Fiscal Multipliers: Is Brazil an Outlier among Emerging Markets?

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Abstract

The global crisis that erupted in 2007 led many countries to embark on counter-cyclical fiscal policies as a way to cushion the blow of a depressed aggregate demand. Advocates of discretionary measures emphasize that fiscal policy can indeed stimulate the economy. The main goal of this work is to assess whether the fiscal policies pursued by the Brazilian government in the aftermath of the 2008 crisis succeeded in bringing the economy back on track in a sustainable fashion. Additionally, we seek to test whether the multipliers associated with these fiscal measures have fared as described in Ilzetzki *et al.* (2013) for the case of developing and emerging markets. To this end, the fiscal multipliers of six different shocks are studied in a New Keynesian framework. The results show that the consumption-tax reduction played an important role in the economic recovery but its effects were short-lived. If Brazilian policymakers were to undertake a long-lasting economic stimulus, they should rely more heavily on public investment outlays.

Key-words: DSGE Models, Fiscal Multipliers, New Keynesian Model.
JEL: C63, E37, E62

1 Introduction

In 2008 the Brazilian government, in an attempt to unleash more resources to households so as to increase private consumption, widened the existing range of top marginal rates in which the personal income tax was structured. In addition, it lowered the tax on manufactured products (IPI) in the acquisition of cars and trucks. On the spending side, public investment plans as well as government current expenditure growth were maintained throughout the year 2009 in the midst of falling fiscal revenues owing to the economic slowdown. (Moreira, 2010).

Expansionary fiscal policies targeted at tackling the sluggish economic activity were indeed common practice elsewhere when the international financial crisis hit hard. Many developed countries had to pull back soon, however, as soaring public deficits quickly rendered public debts unsustainable, thereby leading these countries to engage in belt-tightening as a way to put a halt to this spiraling debt growth.

Nevertheless, it should be made clear that the Brazilian economic situation at the advent of the Great Recession differed substantially from that mentioned above. Brazil faced the recessive impact with plenty of fiscal room and ammunition to prop up aggregate demand, for its net public debt and deficit were low by international standards at that moment. There has been since then a hot debate among Brazilian economists, economic commentators and analysts alike as to whether the fiscal tools chosen by the incumbent government were the most appropriate ones to get the economy out of recession.

This article aims to shed some light on the discussion about the effects of the post-2008 Brazilian fiscal policy. Specifically, we set out to examine whether this fiscal expansion had a positive (and permanent) effect on the economic activity by focusing on the analysis of the fiscal multiplier on each sort of stimulus considered, namely tax cuts on consumption, on labor income, on capital gains, government consumption and investment shocks, and income transfers to households. The baseline model we employ is a New Keynesian one in which both public spending and tax shocks are included and the parameters have been estimated through Bayesian methodology.

As a complement, we are also interested in drawing a comparison between our results and the stylized facts laid out by Ilzetzki *et al.* (2013) so as to get a sense of whether the effects of the countercyclical fiscal measures put in place by the Brazilian authorities fit the patterns displayed in the aforementioned study for the case of emerging market economies[1]. Like these authors, we find that government

[1]It should be said that, within the set of fiscal policy measures that we contemplate in our work, only shocks to government consumption and to public investment can be used as a comparison, since they are the only ones dealt with in our benchmark article.

investment yields the highest multiplier in the long run[2]. Unlike them, we find a negative impact multiplier on this measure.

Concerning government consumption shocks, our model shows that the ensuing impact multiplier in Brazil is positive, but also that it turns into negative figures when a longer time horizon is considered. While this long-run negative multiplier is in consonance with the benchmark's results regarding emerging markets, the former seems to be at odds with them. It may be worth emphasizing that the Brazilian economy, although fairly indebted for its level of development[3], is known to be one of the most closed emerging economies in the world[4], partly because of the high tariffs and non-tariff barriers to trade through which the Brazilian government restricts imports, and partly because of its large domestic market[5] so, according to these authors, through this avenue, fiscal expansions could have high positive effects on output.

As for the remaining fiscal measures, only the tax relief on labor income has positive cumulative effects. Its impact multiplier is nevertheless found to be negative, as opposed to the tax cuts on capital gains and consumption, whose associated impact multipliers as well as long-run multipliers are positive and negative, respectively. Income transfers to households do not appear to have any effect whatsoever on economic activity.

There is an extensive literature on fiscal multipliers: Al-Eyd and Barrell (2005), Broda and Parker (2008), Coronado et al (2005), Heathcote (2005), Johnson et al (2006), Romer and Romer (2008), and Zandi (2008) study the fiscal multipliers of tax reductions. On the other hand, Bryant et al (1988), Dalsgaard et al (2001), Freedman et al (2008), Ilzetzki and Végh (2008), Perotti (2006), and Ramey (2008) center on the effects of government purchases. And Blanchard and Perotti (2002), Cogan et al (2009), Elmendorf and Furman (2008), IMF (2008), and Perotti (2005) deal with the both types of fiscal policy.

It may thus come as a surprise that there is a lack of research covering this topic in the Brazilian economic literature. Our article can be thought of as a humble contribution to closing that gap.

The remainder of the paper is organized as follows: Section 2 introduces the model, sections 3, and 4 explain the data, calibration and estimation of the structural parameters, respectively. Section 5 presents the results and section 6 con-

[2]Although its value is in any case lower than 1, contrary to what Ilzetzki *et al.* (2013) suggest.

[3]The ratio gross public debt-to-GDP reached 57% in 2013(Banco Central do Brasil, 2014).

[4]The average ratio exports plus imports-to-GDP over the period spanning 1995:1 through 2014:2 hovers around 23% (IBGE, 2014).

[5]That is precisely the main reason why we have opted for a closed economy model.

cludes.

2 The Model

We model a decentralized closed economy consisting of households, firms, and a government, which in turn can be split into a Fiscal Authority and a Monetary Authority. The baseline framework which we set up is a standard New Keynesian model with the typical frictions: monopolistic competition and staggered pricing *a la Calvo.*

2.1 Households

The economy is populated by a continuum of identical households, so for simplicity, the number is normalized to 1. The representative household is assumed to maximize its inter-temporal utility by choosing consumption, savings, investment and leisure. As for the saving decision, she can choose between two different instruments - physical capital and government bonds, indexed by j. Overall, the household can purchase consumer goods, capital goods, and/or government bonds. In other words, this agent elects how much to consume, how much to work and how much to save and invest by accumulating financial assets and physical capital in order to maximize the discounted stream of expected utility.

