in the empirical literature applied to Brazil after the Real Plan. Section 2 discusses the application of the DSGE models to the analysis of the coordination between fiscal and monetary policies. Section 3 presents the empirical results. Section 4 concludes.

2. Evidence of passive and active fiscal and monetary policies for Brazil

Inconsistency between fiscal and monetary policies can be one of the possible explanations to the systematic domestic and/or foreign macroeconomic disequilibria the Brazilian economy has been put through in the last 30 years, especially after the oil price shock in the 1970s. The price and output stabilization policies often caused imbalance in domestic and foreign debts. More recently, after the implementation of the Real Plan, both monetary policy and the increase in Brazilian public debts have been hotly debated in the academic milieu and by policymakers. Monetary policy was successful in curbing inflation, despite some shortcomings, whereas Brazilian public debts sharply increased, chiefly in 1998/1999 and 2002/2003, when their sustainability was called into question.

This undesirable behavior of public debt arises from the conflict observed in the roles played by the Brazilian Central Bank (BCB) and by the National Treasury Bureau (NTB). The role of BCB is to control monetary supply in order to set the very short-term interest rate, which remunerates the excess cash of companies and banks, thereby affecting interest, output and price structure. On the other hand, the NTB is in charge of managing the domestic and foreign public bond and contractual debt, which is a direct and indirect responsibility of the government.

Note that both institutions have different roles and goals, and consequently they operate separately, and authorities have continuously attempted to strengthen such distinction. The BCB is in charge of monetary policy whereas the NTB is responsible for fiscal policy. With this distinction it is possible to obtain greater transparency for the policies, which is apparently beneficial to the management of economic policy. However, a remarkable share of public debt is indexed to the interest rate of the Special System for Settlement and Custody (Selic), which is determined by the monetary authority, and is the instrument used by the BCB to meet its main short-term goal, that is, to keep inflation within its target. However, this distinction of roles, and transparency, should not cause lack of coordination between the policies.

BCB’s clear and major goal is to maintain inflation at low levels, whereas the purpose of the NTB is to find better financing for the public sector. Nonetheless, due to the use of the same instrument, their actions are mutually influenced. Thus, the coordination between fiscal and monetary policies can be a means, perhaps the only one, to achieve greater economic stability.

The behavior of public debt in Brazil points to some worrying aspects such as high nominal deficit and the trajectory of public debt (even with successive primary surpluses obtained in the past few years). Moreover, Brazil adopted the inflation targeting regime in 1999, which succeeded in fighting inflation, even in a scenario of fiscal imbalance. Nevertheless, the high interest rates the BCB used in order to meet inflation targets caused public debt to escalate and its solvency to be questioned. This was pretty much so, that in the period that preceded the 2002 elections, when Brazil had to cope with a severe crisis of confidence externally, because of the belief that the new government could fail to maintain the macroeconomic policy, the EMBI spread, which measures the country risk, rose from 757 basis points in April to almost 2,040 basis points in October.

From 1999 onwards, the Brazilian government adopted fiscal adjustment, whose foundations were built upon (a) primary surpluses to GDP ratio to control the expansion of public debt; (b) high tax burden; and (c) increase in the public expenditure to GDP ratio. Even successive primary surpluses were not enough to surpass the debt service value, halting its expansion. Therefore, the uptrend of the debt to GDP ratio was maintained and, as a result, the debt amounted to 64% of GDP in September 2002.

In this context of fiscal imbalance, many economists have suggested that the BCB should include some relevant fiscal variable in its monetary policy rule.[3] These studies basically consist in proposing targets for the debt to GDP ratio or proposing alternative ways for the development of monetary rules that contemplate fiscal restrictions. The argument or intuition that Brazilian fiscal policy affects, to a certain extent, monetary policy, seems to be widespread, and noticeably some economists concur with this perception. This is true especially of studies that assess the period which preceded the 2002 presidential elections, in which the possibility of ascension to the presidency of a candidate who might not be willing to comply with domestic and foreign obligations was imminent. In this case, it seems plausible that fiscal policy variables should be considered in the central bank's monetary policy rule.

The empirical evidence of passive fiscal policy has been investigated by several studies and has spanned different periods of the Brazilian economy. Inflation in Brazil in the late 1970s and early 1980s was explained by Loyo (1999) based on the FTPL hypothesis. A characteristic of the conjuncture back then concerned the recurrent public deficits and high inflation rates, with consequent expansion of nominal debt triggered by high interest rates.

By analyzing a more recent period of the Brazilian economy (1966 through 2000) and using the method proposed by Canzonery, Cumby and Diba (2001), Rocha and Silva (2004) found out that Brazil operates under the Ricardian regime, which implies that the wealth effect of the variations in price level, as pointed out by the FTPL, does not occur. However, this does not mean that the government intertemporal budget constraint is satisfied for any price level by way of adjustments in fiscal variables, as the surplus series included seigniorage revenues. This occurs because the authors used the government's surplus series as GDP ratio added to the series of seigniorage revenues (real variation in the monetary base) as a proxy for the government's surplus.

Following the same methodological line of Canzonery, Cumby and Diba (2001), Portugal and Fialho (2005), using a Markov-switching vector autoregressive (MS-VAR) process for the period between January 1995 and September 2003, indicated that the Brazilian economy operated most of the time under a monetary dominance regime, that is, fiscal policy was Ricardian.

Blanchard (2004) proposes another way whereby the fiscal policy adopted by the government could affect price stability in 2002 and 2003. This consists mainly of the effects of exchange rate on public debt solvency. In an open economy with monetary policy based on interest rates, another limit can be imposed upon the monetary authority. One of the expected results of a contractionary monetary policy, by way of increase in the interest rate, is the improvement in the attractiveness of sovereign bond debts, leading to an inflow of capital and consequently appreciation of the exchange rate. Therefore, the new exchange rate can contribute towards fighting the escalation of inflation. However, if the rise in the interest rate causes the

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[3] Works that somehow develop models which incorporate a fiscal variable into the monetary policy rule or into the monetary authority's reaction function include Freitas and Muinhos (2002), Verdini (2003) and Morais and Andrade (2004).

probability of debt default to be higher, increasing the country's risk of insolvency, the government debt becomes less attractive, leading to exchange rate depreciation due to capital outflow, and contributing to the rise in inflation.

Thus, this could be one more way through which fiscal dominance can restrict the conduct of monetary policy. The study highlights that the economy will be more prone to yield this result the higher the initial rate of debt, the higher the proportion of the debt denominated in foreign currency and the higher the risk aversion of foreign investors. Finally, only after the commitment of the new government towards fiscal austerity did the harmful effect on monetary policy brought about fiscal dominance cease to exist.

