TAX REDUCTION POLICIES AND ITS IMPACTS ON BRAZILIAN ECONOMY

POLÍTICAS DE REDUÇÃO DE IMPOSTOS E SEUS IMPACTOS SOBRE A ECONOMIA BRASILEIRA

Celso José Costa Junior[*]
Armando Vaz Sampaio[**]

ABSTRACT:
There is a widespread feeling in Brazilian society that tax reform has become necessary. Analysts seek to mitigate the perverse impact of taxation on economic efficiency and competitiveness of the productive sector. In view of this, the objective of this work is to contribute to the discussion about tax reduction of the income taxes through a DSGE model. To achieve this purpose, two stochastic shocks will be analyzed in the tax rates changes on labor income and capital income. The main result of these simulations concerns the tax reduction on labor income. Output grew remarkably as a result, and it occurred along with increases in consumption, declines in government revenues, as well as with rises in the quantities of factors of production (capital and labor).
Keywords: DSGE Models. Tax Reduction. Simulation.

JEL Classification: C63, E37, E62

RESUMO:
Há uma sensação generalizada na sociedade brasileira de que a reforma tributária se tornou necessária. Os analistas procuram suavizar o impacto perverso da tributação sobre a eficiência econômica e a competitividade do setor produtivo. Diante disso, o objetivo deste trabalho é contribuir para a discussão sobre a redução tributária dos impostos sobre o rendimento através de um modelo DSGE. Para tanto, serão analisados dois choques estocásticos nas variações das alíquotas tributárias, sobre a renda do trabalho e renda de capital. O principal resultado destas simulações diz respeito à redução do imposto sobre o rendimento do trabalho. Como resultado, a produção cresceu notavelmente e ocorreu junto com aumentos no consumo, declínios nas receitas governamentais, bem como com aumentos nas quantidades de fatores de produção (capital e mão-de-obra).
Palavras-chave: Modelos DSGE. Redução Fiscal. Simulação.

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1 INTRODUCTION

Few topics were more discussed by Brazilian economists that the tax reforms of this country. The general feeling is that the Brazilian Constitution of 1988 initially created a system of insufficient funding for the size of the state. Because of this, the government had to create a series of taxes to supplement state funding without much concern about economic rules of taxation. The main result of this policy was a tax system that adversely affects the competitiveness of the productive sector, among other factors.

The tax literature shows significant differences between the tax reforms in many countries in recent decades. Sandford (1993) contributed a summary listing common elements including reducing the number of tax rates and their maximum marginal value in the income tax of individuals; reduction in the aliquots of corporations; and an increased share of consumption taxes rather than income taxes.

Following this trend, this work aims to contribute to the discussion on tax reforms analyzing tax reductions of the income taxes through a DSGE model. To achieve this purpose, two stochastic shocks will be analysed: the shock from the tax rate on labor income; and the

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[*] Professor da Escola de Economia de São Paulo, EESP-FGV. E-mail: cjcostaj@yahoo.com.br
[**] Professor da Universidade Federal do Paraná - UFPR. E-mail: avsampai@uol.com.br

shock from the tax rate on capital income. Briefly, the question that the paper seeks to answer is: would it be better to have a tax reduction in the income tax on labor or income tax on capital?

There is extensive literature about the possible impact of tax reforms in Brazil: Cavalcanti and Silva (2010); Santana, Cavalcanti and Paes (2012); Paes and Bugarin (2006); Pereira and Ferreira (2010); Araújo and Ferreira (1999); Lledo (2005); and Fochezatto and Salami (2009) evaluated the impacts of proposed reforms in the national tax system. Menezes and Barreto (1999) and Teles and Andrade (2006) simulated the combined effects of tax and pension reforms. The literature cited was basically built using models of overlapping generation (OLG[1]). Instead, this work seeks to contribute to the discussion using a DSGE model. Since this method analyzes the problem stochastically while the other approach is limited to study deterministic changes.