The stand-in consumer's formal problem boils down to,

$$\max E_t \sum_{t=0}^{\infty} \beta^t S_t^C \left[\frac{C_{j,t}^{1-\sigma}}{1-\sigma} - S_t^L \frac{L_{j,t}^{1+\psi}}{1+\psi} \right] \tag{1}$$

subject to her budget constraint,

$$P_t \left(1 + \tau_c \phi_t^c\right) \left(C_{j,t} + I_{j,p,t}\right) + \frac{B_{j,t+1}}{RIS_t R_t^B} = W_t L_{j,t} \left(1 - \tau_l \phi_t^l\right) + R_t K_{j,p,t} \left(1 - \tau_k \phi_t^k\right) + B_{j,t} + TRANS_{j,t} \tag{2}$$

and to the following law of motion for capital,

$$K_{j,p,t+1} = (1-\delta_p) K_{j,p,t} + I_{j,p,t} \tag{3}$$

where E_t is the expectations operator, $\beta \in (0,1)$ is the intertemporal discount factor, C denotes consumption, L denotes labor, S^C refers to the intertemporal shock, S^L is the shock on labor supply, ψ is the marginal disutility of labor and σ is the coefficient of relative risk aversion.

Regarding the budget constraint, P is the general price level, I_p is private investment, B is a one-year government bond, RIS is the risk premium, R^B is the rate of return on the government bond (basic interest rate), W is the wage, R is the return to capital, K_p is the private stock of capital, $TRANS$ is the income transfers to households by the government, ϕ^c, ϕ^l and ϕ^k are the stochastic components of the reduction in the consumption tax, labor income tax and capital gains tax, respectively. Similarly, τ_c, τ_l, τ_k represent the static components of static components of the aforesaid taxes, respectively.

We adopt the convention that B_t is the nominal bond issued in (t-1) and matured in t[6]

For convenience, all bonds are regarded to be one-period bonds. Hence, both B_{t+1} and K_{t+1} are decided in t.

The household purchases consumer goods (C)and investment goods (I_p) at the price level (P). She also buys or sells government bonds (B) maturing in one year. These bonds? interest rate (R^B), which is controlled by the monetary authority, is not risk-free and thus includes a risk premium term (RIS) (see Smets and Wouters (2007) and Christoffel *et al.* (2008)).

Three types of taxes are paid by this representative agent: a consumption tax, labor-income tax and a capital-gains tax. Her total income is derived from four sources: labor income, which depends on the level of nominal wages (W); capital income, which is a function of the rate of return to capital (R); income transfers ($TRANS$) received from the government; and interest payments from government bonds acquired in the previous period (B).

The first order conditions associated with the choices of C_t, L_t, $K_{p,t+1}$ and B_{t+1} are respectively:

Labor supply equation (intratemporal choice),

$$S_t^L L_{j,t}^{\psi} C_{j,t}^{\sigma} \left[\frac{(1+\tau_c \phi_t^c)}{(1-\tau_l \phi_t^l)} \right] = \frac{W_t}{P_t} \tag{4}$$

An increase in the real wage rate induces the stand-in consumer to supply more labor and to consume more. A cut in the consumption tax and in the labor income tax leads to the same results[7]

[6]In practice, a government usually issues bonds in each period that mature at different times in the future. For the sake of convenience, we assume that all bonds last for one period.

[7]Our results can be summarized by expressing:
$L^s = L^s \left[\left(\underset{(+)}{\frac{W}{P}}\right), \left(\underset{(+)}{\phi_t^c}\right), \left(\underset{(+)}{\phi_t^l}\right) \right]$
and

Wealth effects can come about through shifts in the production function (positive shock to productivity). These effects tend to show up first in firms' profits. But it may be worth recalling that the profits accrue to the households who happen to be the owners of the firms. A distinct consideration are wealth effect arising from a change in the real wage rate, given a fixed production function. An increase in W/P benefits the households that sell labor services. However, this benefit is matched by an extra cost for the firms, which buy labor services. Since these firms are owned by households, the overall wealth effect on households from a change in W/P is nil (Barro, 1997).

Euler equations (intertemporal choices),

$$S_t^C C_{j,t}^{-\sigma} = \beta E_t \left\{ \frac{S_{t+1}^C C_{j,t+1}^{-\sigma}}{P_{t+1}\left(1+\tau_c \phi_{t+1}^c\right)} \left[(1-\delta_p) P_{t+1}\left(1+\tau_c \phi_{t+1}^c\right) + R_{t+1}\left(1-\tau_k \phi_{t+1}^k\right) \right] \right\} \tag{5}$$

$$\frac{S_t^C C_{j,t}^{-\sigma}}{P_t\left(1+\tau_c \phi_t^c\right)} = RIS_t R_t^B \beta E_t \left[\frac{S_{t+1}^C C_{j,t+1}^{-\sigma}}{P_{t+1}\left(1+\tau_c \phi_{t+1}^c\right)} \right] \tag{6}$$

2.1.1 Aggregation

When it comes to aggregating the different variables, we opt to follow the functional form $(X = (1-\omega)X_p + \omega X_g)$[8], very common in this type of literature.

Thus, aggregate investment is given by:

$$I_t = (1-\omega_G) I_{p,t} + \omega_G I_{g,t} \tag{7}$$

where ω_G is the share of public investment in the aggregate investment.

2.1.2 Shocks to households

We address two different shocks to households: an intertemporal preference shock (S^C) and a labor supply shock (S^L). While the former affects the intertemporal consumption choice, the latter alters labor supply decisions and the nominal wage determination. The shock to preferences S^C is meant to account for valuation changes occurring between present and future which the literature on intertemporal behavior highlights as key to understanding aggregate fluctuations (Primiceri et al. 2006). Additionally, the shock to labor supply has been included in order to model labor supply variations that Hall (1997) and Chari et al. (2007) identified as

$C^d = C^d \left[\left(\underset{(+)}{\tfrac{W}{P}}\right), \left(\underset{(+)}{\phi_t^c}\right), \left(\underset{(+)}{\phi_t^l}\right) \right]$
where L^s is labor supply and C^d is consumption demand.

[8] $X_t = \int_0^1 X_{h,t} dh = (1-\omega) X_{R,t} + \omega X_{NR,t}$.

responsible for major changes in employment over the business cycle. Three other shocks have been brought into the model to characterize the stochastic component of the three kinds of taxes with which we deal in this work: consumption tax (ϕ^c), labor income tax (ϕ^l) and capital gains tax (ϕ^k). Lastly, a risk premium shock has been considered as well. In fact, a positive shock to RIS curtails both consumption and investment (because the households demand more public bonds), thereby generating a positive co-movement between those two aggregate demand components (Castro et al, 2011).

The laws of motion for such shocks are presented below:

$$\log S_t^C = (1-\rho_{sc}) \log S_{ss}^C + \rho_{sc} \log S_{t-1}^C + \epsilon_{sc,t} \tag{8}$$

$$\log S_t^L = (1-\rho_{sl}) \log S_{ss}^L + \rho_{sl} \log S_{t-1}^L + \epsilon_{sl,t} \tag{9}$$

$$\log \phi_t^c = (1-\rho_c) \log \phi_{ss}^c + \rho_c \log \phi_{t-1}^c - \epsilon_{c,t} \tag{10}$$

$$\log \phi_t^l = (1-\rho_l) \log \phi_{ss}^l + \rho_l \log \phi_{t-1}^l - \epsilon_{l,t} \tag{11}$$

$$\log \phi_t^k = (1-\rho_k) \log \phi_{ss}^k + \rho_k \log \phi_{t-1}^k - \epsilon_{k,t} \tag{12}$$

$$\log RIS_t = (1-\rho_R) \log RIS_{ss} + \rho_R \log RIS_{t-1} + \epsilon_{R,t} \tag{13}$$

where $\epsilon_{sc,t}$, $\epsilon_{sl,t}$, $\epsilon_{c,t}$, $\epsilon_{l,t}$, $\epsilon_{k,t}$, $\epsilon_{R,t}$ are exogenous shocks, and ρ_{sc}, ρ_{sl}, ρ_c, ρ_l, ρ_k, ρ_R are the autoregressive components of the intertemporal preference shock, of the shock on labor supply, of the shock to the consumption tax, to the labor income tax, to the capital income tax and to the risk premium, respectively.