Favero and Giavazzi (2003) introduce an empirical model to assess how public debt and risk premium influence the conduct of monetary policy in Brazil. The relationships between exchange rate, interest rate and probability of default are quite similar to those shown by Blanchard (2004). In their model, the economy goes from a "good" equilibrium to a "bad" one when the debt/GDP ratio exceeds a certain level. Once in this equilibrium, the rise in the Selic rate increases the probability of default, as debt charges are higher. As the exchange rate and the probability of default are correlated variables, there will be exchange rate devaluation rather than appreciation. Nevertheless, this devaluation will generate more inflation and thus the BCB will tend to drive up the interest rate. This behavior causes what the authors call vicious cycle n the conduct of monetary policy.

Zoli (2005) analyzes how fiscal policy affects monetary policy in emerging economies, including Brazil, for the period between January 1991 and January 2004. The author follows the VAR method proposed by Tanner and Ramos (2002). Results indicate a fiscal dominance regime for Brazil throughout the study period. The author also dealt with the effects of fiscal policy on risk premium and exchange rate. Her results concur with those of Favero and Giavazzi (2003) and Blanchard (2004).

Carneiro and Wu (2005) demonstrate two ways by which the high level of indebtedness (both domestic and foreign) can cause monetary policy to yield unwanted results. The first one concerns the level of public indebtedness and the lack of credibility in the solvency of the Brazilian public debt in the long run. The second one refers to the high level of private foreign indebtedness, which stems from the incapacity of emerging countries to issue foreign debt in their own currency, which results in a dollar-denominated foreign liability; and of the credit market, in which credit limits are imposed upon debtors. In their empirical analysis, the authors observed that the effect of public debt stock on risk premium could only be significant in Brazil when the debt exceeded 56% of GDP. From this value, the effect would grow explosively, thus increases in debt stock would have burgeoning effects on risk premium, leaving room for fiscal dominance.

The study by Moreira et al. (2007) used the theoretical basis proposed by Leeper (1991 and 2005) to classify monetary and fiscal policies as active and/or passive. The authors used the monthly data from January 1995 to February 2006 to estimate the reaction functions for the fiscal and monetary authority and an IS curve with a fiscal variable via GMM. The results obtained show that the Brazilian economy is under a regime in which fiscal policy is active and monetary policy is passive. In the context of Leeper's model (1991), this region represents the situation defined by the FTPL, where the fiscal authority avoids a strong adjustment in direct taxes, and the monetary authority generates inflation tax in order to maintain the government budget constraint in balance.

The authors provide evidence of an indirect effect of fiscal deficit on inflation. Thus a 1% reduction in the debt/GDP ratio would decrease the output gap by 0.016% and the 1% reduction in the output gap would lower inflation by 0.016%. The final effect of a 1% reduction in the fiscal deficit would be the decrease in the inflation rate by 0.0003%. This result, even though it did not have economic significance, was statistically significant.

3. Active and passive policies and a DSGE model with price rigidity

The structure of a new Keynesian model, based on Woodford (2003) and Leeper (2005), consists of an aggregate supply (AS) equation, called new Keynesian Phillips curve (NKPC), an intertemporal (forward-looking) IS curve, which results in an intertemporal relationship between investment and savings. In addition, there is a block with the reaction functions of fiscal and monetary authorities. In the fiscal policy rule, the government's revenue follows a rule that relies upon the real value of public debt and of other endogenous variables; and in the monetary policy rule, the nominal interest rate responds to the deviations of inflation from its target and to the deviations of the present output gap from its steady state value. The analysis of DSGE models may require a reduced and log-linearized structure. This occurs due to the fact that the intertemporal maximization of firms and families yields nonlinear equilibrium relationships. To achieve that, the log-linear approximation of the model closer to the steady state is used.

As far as families are concerned, the model consists of the intertemporal maximization of the sum of the present value expected from the utility function of a representative family, subject to a budget constraint. For the sake of simplification, financial markets are assumed to be complete and there are no limits to the loan request relative to the future revenue. The result of the equilibrium relationships of the first-order conditions of families is an aggregate demand function of the economy represented by an intertemporal IS curve. This is shown below in log-linearized form:

$$x_t = E_t x_{t+1} - \sigma(\hat{\imath}_t - E_t \pi_{t+1}) + u_t^D \qquad (1)$$

where x_t is output gap, i_t is nominal interest rate and π_t is the inflation rate. The parameter σ represents the elasticity of intertemporal substitution of consumption and u_t^D is an aggregate demand shock. We measure the variable π_t and $\hat{\imath}_t$ as percentage deviation from their steady state value and x_t as the deviation of output from its trend path.

It is possible to note that this aggregate demand relationship depends mainly on the values expected for short-term variations and not just on present values (*ex-ante*). Therefore, changes in expectational variables are more important than changes in current variables, implying a dynamic relationship between interest rate, inflation and expected shocks on aggregate demand.

Another aspect that should be underscored, given that this study does not aim to assess the deviations between the nominal interest rate and/or real rate of interest and the natural rate of interest, is that the model can be outlined in a simpler form considering the specific case in which steady state inflation is zero. Consequently, the deviations in the nominal interest rate can be seen as deviations in the natural rate of interest. Because of that, the equilibrium output gap will also be zero.

Insofar as firms are considered, each firm faces the same problem, that is, the decision to choose a price that solves the profit maximization problem. In this case, a fraction of asset prices, $0 < \alpha < 1$, remains fixed in each period. So, there is price rigidity as in Calvo (1983). In turn, the aggregate supply relationship, i.e., the structural relationship between inflation dynamics and the level of real activity is obtained by a log-linearized version of the so-called new Keynesian Phillips curve:

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t^S \tag{2}$$

where $\kappa > 0$ is the coefficient that determines the frequency of price level adjustment and marginal cost elasticity in relation to the real level of economic activity, the parameter β, $0 < \beta < 1$, is the discount factor of the representative household and u_t^S is an aggregate supply shock.

Monetary policy can be represented by a central bank's reaction function *a la* Taylor (1993):

$$\hat{\imath}_t = \bar{\imath}_t + \phi_\pi \pi_t + \phi_x x_t \tag{3}$$

Where $\bar{\imath}_t$ is the exogenous intercept term (possibly time-varying) representing changes in the natural rate of interest. The terms ϕ_π,$\phi_x \geq 0$ are the monetary policy coefficients.

When the central bank conducts the monetary policy in such a way that the nominal interest rate complies with the rule above, Woodford (2003) demonstrates that the equilibrium will be determined if and only if the response coefficients satisfy the following inequality:

$$\phi_\pi + \frac{1-\beta}{\kappa}\phi_x \geq 1 \tag{4}$$

This result shows that, according to the new Keynesian Phillips curve, there is a growth of $1 - \beta/\kappa$ base points in the output gap for each percentage point of persistently high inflation. Moreover, the right side of (4) establishes the percentage growth of the long-term nominal interest rate for each permanent growth unit in the inflation rate. Inequality (4) is the mathematical representation of the so-called Taylor principle, in which, at least in the long run, the nominal interest rate should increase more than proportionately to the increase in the inflation rate.