The 1980s has witnessed a major breakthrough in the field of macroeconomic modeling. The first examples of this new methodology emerged from the models of real business cycles (RBC), primarily through the groundbreaking work of Kydland and Prescott (1982). Its builders were criticized for focusing the analysis on only one type of shock in a kind of economic structure and for not recognizing any active role for monetary policy. Therefore from the perspective of a central bank, it was difficult to see how these models could bring any positive contribution to the discussion of monetary policy.

Twenty years later, this controversy was completely dissipated. The main reason was that the methodological innovation overlying the RBC models brought the introduction of frictions that allowed the incorporation of Keynesian principles and new shocks to the initial modeling. The success of this new model made it possible for the main economic institutions to develop their own DSGE models as did Central Bank of Brazil (SAMBA), European Central Bank (NAWM), Bank of Canada (Totem), Bank of England (BEQM), Bank of Japan (JEM), Bank of Chile (MAS), European Community (QUESTIII) and the International Monetary Fund (GEM)). Nowadays, DSGE models are used to answer almost any behavior of an economic phenomenon, including issues related to fiscal policy.

This work begins with this introduction and section two presenting the economic model, with section three detailing the calibration process of the model structural parameters. The work continues with the results in section 4 and ends with the conclusions in section 5.

2 THE MODEL

The economic model of this work is a small and closed economy with sectors for households (Ricardian and Non-Ricardian), firms, and government (Fiscal Authority, Social Security and Monetary Authority). Besides the inclusion of non-Ricardian agents, this model has two other frictions: monopolistic competition and staggered pricing *a la Calvo*. The latter friction aims to avoid the model to have a very fast adjustment in relation to shocks, a factor noticed in empirical evidence.

2.1 Households

The household sector is divided into two types of representative agents: Ricardian, and non-Ricardian. The Ricardian household represents the active workers who are the contributors to the pension system, forming a fraction of a $(1-\omega)$ of the total population, while the non-Ricardian household features the inactive workers (retirees) formed by the

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[1] *Overlapping generations models* is a modelling type that uses representative agents who live a long enough finite period of time to overlap with at least one period of life to another agent.

remaining proportion of the population. The first type of household is able to maximize its intertemporal utility by choosing consumption, savings, investment and leisure. For saving, the household can choose between two different savings instruments - physical capital and government bonds. Briefly, with the disposable income after payment of taxes, the Ricardian household can purchase consumer goods, capital goods, and/or government bonds. On the other hand, the non-Ricardian household just allocates its income (social security benefits) in the acquisition of consumer goods.

2.1.1 Ricardian Households (R) - Workers Active (Taxpayers)

Relying on the behavior described about the households, the Ricardian agent chooses how much to consume, how much to work and how much to acquire financial assets and physical capital to maximize the discounted stream of the expected utility,

$$\max E_t \sum_{t=0}^{\infty} \beta^t S_t^C \left[\frac{C_{R,t}^{1-\sigma}}{1-\sigma} - S_t^L \frac{L_t^{1+\psi}}{1+\psi} \right] \tag{1.1}$$

subject to their budget constraint,

$$P_t \left(1 + \tau_C\right)\left(C_{R,t} + I_t\right) + \frac{B_{t+1}}{R_t^B} = W_t L_t \left(1 - \tau_l \phi_t^l - \tau_p\right) + R_t K_t \left(1 - \tau_k \phi_t^k\right) + B_t \tag{1.2}$$

and in relation to the following law of motion of capital,

$$K_{t+1} = \left(1 - \delta\right) K_t + I_t \tag{1.3}$$

where E is the expectations operator, β is the intertemporal discount factor, C_R is the consumption of Ricardian household, L is the labor, S^C is the intertemporal consumption 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.