2.2 Firms

As is customary in the New Keynesian literature, the productive sector of the economy is divided into two subsectors: final good producers (retail), and intermediate good producers (wholesale). The wholesale sector is composed of a large number of firms, each producing a different good under monopolistic competition. In the retail industry, there is a single firm that aggregates intermediate goods into a final good (Y) which will be consumed by households. In addition to these features, it should be mentioned that input markets are perfectly competitive in our model.

2.2.1 Final Good Producer (Retail)

Let us first define the behavior of the CES aggregator function[9]

The finished good is produced by a single firm that operates in perfect competition. For this purpose, the firm combines a continuum of intermediate goods that are aggregated into a single finished good using the following technology:

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\varphi-1}{\varphi}} dj \right)^{\frac{\varphi}{\varphi-1}} \tag{14}$$

where Y denotes output, Y_j is the intermediate good j, and φ is the elasticity of substitution between intermediate goods.

As laid out above, the retailer is in perfect competition and maximizes its profit by using the technology of equation (20), given the intermediate goods prices. Therefore, the problem that the retail firm seeks to solve is:

$$\max_{Y_{j,t}} P_t Y_t - \int_0^1 P_{j,t} Y_{j,t} dj \tag{15}$$

The first order condition for each intermediate good j is

$$Y_{j,t} = Y_t \left(\frac{P_t}{P_{j,t}} \right)^{\varphi} \tag{16}$$

Equation (16) shows that the demand for the intermediate good j is a decreasing function of its relative price and an increasing function of the aggregate output of the economy.

Due to the existence of perfect competition in the final goods market, deriving the equilibrium price is straightforward. Plugging equation (16) into (14) results in:

$$P_t = \left(\int_0^1 P_{j,t}^{\frac{\varphi-1}{\varphi}} dj \right)^{\frac{\varphi}{\varphi-1}} \tag{17}$$

2.2.2 Intermediate Good Producer (wholesale)

The wholesale firms solve their problem in two steps. In the first one, by taking the input prices as given, wages (W) and the return to capital (R), they determine the quantities of those inputs that will minimize their costs. In the second stage, these firms find both the optimal price of good j and the quantity that will be produced in accordance with this price.

Our goal at this stage is to minimize the cost of production,

[9] The production function employed to aggregate the intermediate goods is also referred to as a Dixit-Stiglitz aggregator (Dixit e Stiglitz, 1977).

$$\min_{L_{j,t},K_{p,j,t}} W_t L_{j,t} + R_t K_{p,j,t} \tag{18}$$

subject to the following technology,

$$Y_{j,t} = A_t K_{p,j,t}^{\alpha_1} L_{j,t}^{\alpha_2} K_{g,j,t}^{\alpha_3} \tag{19}$$

This technology is in line with that presented in Cassou and Lansing (1998), Lansing (1998), Baxter and King (1993) and Ambler and Paquet (1996), where they all introduce the public capital stock into the production function. Hence, $K_{g,t}$ is the stock of public capital, α_1, α_2, α_3 are the participation of private capital, of labor and of public capital in the production of good j, respectively[10], and A denotes productivity, whose law of motion is:

$$\log A_t = (1 - \rho_A) \log Ass + \rho_A \log A_{t-1} + \epsilon_{A,t} \tag{20}$$

where $\epsilon_{A,t}$ is an exogenous shock and ρ_A is the autoregressive component of the productivity shock.

The first order conditions are:

$$W_t = \mu_t \alpha_2 \frac{Y_{j,t}}{L_{j,t}} \tag{21}$$

$$R_t = \mu_t \alpha_1 \frac{Y_{j,t}}{K_{p,j,t}} \tag{22}$$

where μ is marginal cost (MC).

It may prove helpful to use the equation (21) to see the way some given changes affect the demand for labor[11].

It follows from that equation that a decrease in the real wage rate, W/P, leads to a higher quantity of labor demanded. When the real cost of hiring workers falls, firms expand employment until the reduction in the marginal product of labor exactly matches the decrease in W/P (Barro, 1997).

Likewise, an upward shift in the marginal product of labor schedule means a greater demand for labor at any given real wage rate. Employment rises until the decreasing marginal product of labor equals the real wage rate, W/P, again[12].

[10]If firms show constant returns to scale, $\alpha_1 + \alpha_2 + \alpha_3 = 1$, following Cassou and Lanzing (1998), corroborated by empirical studies from Aschauer (1989) and Ai and Cassou (1995).

[11]The same line of reasoning can be applied to private capital.

[12]We can summarize the results by writing:
$L^d = L^d \left[\left(\underset{(-)}{\frac{W}{P}} \right) \right]$

Equations (21) and (22) can combine to yield the following expression:

$$\frac{W_t}{R_t} = \left(\frac{\alpha_2}{\alpha_1}\right)\frac{K_{p,j,t}}{L_{j,t}} \tag{23}$$

2.2.3 Pricing *a la Calvo*

The wholesale firm decides how much to produce in each period according to the Calvo rule (Calvo, 1983) which states that in each period t, a fraction $0 < 1-\theta < 1$ of firms are randomly selected and allowed to choose the price of their good in that period, $P^*_{j,t}$. The remaining firms (the ratio θ) maintain the price set in the previous period ($P_{j,t} = P_{j,t-1}$).

The cost equation (CT),

$$CT_t = \left(\frac{Y_{j,t}}{A_t K^{\alpha_3}_{g,j,t}}\right)^{\frac{1}{\alpha_1+\alpha_2}} \left\{ W_t^{\frac{\alpha_2}{\alpha 1+\alpha_2}} R_t^{\frac{\alpha_1}{\alpha 1+\alpha_2}} \left[\left(\frac{\alpha_1}{\alpha_2}\right)^{\frac{\alpha_2}{\alpha_1+\alpha_2}} + \left(\frac{\alpha_2}{\alpha_1}\right)^{\frac{\alpha_1}{\alpha_1+\alpha_2}}\right]\right\}$$

Differentiating the total cost relative to output gives the nominal marginal cost:

$$\begin{aligned} MC_t = & \left(\frac{1}{\alpha_1+\alpha_2}\right) Y_{j,t}^{\frac{\alpha_3}{\alpha_1+\alpha_2}} \left(\frac{1}{A_t K^{\alpha_3}_{g,j,t}}\right)^{\frac{1}{\alpha_1+\alpha_2}} \\ & W_t^{\frac{\alpha_2}{\alpha 1+\alpha_2}} R_t^{\frac{\alpha_1}{\alpha 1+\alpha_2}} \left[\left(\frac{\alpha_1}{\alpha_2}\right)^{\frac{\alpha_2}{\alpha_1+\alpha_2}} + \left(\frac{\alpha_2}{\alpha_1}\right)^{\frac{\alpha_1}{\alpha_1+\alpha_2}}\right] \end{aligned} \tag{24}$$

The marginal cost represents the cost, relative to each input, of producing an additional unit of the intermediate good. It should be noted that an increase in productivity (A) or/and in the public capital stock (K_g) reduce the marginal cost. A lower marginal cost causes the supply of goods ($Y_{j,t}$) to rise.