Obviously, the model doesn't to take the Ricardian equivalence's hypothesis on the fiscal policy. Therefore, the government sector is inserted in the model for analyze the interactions between fiscal and monetary policy. Assume a cashless economy in which all government debt consists of riskless one-period nominal debt. Then value at issuance rather than at maturity of quantity outstanding of one-period government bonds is, D_t. This nominal value of public debt changes over time as follows:

$$D_t = (1 + i_{t-1})D_{t-1} + (P_t G_t - T_t) \tag{5}$$

where T_t is the nominal net tax collections and G_t is the real government purchases and the difference of both is the primary surplus. Since we are interested in local equilibrium determination it is sufficient to consider fiscal rules that are nearly consistent with a steady state.

The maturity value of real public debt $b_t \equiv (1+i_t)D_t/P_t$. The real debt to output ratio is b_t. Substituting in (5) and dividing by Y_t, the latter can be written as[4]:

$$b_t - b_{t-1} = (\hat{\imath}_t - \pi_t - g_t)b_{t-1} + (\hat{G}_t - \tau_t) + u_t^B \tag{6}$$

where g_t is the nominal GDP growth and u_t^B are exogenous and random shocks on the process described above, which could affect the level of indebtedness. The equation (6) gives the evolution of the real debt ratio. Higher debt increases real debt as interest payments rise, as does the primary deficit ratio or excess of real government expenditure over taxation as a ratio to output. Therefore high debt levels can imply exploding unsustainable debt.

In order to generate solvency for the fiscal sector, the model employ a fiscal rule. The rule is designed to guarantee that the intertemporal budget constraint of the government is satisfied. The linear approximation of a reaction's function of the fiscal authority to form as follows:

$$\hat{\tau}_t = \theta_b \hat{b}_{t-1} + \theta_g \hat{G}_t + \theta_\pi \pi_t + \theta_y x_t + \theta_i \hat{\imath}_t + u_t^\tau \tag{6}$$

In this fiscal policy rule, the government's tax revenue responds to the government's debt with a lag period, and also to the other economic variables. The term u_t^τ is an exogenous and random shocks on tax revenue. According to Woodford, the government's fiscal policy rule will be regarded as locally Ricardian if the trajectory of $\{b_t\}$ substituted in government's budget constraint (5) remains restricted to approximately to the steady state value, for when the trajectories of endogenous variables $\{\pi_t, x_t, i_t\}$ are close to their steady state values $\{0, \bar{Y}, \bar{\imath}\}$, and for small variations in the values of exogenous variables, including $\{\bar{G}_t\}$.

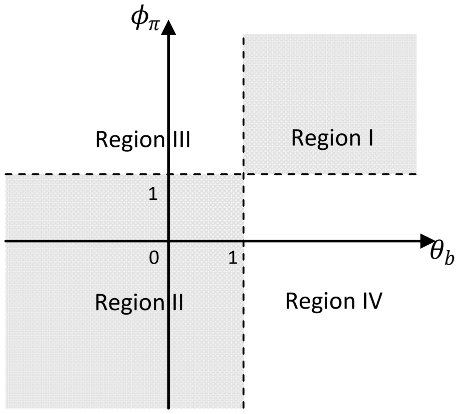
As corroborated by Leeper (1991), fiscal and monetary policies can be classified as active or passive according to the reaction function parameters of fiscal and monetary authorities in order for the equilibrium conditions of Blanchard and Kahn (1980) to be satisfied, resulting in four different regions.

Figure 1 indicates the four possible equilibrium regions. In Region I, we have an active monetary policy, $\phi_\pi > 1$, and a passive fiscal policy, $\theta_b > 1$. In this case, there is a unique equilibrium, monetary shocks produce usual monetary forecasts and fiscal shocks are irrelevant. The resulting equilibrium is consistent with the Ricardian equivalence and thus monetary policy is active while the fiscal one is passive. Leeper (2005) demonstrated that this region is suitable for the implementation of an inflation targeting regime via interest rate control. Monetary policy does not have any restrictions and may act aggressively so as to obtain price stability and fiscal policy will passively adjust direct taxes in order to balance the budget.

In Region II, monetary policy is passive, $\phi_\pi < 1$, and fiscal policy is active, $\theta_b < 1$. In this region, there is unique equilibrium and one has the case defined by the FTPL, in which shocks on taxes produce inflation and monetary shocks produce non-monetary impacts. Thus, inflation is a fiscal and monetary phenomenon.

[4] Using the approximation $(1+\hat{\imath}_t)/(1+\pi_t)(1+g_t) = 1 + \hat{\imath}_t - \pi_t - g_t$

Figure 1 – Equilibrium Regions of the Model



Source: Elaborated by the Authors

Leeper (2002) argues that, under certain conditions, current policy shocks may not cause changes in expected future taxes and that this is an essential element of FTPL. More precisely, the fiscal authority does not make a strong adjustment in direct taxation, preventing shocks on deficits from being entirely financed through future taxes. Therefore, the monetary authority will abide by the restrictions imposed by the behavior of fiscal policy and of the private sector, allowing money stock to respond to the shocks on deficit.

In Region III, monetary policy is passive, $\phi_\pi < 1$, and fiscal policy is passive, $\theta_b > 1$. Without the additional restriction imposed by an active behavior authority, there are infinite processes of monetary expansion, associated with an initial monetary shock, which are consistent with the equilibrium conditions, that is, the equilibrium is undetermined. For this case, Leeper (2002) proposed an interaction between fiscal and monetary policies in order to make the economy move out to Region I.

In Region IV, monetary policy is active, $\phi_\pi > 1$, and fiscal policy is active, $\theta_b < 1$. In this case, there is no equilibrium, each authority disregards the budget constraint and tries to determine the price level. This way, there will no process of monetary expansion that guarantees that the investor will maintain government's public debt bonds, so the debt will exhibit an explosive behavior in the long run, and the central bank will apply an increasing interest rate.

The first two regions provide the results of interest of this paper. In Region I, the results obtained are those in which the fiscal authority seeks to control the debt while the monetary authority can do without the restrictions described in the first chapter. On the other hand, when the economy is in Region II, the results obtained are those recommended by the FTPL, in which the monetary authority is compelled to generate inflation tax to warrant the balance of the government budget.

The model's equilibrium is described by 10 equations, five of which are endogenous and five, exogenous, also including 10 variables, five endogenous ones $\left(\hat{x}_t, \pi_t, \hat{b}_t, \hat{\imath}_t, \hat{\tau}_t\right)$ and five exogenous ones $(u_t^S, u_t^D, u_t^\tau, u_t^B, \bar{\imath}_t)$.