In the budget constraint, P is the general price level, I is the investment, B is the government bond maturing in one period, R^B is the rate of return on government bond (basic interest rate), W is the wage, R is the return to capital, K is the stock of capital, ϕ^l and ϕ^k are the stochastic components of the income tax on labor and income tax on capital, respectively. While $\tau_C, \tau_l, \tau_k, \tau_p$ represent the static components of the tax on consumption, income tax on labor, income tax on capital and on social security contribution, respectively. In this work, is being adopted the convention that B_t is the nominal bond issued in (t-1) and matured in t. Then, B_{t+1} and K_{t+1} are decided in t.

The Ricardian household purchases of consumer goods and investment goods at the price level, also buys or sells government bonds maturing in one period. These bonds pay a risk-free rate, which is also controlled by the monetary authority.

This kind of household pays three types of taxes (consumption tax, income tax on labor and income tax on capital) and also contributes to social security. Its income comes from three sources: labor income, which depends on the level of nominal wages; return on capital rental to firms, which is a function of the rate of return to capital; and income from government bonds acquired in the previous period.

The first order conditions associated household's problem are:

$$S_t^L L_t^\psi C_{R,t}^\sigma \left[\frac{(1 + \tau_C)}{(1 - \tau_l \phi_t^l - \tau_p)} \right] = \frac{W_t}{P_t} \tag{1.4}$$

$$S_t^L C_{R,t}^{-\sigma} = \beta E_t \left\{ S_{t+1}^L C_{R,t+1}^{-\sigma} \left[(1 - \delta) + \frac{R_{t+1}}{P_{t+1}} \left(\frac{1 - \tau_k \phi_{t+1}^k}{1 + \tau_C} \right) \right] \right\} \tag{1.5}$$

$$\frac{S_t^L C_{R,t}^{-\sigma}}{P_t} = R_t^B \beta E_t \left(\frac{S_{t+1}^L C_{R,t+1}^{-\sigma}}{P_{t+1}} \right) \tag{1.6}$$

2.1.2 Non-Ricardian Households (NR) - Workers Inactive (Retired)

Non-Ricardian agents[2] have a simpler behavior. Because they do not maximize their intertemporal utility, their consumption is limited to the value of the pension benefit received (PEN). Under this hypothesis:

$$P_t(1 + \tau_C)C_{NR,t} = PEN \tag{1.7}$$

2.1.3 Aggregate Consumption

The aggregate consumption of this work follows the functional form $[C = (1 - \varpi)C_R + \varpi C_{NR}]$ very common in this type of literature (Boscá et al, 2010; Galí et al, 2007; Itawa, 2009; Coenen and Straub, 2004; Furlanetto, 2007; Dallari, 2012; Mayer et al, 2010; Stahler and Thomas, 2011; Swarbrick, 2012; Motta and Tirelli, 2010; Díaz, 2012; Colciago, 2011; Mayer and Stahler, 2009; and Forni et al, 2009).

Thus, aggregate consumption of the individuals Ricardian and non-Ricardian is performed as follows:

$$C_t = (1 - \varpi)C_{R,t} + \varpi C_{NR,t} \tag{1.8}$$

2.1.4 Shocks to Related Households

There are two shocks related to Ricardian household behavior: the shock in intertemporal preferences and the shock on labor supply. While the first affects the choice of intertemporal consumption, the second affects labor supply and determination of nominal wages. The shock S^C was included to capture changes in valuation between the present and the future which the literature on intertemporal behavior suggested as a key to the understanding of aggregate fluctuations (Primiceri et al. 2006). Additionally the shock S^L was added to model changes in labor supply that Hall (1997) and Chari et al. (2007) identified as responsible for major changes in employment over the business cycle. There are two other shocks in the stochastic components of the taxes on labor income and on capital income. These shocks were included to characterize the stochastic component related to these two types of taxes, which are the objects of study in this work.