The wholesale firm has a probability θ to keep the price of the good fixed in the next period and a probability $(1-\theta)$ to set the price optimally. Once the price has been set in period t, there is the probability θ that this price will remain fixed in period t+1, a probability θ^2 that this price will remain fixed in period t+2, and so on. Accordingly, this firm should take into account these probabilities when setting the price of its own good.

The problem of the firm that adjusts the price of the good in period t is:

$$\max_{P^*_{j,t}} E_t \sum_{i=0}^{\infty} (\beta\theta)^i \left[P^*_{j,t} Y_{j,t+i} - R_{t+i} K_{j,t+i} - W_{t+i} L_{j,t+i}\right] \tag{25}$$

where θ is the parameter governing price rigidity and $P^*_{j,t}$ the optimal price set by the firm. Equation (40) is the discounted profit of the firm during the period over

where L^d is labor demand.

which the price ($P_{j,t}^*$) will be kept fixed.

The following first order condition is obtained by rearranging further the preceding equation:

$$P_{j,t}^* = \frac{\varphi}{\varphi - 1} E_t \sum_{i=0}^{\infty} (\beta\theta)^i MC_{t+i} \tag{26}$$

Combining now the pricing rule (17) with the assumption that all price-changing firms set an equal price and that price-maintaining firms leave the price unaffected yields the overall final price:

$$P_t = \left[\theta P_{t-1}^{1-\varphi} + (1-\theta) P_t^{*1-\varphi}\right]^{\frac{1}{1-\varphi}} \tag{27}$$

Dividing both sides by P_{t-1},

$$\pi_t = \left[\theta + (1-\theta)\left(\frac{P_t^*}{P_{t-1}}\right)^{1-\varphi}\right]^{\frac{1}{1-\varphi}} \tag{28}$$

where $\pi = \frac{P_t}{P_{t-1}}$ is the gross inflation rate between t-1 and t. It is worth noticing that, as shown below, all firms will choose the same price because they face an identical problem. It follows from (28) that in a steady state with zero inflation ($\pi = 1$), $P_t^* = P_{t-1} = P_t$ for all t.

The equation derived from the combination of (26) and (28) is referred to as the New Keynesian Phillips curve. Briefly, inflation will increase if marginal costs rise.

2.3 Government

In this section the government is introduced into the model. Its main role is to provide public goods and services. These expenditures must be paid for through taxation and/or borrowing[13]. Another major goal of this economic agent is to achieve price stability. The principal tool for accomplishing this latter objective is monetary policy. Hence, in order to account for both aforesaid roles which the government is usually taken to play in modern economies, we distinguish between two subsectors: Fiscal Authority and Monetary Authority.

2.3.1 Fiscal Authority

The government collects taxes and issues bonds to finance its spending on goods and services. Therefore, the public debt dynamics is captured by the following rule:

[13] A third way to finance public spending is by printing money, but we do not allow the latter to have a role in this paper.

$$\frac{B_{t+1}}{RIS_t R_t^B} - B_t = TS_t - TAX_t \tag{29}$$

where TS and TAX are total public spending and tax revenue, respectively.

As intuition would dictate, total government spending TS is known to be sensitive to the size of the public debt, (B_t), relative to its steady-state level, (B_{ss}).In other words, the former variable can be thought to have an automatic stabilizing property (Lim and McNelis, 2008):

$$TS_t - TS_{ss} = \chi(B_t - B_{ss}) \tag{30}$$

where χ is the sensitivity of total public spending relative to the size of the public debt.

The total government spending is given by:

$$TS_t = G_t P_t + I_{g,t} P_t + TRANS_t \tag{31}$$

where G, $I_{g,t}$ and $TRANS$ are current spending, public investment and income transfers, respectively.

These spending items behave according to the following rules:

$$G_t = \xi_G S_t^G Y_t \tag{32}$$

$$\log S_t^G = (1 - \rho_G) \log S_{ss}^G + \rho_G \log S_{t-1}^G + \epsilon_{G,t} \tag{33}$$

$$I_{g,t} = \xi_{I_g} S_t^{I_g} Y_t \tag{34}$$

$$\log S_t^{I_g} = (1 - \rho_{I_g}) \log S_{ss}^{I_g} + \rho_{I_g} \log S_{t-1}^{I_g} + \epsilon_{I_g,t} \tag{35}$$

$$\frac{TRANS_t}{P_t} = \xi_{Tr} S_t^{Tr} Y_t \tag{36}$$

$$\log S_t^{Tr} = (1 - \rho_{Tr}) \log S_{ss}^{Tr} + \rho_{Tr} \log S_{t-1}^{Tr} + \epsilon_{Tr,t} \tag{37}$$

where $\epsilon_{G,t}$, $\epsilon_{I_g,t}$ and $\epsilon_{Tr,t}$ are exogenous shocks, and ρ_G, ρ_{I_g} and ρ_{Tr} are the autoregressive components of current public spending, of public investment and of income transfers, respectively.

The stock of public capital obeys the following law of motion:

$$K_{g,t+1} = (1-\delta_g)K_{g,t} + I_{g,t} \tag{38}$$

We now turn to exploring alternative ways of taxation. An actual possibility would be the one whereby tax revenue behaves as:

$$TAX_t = \tau_c \phi_t^c P_t (C_t + I_{p,t}) + \tau_l \phi_t^l W_t L_t + \tau_k \phi_t^k R_t K_{p,t} \tag{39}$$

2.3.2 Monetary Authority

The Central Bank's task is twofold: to foster output growth and to attain price stability. In order to accomplish this dual goal, it pursues a simple Taylor rule.

$$\frac{R_t^B}{R_{ss}^B} = \left(\frac{R_{t-1}^B}{R_{ss}^B}\right)^{\eta} \left[\left(\frac{Y_t}{Y_{ss}}\right)^a \left(\frac{\pi_t}{\pi_{ss}}\right)^b\right]^{(1-\eta)} S_t^M \tag{40}$$

where S_t^M is a monetary shock, η is a smoothing parameter which allows lagged interest rates to play a significant role in the determination of the current interest rate, (a) and (b) are coefficients measuring the sensitivity of the basic interest rate to output and to the inflation rate, respectively.