Dynamic IS curve: $\hat{x}_t = E_t\hat{x}_{t+1} - \sigma(\hat{\imath}_t - E_t\pi_{t+1}) + u_t^D$
New Keynesian Phillips Curve: $\pi_t = \kappa x_t + \beta E_t\pi_{t+1} + u_t^S$
Government budget constraint: $b_t - b_{t-1} = (\hat{\imath}_t - \pi_t - g_t)b_{t-1} + (\hat{G}_t - \tau_t) + u_t^B$
Monetary policy rule: $\hat{\imath}_t = \bar{\imath}_t + \phi_\pi\pi_t + \phi_x x_t$

Fiscal policy rule: $\hat{\tau}_t = \theta_b \hat{b}_{t-1} + \theta_g \hat{G}_t + \theta_\pi \pi_t + \theta_y x_t + \theta_i \hat{\imath}_t + u_t^\tau$
Equation of motion for the debt: $u_t^B = \rho_B u_{t-1}^B + \varepsilon_B$
Equation of motion for the natural rate of interest: $\bar{\imath}_t = \rho_i \bar{\imath}_{t-1} + \varepsilon_i$
Equation of motion for supply shock: $u_t^S = \rho_S u_{t-1}^S + \varepsilon_S$
Equation of motion for demand shock: $u_t^D = \rho_D u_{t-1}^D + \varepsilon_D$
Equation of motion for government's tax revenue: $u_t^\tau = \rho_\tau u_{t-1}^T + \varepsilon_\varphi$

The exogenous processes described by the latter five equations take the form of an AR(1), where ε are the stochastic terms. To obtain the solutions to the rational expectations model the Dynare for Matlab was used. The program used a second-order approximation to the policy function, as shown by Collard and Juillard (2001) and Schmitt-Grohe and Uribe (2004).

4. Bayesian estimation of the model

To check the empirical evidence of this study, we will use the Bayesian estimation method. This technique has become quite popular in macroeconomics. According to An and Schorfheide (2006), there are several advantages in using Bayesian methods to estimate a model, but four of them play a major role. First, the Bayesian method estimates the whole DSGE model, unlike the GMM method, that is based on a particular equilibrium relationship, as for instance a consumption Euler's equation. Secondly, the Bayesian method allows for the insertion of priors, which operate as weighting factors in the estimation process of *a posteriori* distributions. Thirdly, the insertion of priors facilitates the identification of parameters, thus avoiding parameters with absurd values. Fourthly, the Bayesian estimation attributes the specification errors of the model directly to the exogenous shocks on structural equations, which can be interpreted as observation errors.

Didactically, Mancini-Griffoli (2007) explains the Bayesian estimation method as a bridge between calibration and maximum likelihood estimation. This occurs due to the fact that calibration is a way to specify priors, whereas maximum likelihood estimation is based on confronting the model with the data. By putting both together, the priors can be interpreted as weighting factors of the likelihood function, thus adding importance to certain areas of the parametric subspace. Technically, these two blocks, the prior and the likelihood function, are associated with each other via Bayes' theorem.

First, *a priori* distributions, which are described by the following density function, are assumed:

$$p(\boldsymbol{\theta}_{\mathcal{A}}|\mathcal{A})$$

where $\boldsymbol{\theta}_{\mathcal{A}} \equiv (\phi_\pi, \phi_x, \theta_b, \theta_g, \theta_\pi, \theta_y, \theta_i, \beta, B, \sigma, \kappa, \rho_i, \rho_S, \rho_D, \rho_B, \rho_\tau, \varepsilon_S, \varepsilon_D, \varepsilon_B, \varepsilon_i, \varepsilon_\tau)$ are the structural parameters which will be estimated from a database for the model presented in the previous section, herein abbreviated as $\mathcal{A}$. Therefore, $p(.)$ is a probability density function which represents the belief about the probability distribution around the value where the parameter is assumed to be located.

Secondly, the likelihood function, which describes the density of observed data, given the model and its parameters, is given by,

$$\mathcal{L}(\boldsymbol{\theta}_{\mathcal{A}}|\boldsymbol{Y}_T,\mathcal{A}) \equiv p(\boldsymbol{Y}_t|\boldsymbol{\theta}_{\mathcal{A}},\mathcal{A})$$

Where $\boldsymbol{Y}_T$ is the dataset up to period T. For a given set of initial values for parameters $\boldsymbol{\theta}_{\mathcal{A}}$, the model is put in state space form so that the Kalman filter can be used to obtain the likelihood function. By writing the likelihood function in recursive form, we have:

$$p(\boldsymbol{Y}_t|\boldsymbol{\theta}_{\mathcal{A}},\mathcal{A}) \equiv p(y_0|\boldsymbol{\theta}_{\mathcal{A}},\mathcal{A})\prod_{t=1}^{T} p(y_t|\boldsymbol{Y}_{t-1},\boldsymbol{\theta}_{\mathcal{A}},\mathcal{A})$$

In general, one has an *a priori* density function $p(\boldsymbol{\theta})$ on the one hand and a likelihood function $p(\boldsymbol{Y}_T|\boldsymbol{\theta})$ on the other hand. However, the idea is to obtain *a posteriori* distribution of the type $p(\boldsymbol{\theta}|\boldsymbol{Y}_T)$. To do that, we use the Bayes' theorem, which establishes that:

$$p(\boldsymbol{\theta}|\boldsymbol{Y}_T) = \frac{p(\boldsymbol{\theta};\boldsymbol{Y}_T)}{p(\boldsymbol{Y}_T)}$$

Such that:

$$p(\boldsymbol{Y}_T|\boldsymbol{\theta}) = \frac{p(\boldsymbol{\theta};\boldsymbol{Y}_Y)}{p(\boldsymbol{\theta})} \Leftrightarrow p(\boldsymbol{\theta};\boldsymbol{Y}_T) = p(\boldsymbol{Y}_T|\boldsymbol{\theta}) \times p(\boldsymbol{\theta})$$

Using these identities, one can combine the density of the prior and the likelihood function presented above to obtain the density of the *a posteriori* distribution:

$$p(\boldsymbol{\theta}_{\mathcal{A}}|\boldsymbol{Y}_T,\mathcal{A}) = \frac{p(\boldsymbol{Y}_T|\boldsymbol{\theta}_{\mathcal{A}},\mathcal{A})p(\boldsymbol{\theta}_{\mathcal{A}}|\mathcal{A})}{p(\boldsymbol{Y}_T|\mathcal{A})}$$

where $p(\boldsymbol{Y}_T|\mathcal{A})$ is the marginal density of the data conditional on the model:

$$p(\boldsymbol{Y}_T|\mathcal{A}) = \int p(\boldsymbol{\theta}_{\mathcal{A}};\boldsymbol{Y}_T|,\mathcal{A})d_{\boldsymbol{\theta}_{\mathcal{A}}}.$$