The monetary shock takes the following form:

$$\log S_t^M = (1-\rho_M)\log S_{ss}^M + \rho_M S_{t-1}^M + \epsilon_{M,t} \tag{41}$$

where $\epsilon_{M,t}$ and ρ_M are exogenous shocks and the autoregressive components of the monetary authority.

2.4 Goods Market Equilibrium Condition

To close the model, one step further is required: we need to explicitly set up the good market equilibrium condition. This states that aggregate production Y_t is demanded by households (C_t and I_t) and the government (G_t):

$$Y_t = C_t + I_t + G_t \tag{42}$$

3 Data

We then proceed to estimate the model using quarterly data spanning from 2003Q1 to 2013Q4 (44 data points). We use 11 model variables as observables (P, $TRANS$, Ig, RTL, RTKp, RTC[14], R^B, Y, G, C and L) which they are described in the Table

[14] $RTL = \tau_l WL$, $RTKp = \tau_k RKp$ and $RTC = \tau_c(C + Ip)$.
where RTL, RTKp and RTC are revenue collected from the taxes on labor income, on capital gains and

1. We have chosen this set of observables due to data availability and their relevance to our research purposes. Furthermore, a large set of observables mitigates the problem of identification.

Before estimating the model, we engage in deflating the data using the IPCA, de-trending and seasonally adjusting non-stationary series, and applying first log-differences[15]. Figure 1 provides the graphs of the series after these transformations.

Table 1: Observable variables of the model.

Variable	Series	Source
P	Series constructed using the IPCA (%a.m.)	IBGE/SNIPC
TRANS	Benefícios assistenciais (LOAS e RMV) R$ (milhões)	Min. Fazenda/STN
Ig	Custeio e investimento - R$ (milhões)	Min. Fazenda/STN
RTL	IR - pessoas físicas R$ (milhões)	Min. Fazenda/SRF
RTKp	IR - pessoas jurídicas R$ (milhões)	Min. Fazenda/SRF
RTC	ICMS and IPI R$ (milhões)	Min. Fazenda/SRF
R^B	Selic Over (% a.m.)	BCB Boletim/M. Finan.
Y	PIB - preços de mercado - R$ (milhões)	IBGE/SCN 2000 Trim.
G	Consumo final - adm. pública - R$ (milhões)	IBGE/SCN 2000 Trim.
C	Consumo final - famílias - R$ (milhões)	IBGE/SCN 2000 Trim.
L	Horas pagas - indústria - índice (mídia 2006 = 100)-SP	Fiesp

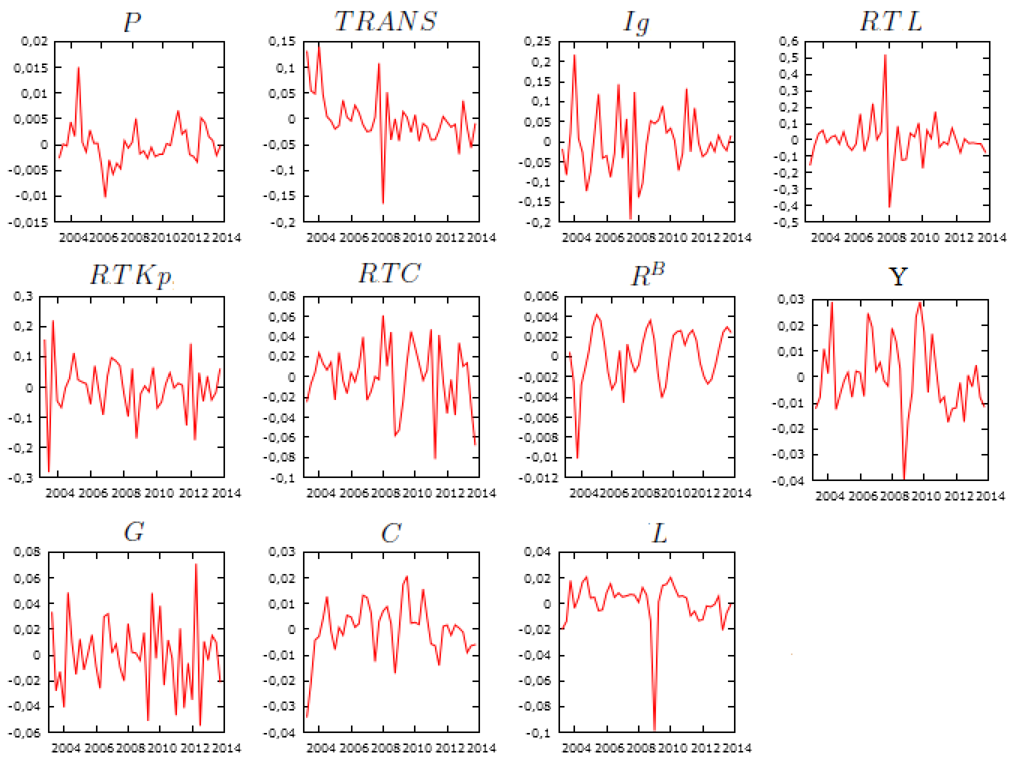

Figure 1: Data series (after transformation).
Source: Prepared by the authors.

on consumption.

[15] $\widetilde{X_t} = \ln\left(\frac{X_t}{X_{t-1}}\right)$

4 Calibrated Parameters and Prior

In this section we pursue a two-tier approach: the parameters not directly related to the questions which we endeavor to answer throughout this article are calibrated, while those relevant parameters for the analysis of the shock propagation are estimated using the Bayesian methodology. The main calibration procedure employed here is to pick up the values of parameters from other relevant articles in the DSGE model literature.

Cavalcanti and Vereda (2010) analyze the dynamic properties of a DSGE model for Brazil under alternative parameterizations and identify 'allowable ranges' of values for some of the key parameters in the literature. In this regard, we resort to making use of those parameters from their study that coincide with ours which turn out to be the discount factor (β), the coefficient of relative risk aversion (σ), and the marginal disutility of labor (ψ).

In addition, the parameters governing the structure of the firms draw on two studies, the index of price stickiness (θ) and the elasticity of substitution between intermediate goods (φ) were sourced from Lim and McNelis (2008). The shares of private capital (α_1), of labor (α_2) and of public capital (α_3) in total output were obtained from Mussolini (2011). Table 2 summarizes the calibration of the parameters.

Table 2: Calibration of the Parameters.

Parameters	Value	Source
β	0,985	Cavalcanti and Vereda (2010)
σ	2	Cavalcanti and Vereda (2010)
ψ	1,5	Cavalcanti and Vereda (2010)
α_1	0,32	Mussolini (2011)
α_2	0,6	Mussolini (2011)
α_3	0,08	Mussolini (2011)
θ	0,85	Lim and McNelis (2008)
φ	6	Lim and McNelis (2008)

The values of the priors were chosen as follows: we relied on Araújo and Ferreira (1999) as regards taxation parameters. These authors aimed at computing the ratio of each type of tax considered, and of related variables, to GDP. Concerning the consumption tax rate (τ_c), $\tau_c C = 0,1282Y$, with $C/Y = 0,8045$, resulting in $\tau_c = 0,1594$. As for the capital gains tax (τ_k), $\tau_k RK = 0,0399Y$, with $R = 0,1647$ and $K/Y = 2,98$, arriving at $\tau_k = 0,0813$. With regard to taxation on labor income (τ_l), $\tau_l WL = 0,0881$, with $WL/Y = 0,5092$, coming up with $\tau_l = 0,1730$. And finally, the coefficient associating government spending with the public debt (χ) was taken from Lim e McNelis (2008).

We used the series *Benefícios Assistenciais (LOAS e RMV), Custeio e Investimento, Consumo Final - Adm. Pública and PIB - Preços de Mercado* to calculate the parameters values of ω_G, ξ_g, ξ_{Ig} and ξ_{Tr} using the relationship $I_g/I = 0,19$, $G/Y = 0,2$, $I_g/Y = 0,05$ and $TRANS/Y = 0,007$, respectively. Furthermore, the rate of capital depreciation (δ_p) (using the same value for the rate of public depreciation (δ_g)) was sourced from Cavalcanti and Vereda (2010).

On the monetary side, for the case of the parameters relating the basic interest rate to output (a) to the inflation rate (b) plus the interest smoothing parameter (eta) we rested on Castro et al (2011). The autoregressive components (ρ_R, ρ_A, ρ_{sc}, ρ_{sl}, ρ_c, ρ_l, ρ_k, ρ_M, ρ_G, ρ_{I_g} and ρ_{Tr}) and exogenous shocks (ϵ_R, ϵ_A, ϵ_{sc}, ϵ_{sl}, ϵ_c, ϵ_l, ϵ_k, ϵ_M, ϵ_G, ϵ_{I_g} and ϵ_{Tr}), draw on Castro et al (2011)[16]. Table 3 displays the prior distribution of the model.

Table 3: Prior distribution of the model.

Parameters	Distribution	Average	Standard Deviation	Source
τ_c	gamma	0,1594	0,1	Ara?jo and Ferreira (1999)
τ_k	gamma	0,0813	0,04	Ara?jo and Ferreira (1999)
τ_l	gamma	0,1730	0,1	Ara?jo and Ferreira (1999)
χ	beta	0,1	0,05	Lim and McNelis (2008)
ω_G	beta	0,19	0,08	Authors
ξ_g	beta	0,2	0,015	Authors
ξ_{Ig}	beta	0,05	0,005	Authors
ξ_{Tr}	beta	0,007	0,002	Authors
δ_p	beta	0,025	0,002	Cavalcanti and Vereda (2010)
δ_g	beta	0,025	0,01	Cavalcanti and Vereda (2010)
a	gamma	0,16	0,2	Castro et al (2011)
b	gamma	2,43	0,5	Castro et al (2011)
η	beta	0,79	0,09	Castro et al (2011)
ρ_A	beta	0,5	0,1	Castro et al (2011)
ρ_{sc}	beta	0,5	0,1	Castro et al (2011)
ρ_{sl}	beta	0,5	0,1	Castro et al (2011)
ρ_c	beta	0,5	0,1	Castro et al (2011)
ρ_l	beta	0,5	0,1	Castro et al (2011)
ρ_k	beta	0,5	0,1	Castro et al (2011)
ρ_G	beta	0,5	0,1	Castro et al (2011)
ρ_{I_g}	beta	0,5	0,1	Castro et al (2011)
ρ_{Tr}	beta	0,5	0,1	Castro et al (2011)
ρ_R	beta	0,5	0,1	Castro et al (2011)
ρ_M	beta	0,5	0,1	Castro et al (2011)
ϵ_A	invgamma	1	inf	Castro et al (2011)
ϵ_{sc}	invgamma	1	inf	Castro et al (2011)
ϵ_{sl}	invgamma	1	inf	Castro et al (2011)
ϵ_c	invgamma	1	inf	Castro et al (2011)
ϵ_l	invgamma	1	inf	Castro et al (2011)
ϵ_k	invgamma	1	inf	Castro et al (2011)
ϵ_G	invgamma	1	inf	Castro et al (2011)
ϵ_{I_g}	invgamma	1	inf	Castro et al (2011)
ϵ_{Tr}	invgamma	1	inf	Castro et al (2011)
ϵ_R	invgamma	1	inf	Castro et al (2011)
ϵ_M	invgamma	1	inf	Castro et al (2011)

[16]Castro *et al.*(2011) chose the same mean value and standard deviation for the autoregressive component and for the stochastic shocks.

4.1 Posterior Values

Given the prior distributions of the parameters, we estimate the posterior distributions using a Markov chain process via the Metropolis-Hastings algorithm with 1.000.000 iterations, a scale value 0,4 to be used for the jumping distribution, and 2 parallel chains for Metropolis-Hastings algorithm. The results of the Bayesian estimation are shown in Table 4 and Figure 2.

Table 4: Posterior distribution of the model. Source: Prepared by the authors.

Parameter	prior mean	post. mean	90% HPD interval	prior	pstdev
Fiscal Parameters					
ω_G	0,190	0,0679	0,0189 0,1193	beta	0,08
τ_c	0,159	0,1814	0,1319 0,2298	gamma	0,1
τ_k	0,081	0,0223	0,0074 0,0360	gamma	0,0400
τ_l	0,173	0,0361	0,0078 0,0635	gamma	0,1
ξ_g	0,200	0,5419	0,5057 0,5807	gamma	0,1500
ξ_{Ig}	0,050	0,0376	0,0327 0,0425	gamma	0,0050
ξ_{Tr}	0,007	0,0073	0,0048 0,0095	gamma	0,0020
χ	0,100	0,1800	0,1279 0,2284	beta	0,0500
Autoregressive Components					
ρ_{sc}	0,5	0,4508	0,3533 0,5495	beta	0,1
ρ_{sl}	0,5	0,5754	0,4663 0,6899	beta	0,1
ρ_G	0,5	0,4491	0,3349 0,5630	beta	0,1
ρ_{I_g}	0,5	0,4289	0,3378 0,5240	beta	0,1
ρ_{Tr}	0,5	0,6294	0,4823 0,7636	beta	0,1
ρ_M	0,5	0,3566	0,2761 0,4334	beta	0,1
ρ_R	0,5	0,2095	0,1322 0,2851	beta	0,1
ρ_c	0,5	0,4535	0,3655 0,5318	beta	0,1
ρ_l	0,5	0,5022	0,3539 0,6731	beta	0,1
ρ_k	0,5	0,5081	0,3903 0,6200	beta	0,1
ρ_A	0,5	0,5670	0,4552 0,7088	beta	0,1
Exogenous Shocks					
ϵ_G	1	0,1315	0,1176 0,1465	invg	Inf
ϵ_{I_g}	1	0,1486	0,1217 0,1726	invg	Inf
ϵ_{Tr}	1	0,1423	0,1177 0,1628	invg	Inf
ϵ_c	1	0,2115	0,1478 0,2718	invg	Inf
ϵ_l	1	0,4021	0,2063 0,5956	invg	Inf
ϵ_k	1	0,5335	0,2348 0,8298	invg	Inf
ϵ_A	1	0,1304	0,1176 0,1443	invg	Inf
ϵ_{sc}	1	0,2017	0,1570 0,2446	invg	Inf
ϵ_{sl}	1	0,2039	0,1632 0,2429	invg	Inf
ϵ_M	1	0,2089	0,1541 0,2649	invg	Inf
ϵ_R	1	0,1330	0,1176 0,1488	invg	Inf
Others					
δ_p	0,025	0,0263	0,0248 0,0280	beta	0,002
δ_g	0,025	0,0255	0,0073 0,0457	beta	0,01
η	0,790	0,9844	0,9791 0,9899	beta	0,09
a	0,160	0,9619	0,7216 1,2320	gamma	0,2
b	2,430	2,5356	1,9187 3,0266	gamma	0,5