Finally, the a *posteriori* kernel corresponds to the numerator of the *a posteriori* density:

$$p(\boldsymbol{\theta}_{\mathcal{A}}|\boldsymbol{Y}_T;\mathcal{A}) \propto p(\boldsymbol{Y}_T|\boldsymbol{\theta}_{\mathcal{A}},\mathcal{A})p(\boldsymbol{\theta}_{\mathcal{A}}|\mathcal{A}) \equiv \mathcal{K}p(\boldsymbol{\theta}_{\mathcal{A}}|\boldsymbol{Y}_T,\mathcal{A})$$

This equation is of utmost importance as it allows reconstructing all the moments of interest of the *a posteriori* distribution. Therefore, the *a posteriori* distribution is obtained by the

Metropolis-Hastings algorithm.[5] The rationale is to simulate a Markov chain ϑ_t, $t = 1,2 ...$, which converges to the *a posteriori* distribution. Intuitively, the distribution of transition $T(\vartheta_t|\vartheta_{t-1})$ of a Markov process is built to behave like a stochastic version of a stepwise mode-finding algorithm, and in most cases, the process works in such a way that the *a posteriori* distribution is enhanced, whereas it is seldom used to decrease the distribution.

To guarantee the convergence of the Markov process, one million simulations in five parallel chains were made for each estimation, but only the second half of the simulations was used. The scale factor of the Metropolis-Hastings algorithm was chosen to yield a rate of acceptance of 15 to 45%. To assess the convergence of the Markov chain for the *a posteriori* distribution, we used the convergence diagnostic test proposed by Brooks and Gelman (1998).

The computational implementation of this method is obtained by the Dynare for Matlab. The program routine estimates the model in two steps. In the first step, the *a posteriori* mode of the model's parameters is calculated from the distributions using the likelihood function optimization routine (CSMINWEL) developed by Sims (2002). Using the *a posteriori* mode as starting point, the Metropolis-Hastings algorithm is used to make the simulations and to obtain the *a posteriori* distribution.

4.1 Data treatment and *a priori* distributions

The sample used for the Bayesian estimation of the DSGE model includes log-linearized observations for the output gap, nominal inflation rate, nominal interest rate, public deficit to GDP ratio and tax revenue.[6] The period chosen for the series was the one that begins with the simultaneous period of the floating exchange rate and primary surplus targets, which goes from the first quarter of 2000 to the fourth quarter of 2008.

The quarterly average of the federal government's primary surplus to GDP ratio accumulated in the past 12 months was used as proxy for the fiscal variable. The monthly IPCA (the Brazilian consumer price index used by the Central Bank to target inflation), whose value was accumulated in three months to obtain the quarterly data, was used for the inflation rate. The monthly Selic rate, which is the primary interest rate in Brazil, was used for nominal interests, and it was also converted into the quarterly regime. The direct taxes revenue is given by the sum of income and land taxes accumulated in three months. Besides The variables were demeaned and putted in the natural log form.

The series for the output gap was built from the application of the stochastic Hodrick-Prescot (HP) filter, with smoothing parameter set at 1.600 and the chain-linked series of the Brazilian quarterly GDP with seasonal adjustment. Note that other measures of potential GDP and consequently of the output gap yielded similar estimation results, such as the linear trend and the Kalman filter. The estimation was made by a program built in the Dynare package for Matlab, which reduces the computational cost of implementation, as this package has some previously programmed routines.[7] The first procedure is to choose the *a priori* distributions for each one of the model's parameters, considered to be independent from each other (Table 1).

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[5] A full description of this method is found in An and Schorfheide (2006). Clarin et al. (1995) also provide a quite intuitive description of this method.

[6] All series are available from www.ipeadata.gov.br, except for the output gap series built here.

[7] To obtain the full program, please request it from the authors at nunesdenunes@hotmail.com .

Since the information set needed to determine certain characteristics of the parameters, such as the second and third moments, is limited, a very common procedure in the Bayesian estimation method is the determination of diffuse *a priori* distributions, i.e., only the interval of parameter variation is selected. To do that, one chooses a uniform distribution so that all values within the interval will have the same probability to occur, whereas values outside this interval have zero probability.

Table 1 – *A priori* distributions

Parameter	Domain	Density	Mean	Variance
ϕ_π	[0;5]	Uniform	2.5000	1.4434
ϕ_x	[0;5]	Uniform	2.5000	1.4434
θ_b	[0;5]	Uniform	2.5000	1.4434
θ_g	[0;5]	Uniform	2.5000	1.4434
θ_π	[0;5]	Uniform	2.5000	1.4434
θ_y	[0;5]	Uniform	2.5000	1.4434
θ_i	[0;5]	Uniform	2.5000	1.4434
β	[0;1)	Uniform	0.5000	0.0833
σ	[0;2]	Uniform	1.0000	0.5774
κ	[0;2]	Uniform	1.0000	0.5774
ρ_i	[0;1)	Uniform	0.5000	0.0833
ρ_D	[0;1)	Uniform	0.5000	0.0833
ρ_S	[0;1)	Uniform	0.5000	0.0833
ρ_τ	[0;1)	Uniform	0.5000	0.0833
ρ_B	[0;1)	Uniform	0.5000	0.0833
ε_i	$\Re^+$	Inv. Gamma	0.0200	Infinite
ε_D	$\Re^+$	Inv. Gamma	0.2000	Infinite
ε_S	$\Re^+$	Inv. Gamma	0.2000	Infinite
ε_τ	$\Re^+$	Inv. Gamma	0.2000	Infinite
ε_B	$\Re^+$	Inv. Gamma	0.0200	Infinite

Source: Elaborated by the authors

The Taylor rule and the fiscal reaction function parameters have restriction of non-negativity imposed by the equilibrium condition of the model proposed by Woodford (2003), that is, $\phi_\pi, \phi_x, \theta_b, \theta_g, \theta_\pi, \theta_y, \theta_i \geq 0$. Thus, the Taylor rule parameters had a uniform distribution with the interval based on the results observed in the estimation literature available on Brazil. In the case of the fiscal reaction function, for which the studies applied to the Brazilian economy are scarce, a uniform distribution was also chosen, but with a larger interval.

The parameter κ of the new Keynesian Phillips curve, which represents price level rigidity, according to the results described in the literature (Walsh (2003)), belongs to the interval [0;2], thus the prior chosen for this parameter consists of a uniform (0,2). In the same equation, the intertemporal discount factor, β, has the domain [0;1), consequently the selected *a priori* distribution was the uniform one restricted to this period. In the IS curve, the same distribution was attributed to the parameter that represents the inverse of the intertemporal elasticity of substitution, σ, as the values portrayed in the literature indicate that the parameter belongs to interval [0,2], as in McCallum and Nelson (1999) and Carneiro and Duarte (2001).