These graphs are especially relevant in that they present key results, but they can also serve as tools to detect problems or build additional confidence in one's results. First, the prior and the posterior distribution should not be excessively different from one another. Second, the posterior distributions should be close to normal, or at least not display a shape that is clearly non-normal. Third, the green mode should not be too far away from the mode of the posterior distribution.

It is worth stressing that the overall result was satisfactory. Nevertheless, by concentrating on the fiscal area, since it constitutes the target of our work, we are able to further discriminate against the distinct performance of each fiscal parameter under study. Thus, τ_c, τ_k, τ_l, ξ_g, ξ_{Tr} and χ were found to perform greatly (they all have normal distributions and their prior values do not differ considerably from the posteriors), while ω_G, ξ_{Ig} showed only acceptable results.

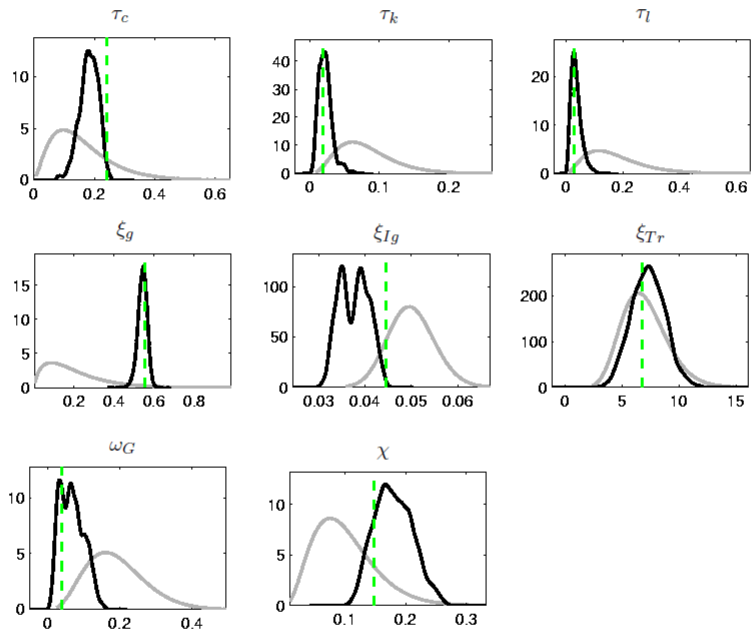

Figure 2: Priors and posteriors for τ_c, τ_k, τ_l, ξ_g, ξ_{Ig}, ξ_{Tr}, ω_G and χ.
Source: Prepared by the authors.

5 Results

This section analyzes the dynamic properties of the model by focusing on the variance decomposition of the GDP and the fiscal multipliers.

5.1 Variance Decomposition

One way to assess the effects of the different shocks on GDP fluctuations is to look into the decomposition of these shocks (Figure 3).

Point A in Figure 6 indicates the recovery point of the Brazilian GDP after the 2008 crisis. Here, we seek to ascertain whether, and to what extent, the fiscal policy measures implemented by the Brazilian government in order to combat the fall in aggregate demand were successful in boosting output.

In a nutshell, within the set of expansionary fiscal measures conducted by the Brazilian government in the aftermath of the international financial crisis, the reduction in the consumption tax could be deemed as the only shock whose effects on output were non-neutral. In fact, this tax cut sparked (or played an important role in) the economic recovery right after the crisis, in the period ranging from 2009:3 up to 2011:4, although these positive effects died out thereafter, and even became negative between 2012 and 2013, thereby contributing to dragging GDP growth down in the last two years of our study.

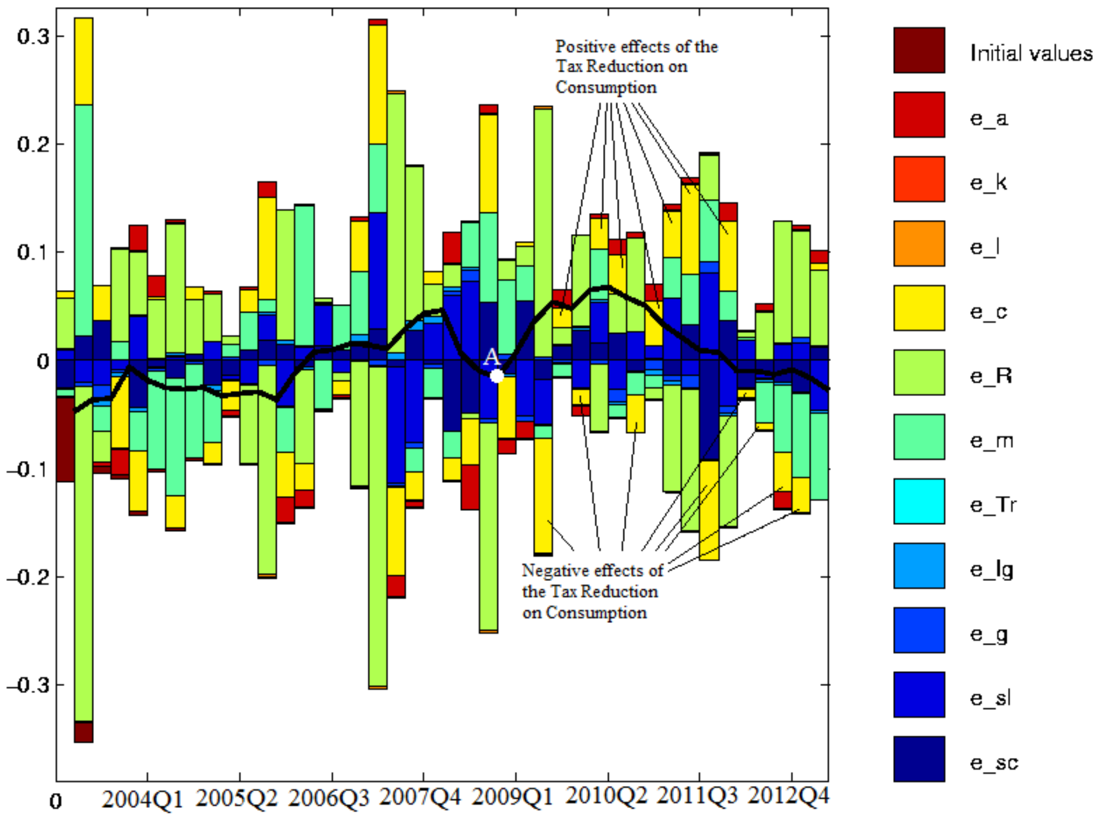

Figure 3: GDP Variance Decomposition
Source: Prepared by the authors.