As to the parameters of the equations that represent exogenous processes $(\rho_i, \rho_s, \rho_D, \rho_B, \rho_\tau)$, to guarantee the stationarity of these equations, they were restricted to the interval [0;1). Finally, for the standard deviations of the shocks, an inverse gamma distribution with mean equal to 0.2 and infinite variance was selected. The subsequent step is to use data that change the initial belief, as indicated by the *a priori* distributions. To achieve that, as mentioned above, the Metropolis-Hastings algorithm was used.

4.2 Empirical results for the 2000I – 2008IV period

First, the model was estimated for the whole sample period, which covers from the first quarter of 2000 to the fourth quarter of 2008. The results of the estimated parameters are shown in Table 2, with 95% confidence intervals, and in Figure 2, which shows the *a priori* distributions (gray), *a posteriori* distributions (black) and a green line which represents the *posteriori* mode. The results indicate that the estimated parameters are consistent with those described in the literature for Bayesian DSGE models using Brazilian data[8]. Besides, the posterior mean of the elasticity intertemporal substitution in consumption indicate that Brazilians demand is responsive to changes in real interest rate, so that the conventional interest rate channel on monetary policy transmission is effective in the Brazilian economy and the parameters of shocks are stationary.

It is possible to conclude that the Brazilian Central Bank follows an anti-inflationary policy, as $\phi_\pi > 1$, a result that is expected for a monetary authority that uses the inflation targeting regime. Therefore, the Taylor principle is satisfied, as the central bank responds to fluctuations in the current inflation rate with more than proportionate changes in the interest rate, causing the real rate of interest to rise. The coefficient of reaction of the monetary policy to an inflation rate greater than one is consistent with what Leeper (1991) calls active monetary policy, demonstrating that the central bank seeks to meet the inflation target regardless of the way the fiscal policy is conducted. However, the BCB exhibits a smaller coefficient for the reaction of the interest rate to the output gap, ϕ_x, indicating that the monetary authority responded more aggressively to the deviations of the inflation rate from its target than to deviations of the rate of GDP growth to the potential GDP.

The fiscal reaction function estimation shows that the fiscal authority attempted to balance the debt to GDP ratio which, according to the classification proposed by Leeper (1991), characterizes a passive fiscal policy or, as referred to by Woodford (2003), a Ricardian policy. In practice, a parameter θ_b=1,4, implies that, for every 1% growth in the debt to GDP ratio, the government tax revenue to GDP ratio responded with a growth of around 1.4%. Note also that the 95% interval for the *a posteriori* distribution of the parameter does not include values smaller than one, which makes the estimation result more robust. Nevertheless, not surprisingly, the parameters with a greater impact on the government tax revenue, *ceteris paribus*, are the inflation rate and the rate of economic growth.

For the 2000I-2008IV period, the conclusion is that the BCB follows an active monetary policy, as it adopts an anti-inflationary policy without any restrictions from the fiscal policy. In a

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[8] Silveira (2008) and Furlani et. al. (2010)

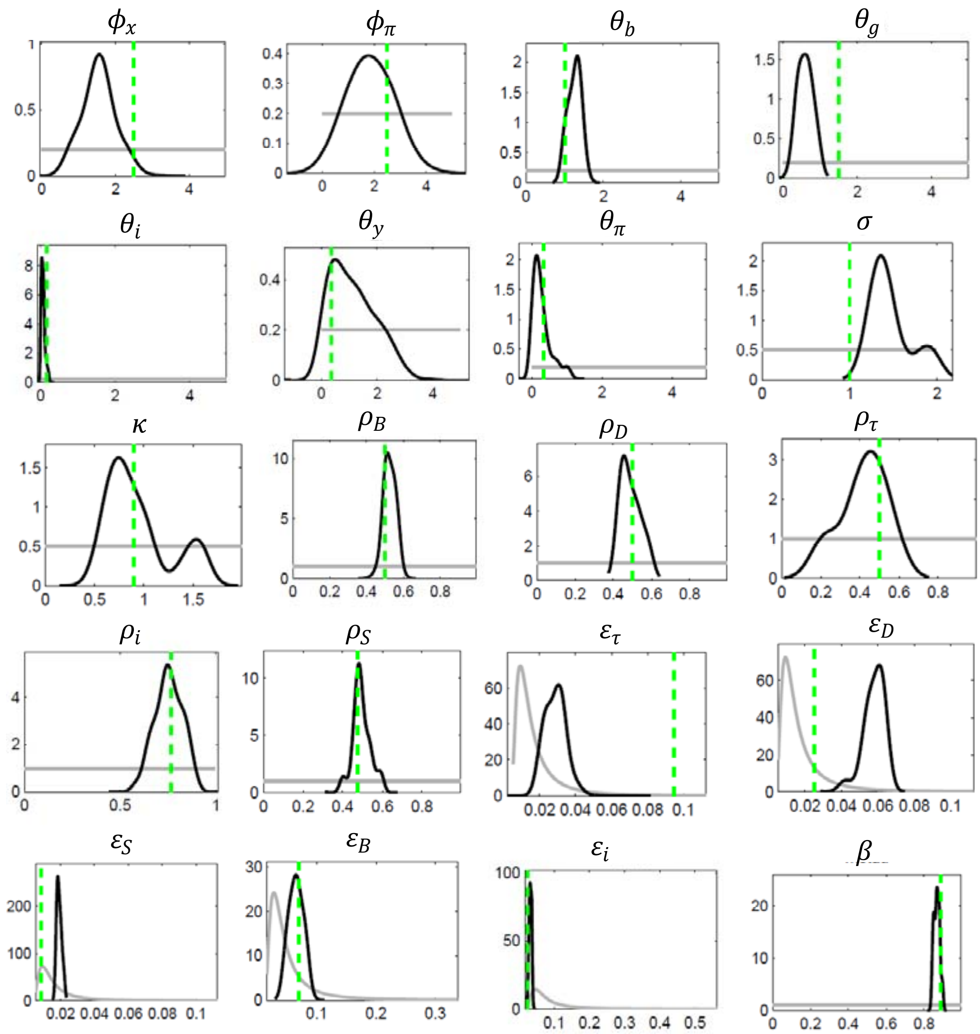
coordinate fashion, fiscal policy has a passive behavior, seeking to balance the debt to GDP ratio in the long run. This environment, with passive fiscal policy and active monetary policy, is described by Woodford (2003) and Leeper (1991), among others, to be ideal for the adoption of inflation targets. This results from the fact that a credible monetary authority in an environment in which public debt is balanced is fully capable of controlling inflation through the determination of the nominal interest rate.

Table 2 – Estimated Parameters

	***A Priori* Distribution**	***A Posteriori Distribution***		
Parameter	**Mean**	**5%[1]**	**Mean**	**95%[1]**
ϕ_π	2.5000	0.8451	1.5509	2.2528
ϕ_x	2.5000	0.6836	1.8350	3.2765
θ_b	2.5000	0.9944	1.2534	1.4440
θ_g	2.5000	0.3654	0.5966	0.9442
θ_π	2.5000	0.0045	0.2323	1.0413
θ_y	2.5000	-0.0781	0.1810	0.2210
θ_i	2.5000	0.0037	0.1002	0.1102
β	0.5000	0.8599	0.9121	0.9415
σ	1.0000	1.2664	1.4683	1.9273
κ	1.0000	0.7608	0.9834	1.3092
ρ_i	0.5000	0.7104	0.7681	0.7932
ρ_D	0.5000	0.4603	0.5012	0.5974
ρ_S	0.5000	0.4527	0.4890	0.5223
ρ_τ	0.5000	0.3878	0.4052	0.5266
ρ_B	0.5000	0.4843	0.5029	0.571
ε_i	0.0200	0.0367	0.0545	0.0720
ε_D	0.2000	0.0431	0.0580	0.0677
ε_S	0.2000	0.0177	0.0224	0.0250
ε_τ	0.2000	0.2766	0.3202	0.4433
ε_B	0.0200	0.0684	0.0690	0.0698

Source: Elaborated by the authors

Figure 2 – *A Posteriori* Distribution of Parameters



Source: Elaborated by the authors

4.3 Empirical results for the subsamples

In the estimations (Table 3) for the 2000I – 2003IV, 2001I – 2004IV and 2002I – 2005IV periods, the parameter of fiscal policy response to government debt was smaller than one ($\theta_b < 1$) which, according to the theoretical models outlined in Section 3, corresponds to an active or non-Ricardian fiscal policy. Thus, in these periods, the fiscal authority probably did not have a primary surplus to GDP ratio that was large enough to guarantee the credibility of the government's commitment before public bond investors and other economic agents towards meeting the intertemporal budget constraint and paying off the public debt in the future.

Therefore, the monetary policy results may have been less efficient, making it harder to bring inflation towards the established target.

On the other hand, the monetary reaction function response to increases in inflation also had a value greater than one ($\phi_\pi > 1$), indicating that the monetary policy exhibited an active behavior. In other words, the BCB responded to increases in the inflation rate with more than proportionate increases in the interest rate. This result demonstrates that the monetary authority is committed to keeping tabs on inflation.

As corroborated by the theoretical literature, it is not possible to obtain a stable equilibrium in rational expectations when both the fiscal and monetary policies have an active behavior. To attain that, Leeper(1991), Leeper (2005), Woodford and Rotemberg (1996) and Woodford (2003), among others, suggest an interaction between these policies so that an active monetary policy/passive fiscal policy can be obtained.

For similar periods, more specifically for the years 2002 and 2003, the studies by Blanchard (2004) and Zoli (2005) assert that, for an open economy, fiscal policy influenced monetary policy results. Likewise, using the model developed by Leeper (1991), Moreira et al. (2007) found that Brazil, between 1999 and 2004, operated in a regime in which fiscal and monetary policies had an active behavior, resulting in the same indeterminacy of price level in the long run. The authors concluded that the interaction between policies would be an alternative to obtain an equilibrium result.

It should also be highlighted that the estimations for the period prior to 2003I – 2006IV revealed that the monetary authority responded more strongly to increases in inflation, to the detriment of a more aggressive response to deviations of output from its potential value. This may have led to lower growth rates for the economy during that time, as was actually observed. It is easy to perceive that in the same period the primary surplus response to the debt was too poor. Then, this factor may have pressured the BCB into adopting higher interest rates than what would be necessary if the fiscal policy was passive.

Also important are the estimations for the 2003I – 2006IV, 2004I – 2007IV, 2005I – 2008IV periods, in which the fiscal authority always adopts a passive approach, with a parameter $\theta_b > 1$, and in the same period, the parameter value for the monetary policy response to the output gap (ϕ_x) is significantly higher. In other words, it might not be by happenstance that when the fiscal policy begins to exhibit a passive behavior, the monetary authority is free to reduce the interest rate, placing a greater relative weight upon deviations of output from its potential than upon the inflation rate. The practical result of this behavior may have been higher rates of GDP growth and lower interest rates during this period.

Nonetheless, one cannot dissociate the conjuncture that involved these periods. First, in the subsamples in which year 2002 was included, since it was an election year, the monetary authority may have delayed increasing the benchmark interest rate, resulting in the necessity for a more abrupt adjustment in the interest rate in the post-election period. In addition, the imminent ascension to the presidency of a candidate who could fail to maintain the ongoing economic policy led to greater market aversion to the bonds issued by the Brazilian government, giving rise to a strong crisis of credibility, making the market demand a higher risk premium in order to purchase them. This higher aversion to assets denominated in national currency also caused strong exchange rate depreciation, having a direct impact on the dollar-denominated debt share. This way, the increase in the level of indebtedness in this period is closely related to exchange rate depreciation. Therefore, only when the market believed in the new government's commitment to fiscal austerity did the deleterious effect on the monetary policy derived from the active fiscal policy cease to exist.

After 2004, Brazil started to exhibit higher growth rates combined with record trade balances in an international environment of abundant liquidity. Thus, the rollover of government debt became easier, allowing for interest rate reductions. Note that the indexation of public debt was modified, and little by little the bonds indexed to the Selic rate were replaced with bonds indexed to the inflation rate.

Finally, based on the estimations, the BCB adopted an active monetary policy throughout the period (2000I to 2008IV). This way, the above-target increases in the inflation rate were responded with increases in the real rate of interest. As to the conduct of fiscal policy, two distinct behaviors were perceived. In the subperiod between 2000I and 2002IV, there existed an active behavior, in such a way that the growth in the debt/GDP ratio did not have as response a similar increase in the primary surplus/GDP ratio. According to the theory postulated by Woodford (2003) and Leeper (1991), this may have resulted in the adoption of a higher interest rate than was necessary to fight inflation in the case of a passive fiscal policy. However, in the subperiod between 2003I and 2008IV, the fiscal authority had a passive behavior, creating a more favorable environment to the adoption of the inflation targeting regime.