5.2 Fiscal Multipliers Analysis

After having carried out a qualitative examination of the fiscal policy outcomes in the preceding section, we now turn to gauging the effects of each fiscal measure from a quantitative perspective.

Table 5 exhibit the analysis of the fiscal multipliers, whereas Figure 4 illustrates the impulse response functions of GDP for each fiscal shock. The calculations were performed at different forecasting horizons, namely two quarters, six quarters and twelve quarters. We also computed the cumulative response of output to each fiscal measure. In the first two quarters, the multipliers of those policies with a greater impact on consumption (reduction in the consumption tax and government consumption) yielded the highest results, 0,1601 and 0,1910, respectively. In contrast, supply-side fiscal policies (tax cuts on income received by production factors and public investment) had negative or no effects on economic activity.

Table 5: Fiscal Multipliers Results. Source: Prepared by the authors.

quarters	Mult_c	Mult_l	Mult_k	Mult_g	Mult_{Ig}	Mult_{Tr}
2	0,1601	-0,0003	0,0010	0,1910	-0,0202	0,0
6	-0,0958	0,0063	-0,0005	0,1667	-0,0122	0,0
12	-0,1016	0,0069	-0,0005	0,0830	0,0015	0,0
total	-0,0774	**0,0081**	-0,0003	-0,2281	**0,0960**	0,0

$Mult_c$=Fiscal Multiplier - tax reduction on consumption;
$Mult_l$=Fiscal Multiplier - tax reduction on labor income;
$Mult_k$=Fiscal Multiplier - tax reduction on capital income;
$Mult_g$=Fiscal Multiplier - government consumption;
$Mult_{Ig}$=Fiscal Multiplier - public investment; and
$Mult_{Tr}$=Fiscal Multiplier - income transfer to households.

However, when the time horizon was extended to six quarters, the multiplier on the consumption-tax cut ceased to be positive (-0,0958), and reached a value of -0,0774 when its cumulative effects were accounted for. Interestingly, the government-consumption multiplier during the first twelve quarters remained positive, but also presented a negative cumulative effect (-0,2281). On the other hand, the multipliers on tax reduction on labor income and government investment were initially negative, but they delivered positive cumulative effects, 0,0081 and 0,0960, respectively.

Finally, the multipliers of the tax reduction on capital income and of income transfers to households showed irrelevant results.

A second step in this section is to put these above results into an international context by comparing them to the ones presented by Ilzetzki *et al.* (2013). As these authors point out, government investment in developing and emerging countries tends to give rise to high and positive fiscal multipliers, both on impact and in the long run. Our study confirms this last fact (although we find that these cumulative effects are actually lower than 1), but it fails to capture the positive effect on output on impact.

As far as government purchases in an emerging economy, these authors underscore that their associated multipliers, both on impact and in the long run, should be negative, provided the country involved is a small open economy operating flexible exchange rates and suffering from a sufficiently high degree of public indebtedness. Our findings do not completely match theirs, for our multiplier on impact turns out to be positive. This might be due to the fact that Brazil is deemed as one of the most closed emerging economies and it benefits from a large domestic market as well. This feature might be more than offsetting the others favoring a negative short-run multiplier. As Ilzetzki *et al.* (2013) put it: "Economies that are relatively closed (whether due to trade barriers or larger internal markets) have long-run multipliers of around 1, but relatively open economies have negative multipliers". It should be acknowledged though that the short-run government-consumption multiplier that our model delivers falls short of 1.

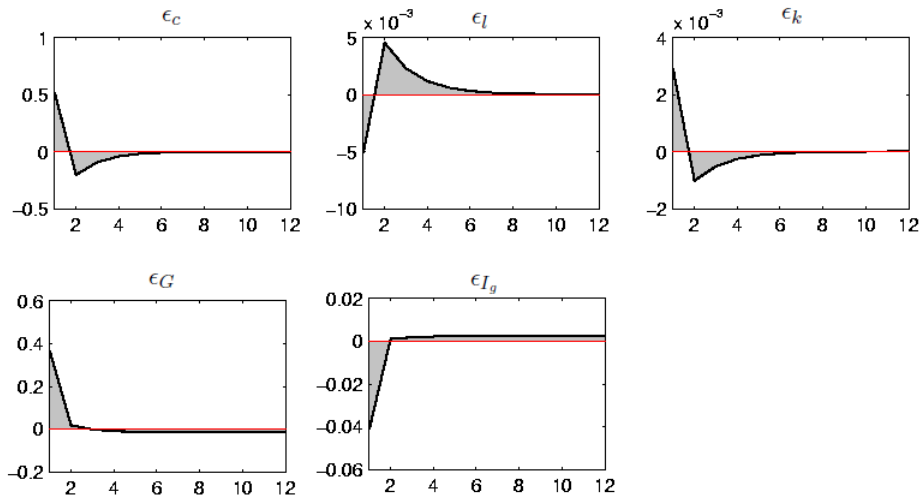

Figure 4: Impulse-responses to fiscal shocks.
Source: Prepared by the authors.

6 Conclusions

This article intended to make a contribution to the discussion about the effects of the Brazilian fiscal policy after the 2008 crisis. In this vein, a variance decomposition for Brazilian GDP as well as a multiplier analysis of each fiscal shock were undertaken under the framework of a New Keynesian model.

The first exercise underlined that the tax reduction on consumption emerged as one of the most important factors kicking-start the economic recovery after the crisis, but also emphasized that these positive effects were short-lived, and that this policy measure eventually became a drag that hindered growth and contributed to the poor performance of the Brazilian economy over the years 2012 and 2013.

As for the analysis of fiscal multipliers, public investment was found to be the most effective fiscal policy measure in the long term (total multiplier of 0,096), whereas those policies that appear to have been the preferred ones of the incumbent government, that is to say, those impacting consumption more heavily, like consumption-tax cuts and government spending, brought about long-run negative fiscal multipliers.

At the same time, we also carried out a comparison between our government-spending multipliers results and the stylized facts applied to the emerging markets displayed by Ilzetzki *et al.* (2013). The Brazilian economy seems to fare as expected when it comes to government investment in the long run (although the size of the multiplier is considerably lower than the value found by those authors, roughly 1). With regard to the government-consumption multiplier, our results are correctly signed in the long run but not on impact, according to the referred article.

In sum, according to our model, the success of fiscal policies in increasing consumption is guaranteed only in the very short run. If the government were to achieve long-lasting results, it should resort to public investment as a stimulus policy. Finally, it is worth mentioning that all the fiscal multipliers studied were found to be less than one, contrary to what the traditional Keynesian models predict (IS-LM model and its relatives, Mundell-Fleming and AS-AD).

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