Table 3 – *A Posteriori* Distributions of Estimations for Different Periods

Periods	2000I – 2003IV			2001I – 2004IV			2002I – 2005IV			2003I – 2006IV			2004I – 2007IV			2005I – 2008IV		
Parameter	**5%[1]**	**Mean**	**95%[1]**	**5%[1]**	**Mean**	**95%[1]**	**5%[1]**	**Mean**	**95%[1]**	**5%[1]**	**Mean**	**95%[1]**	**5%[1]**	**Mean**	**95%[1]**	**5%[1]**	**Mean**	**95%[1]**
ϕ_π	0.4023	1.1250	2.7155	0.717	1.2335	3.0820	0.2211	1.3921	3.0815	0.7471	1.4549	2.3581	1.0432	1.1628	2.3332	0.736	1.2912	2.1528
ϕ_x	0.0044	0.0822	0.1105	0.0352	0.4523	0.9062	0.0632	0.8361	1.2242	1.0836	0.8350	0.9265	1.0293	1.9662	3.3941	1.6019	2.1604	3.8385
θ_b	0.3023	0.5441	0.5700	0.119	0.5277	0.9359	0.3472	0.6382	0.9229	0.5964	1.1294	1.4840	1.331	1.3825	1.9027	1.3321	1.5791	1.6005
θ_g	0.2289	0.6912	0.7762	0.1494	0.5041	0.9757	0.1360	0.6207	0.8903	0.3654	0.5966	0.9442	0.0198	0.6901	0.7189	0.0602	0.7087	1.0008
θ_π	0.6159	0.7054	1.1033	0.2777	0.5653	1.0019	0.0041	0.0081	0.0415	0.0345	0.2503	0.5303	0.0337	0.1459	1.4438	1.1006	1.4489	1.6676
θ_y	0.0259	0.0561	0.0591	0.03148	0.0635	0.9409	0.0727	0.0955	0.4388	-0.138	0.2210	0.3230	0.0789	0.0952	0.1980	0.0736	0.1008	0.1805
θ_i	0.0155	0.0151	0.0766	0.0300	0.0395	0.0646	0.1004	0.1203	0.1711	0.0074	0.1035	0.3102	0.072	0.0543	0.1083	0.0405	0.0751	0.2305
β	0.9096	0.9593	0.9743	0.8342	0.9199	0.9999	0.9807	0.9999	0.9999	0.8599	0.9121	0.9415	0.8319	0.9299	0.9754	0.8094	0.8934	0.9999
σ	0.7157	0.9182	1.0282	1.0188	1.0973	1.3056	1.0938	1.1423	1.4714	1.2664	1.4683	1.9273	1.185	1.2365	2.006	1.0431	1.5026	2.0282
κ	0.3281	0.7667	1.0678	0.4614	0.5269	0.6766	0.9078	1.1445	1.1723	0.7108	0.9345	1.2492	0.7118	0.8463	1.2541	0.7094	0.8469	1.1201
ρ_i	0.749	0.7942	0.9531	0.7365	0.8667	0.8838	0.5345	0.5458	0.5766	0.7104	0.7681	0.7932	0.6763	0.7413	0.7952	0.7074	0.8055	0.774
ρ_D	0.2899	0.5553	0.6431	0.3866	0.5233	0.7016	0.4842	0.5699	0.6697	0.4603	0.5012	0.5974	0.3443	0.4387	0.4301	0.2916	0.478	0.9979
ρ_S	0.401	0.5104	0.5563	0.4858	0.653	0.7493	0.6253	0.6975	0.7238	0.4527	0.4890	0.5223	0.4955	0.5357	0.5714	0.4758	0.5243	0.9967
ρ_τ	0.0102	0.4193	0.8248	0.5041	0.5407	0.5747	0.5854	0.5911	0.6147	0.3878	0.4052	0.5266	0.4857	0.4867	0.4876	0.071	0.3576	0.9999
ρ_B	0.1241	0.7236	0.7978	0.7739	0.7885	0.8016	0.6666	0.6993	0.7196	0.4843	0.5029	0.571	0.4205	0.4242	0.4312	0.3595	0.4682	0.9262
ε_i	0.2913	0.1002	0.1104	0.0733	0.0921	0.1044	0.0512	0.0559	0.1232	0.0337	0.0753	0.0798	0.0401	0.0783	0.0888	0.0212	0.0376	0.0630
ε_D	0.0024	0.0087	0.0089	0.0147	0.0171	0.0201	0.0331	0.0823	0.1092	0.0441	0.0551	0.0737	0.0537	0.08834	0.0927	0.0454	0.0673	0.0899
ε_S	0.0054	0.0083	0.0112	0.0021	0.0102	0.0192	0.0212	0.0242	0.0296	0.0165	0.0232	0.0260	0.0154	0.0335	0.0451	0.0296	0.0564	0.0699
ε_τ	0.0857	0.1017	0.1134	0.1048	0.3313	0.515	0.6368	1.0708	1.277	0.2766	0.3202	0.4433	0.0642	0.0793	0.0892	0.0142	0.1725	0.2281
ε_B	0.0371	0.0703	0.0907	0.0295	0.0454	0.0643	0.0300	0.0540	0.0984	0.0684	0.0690	0.0698	0.049	0.02368	0.0753	0.0543	0.0787	0.0189

[1] 5% and 95% percentiles

Source: Elaborated by the authors

5. Conclusion

The aim of the present paper was to discuss the interaction between fiscal and monetary policies in the context of DSGE models for Brazil after the adoption of the inflation targeting regime. Using Bayesian econometric tools to assess the behavior of fiscal and monetary policies, the results obtained indicate that the estimated parameters are consistent with the ones described in the literature.

For the period between 2000I and 2008IV and for the subperiod between 2003I and 2008IV, the BCB followed an active monetary policy, seeking to adopt an anti-inflationary policy without any restrictions imposed by the fiscal policy. In other words, the BCB operates independently, as it is not pressured into generating inflation tax to meet the restriction made by the government. On the other hand, fiscal policy is passive, seeking a balanced debt to GDP ratio in the long run. This environment, with passive fiscal policy and active monetary policy, is described by Woodford (2003) and Leeper (1991), among others, to be ideal for the adoption of the inflation targeting regime. This results from the fact that a credible monetary authority in an environment in which public debt is balanced is fully capable of controlling inflation through the determination of the nominal interest rate.

However, an opposite result was obtained when smaller samples were analyzed, particularly those in which the year 2002 was included. The results for the 2000I – 2002IV period show that both authorities had an active behavior. This result can be a consequence of the high indexation of public debt to the benchmark interest rate at a time when there was strong disbelief that an orthodox macroeconomic policy would be maintained by the new government, which was sworn into office in 2003, in addition to a delay of the BCB in increasing the interest rate in order to keep tabs on inflation since there were presidential elections in that year. Nevertheless, regardless of the scenario, the high debt to GDP ratio in that period, as well as its uptrend, was possibly some of the factors that led to a two-digit inflation in 2002, even with recurrent monetary tightness.

By comparing this study with the existing literature, the present paper is closer to the work of Moreira et al. (2007), whereas a general equilibrium model and the classifications of Leeper (1991) are used for the fiscal and monetary policies. Moreira et al. (2007) found a fiscal dominance regime for the whole period between 1995I and 2006II. In this paper, we observed that an active fiscal policy, or fiscal dominance, for the period after 2000I was more concentrated in the year 2002.

Finally, the model used in this paper has a serious limitation by considering a closed economy. Thus, the introduction of a market for commodities and for foreign financial assets would allow clarifying why policies exhibited an active behavior in the 2000I-2002IV period. Therefore, the analysis of fiscal and monetary policies in a small open economy is a possible topic for further investigation.

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