Thus, the movement rules of such shocks are presented below:

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[2] Generally, the DSGE literature treats the non-Ricardian agent as an individual without capacity to maximize the intertemporal utility due to liquidity conditions. In this work, the assumption is that this type of agent does not maximize its utility due to retirement.

$$\log S_t^C = (1 - \rho_{SC})\log S_{SS}^C + \rho_{SC}\log S_{t-1}^C + \varepsilon_{SC,t} \qquad (1.9)$$

$$\log S_t^L = (1 - \rho_{SL})\log S_{SS}^L + \rho_{SL}\log S_{t-1}^L + \varepsilon_{SL,t} \qquad (1.10)$$

$$\log \phi_t^l = (1 - \rho_l)\log \phi_{SS}^l + \rho_l \log \phi_{t-1}^l + \varepsilon_{l,t} \qquad (1.11)$$

$$\log \phi_t^k = (1 - \rho_k)\log \phi_{SS}^k + \rho_k \log \phi_{t-1}^k + \varepsilon_{k,t} \qquad (1.12)$$

where $\varepsilon_{SC,t}, \varepsilon_{SL,t}, \varepsilon_{l,t}, \varepsilon_{k,t}$ are exogenou shocks, and $\rho_{SC}, \rho_{SL}, \rho_l, \rho_k$ are autoregressive components, of the intertemporal consumption shock, of the shock on labor supply, of the shock of the taxes on labor income and of the shock of the taxes on capital income, respectively.

2.2 Firms

The productive sector of the economy in this work is divided into two subsectors: firm producers of finished goods (retail); and firm producers of intermediate goods (wholesale). The wholesale sector is formed by a great number of firms, each producing a different good according to the structure of monopoly competition. In the retail industry, there is a single firm that aggregates intermediate goods in a single good that will be consumed by economic agents. Besides these features, it should be mentioned that the markets for productive factors follow a structure of perfect competition.

2.2.1 Firm Producers of Finished Goods (Retail)

First, it is necessary to define the aggregator behavior of the production function. 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 and aggregates them into a single finished good using the following technology:

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\varphi - 1}{\varphi}} \, dj \right)^{\frac{\varphi}{\varphi - 1}} \qquad (2.1)$$

where Y_t is aggregate output, $Y_{j,t}$ is the intermediate product j, φ is the elasticity of substitution between intermediate goods. The form adopted to aggregate the assets is called an Dixit-Stiglitz aggregator (Dixit e Stiglitz, 1977).

As mentioned, the finished goods producer is in perfect competition and maximizes its profit by using the technology of equation (2.1), whereas the prices of intermediate goods are given. Therefore, the problem of the retail firm is:

$$\max P_t Y_t - \int_0^1 P_{j,t} Y_{j,t} dj \qquad (2.2)$$

first order condition for each intermediate good j is:

$$Y_{j,t} = Y_t \left(\frac{P_t}{P_{j,t}} \right)^{\varphi} \qquad (2.3)$$

Equation (2.3) demonstrates that the demand for intermediate good j is a decreasing function of its relative price and increasing in relation to the aggregate output of the economy.

The general price level is obtained by substituting equation (2.3) in (2.1):

$$P_t = \left(\int_0^1 P_{j,t}^{1-\varphi} \, dj \right)^{\frac{1}{1-\varphi}} \tag{2.2.4}$$

2.2.2 Firm Producers of intermediate goods (Wholesalers)

The wholesaler firms solve the problem in two steps. In the first step, firms take as given the prices of production factors: wages and return to capital. They determine the quantities of those inputs that will minimize their costs. In the second stage, firms determine the optimal price of good j and they determine the quantity that will be produced in accordance with this price.

The objective of the first step is to minimize the cost of production,

$$\min W_t L_t + R_t K_t \tag{2.5}$$

subject to the following technology,

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{2.6}$$

where α is the share of capital in output, e A is the productivity, whose law of motion is:

$$\log A_t = (1 - \rho_A) \log A_{SS} + \rho_A \log A_{t-1} + \varepsilon_{A,t} \tag{2.7}$$

where $\varepsilon_{A,t}$ is exogenous shocks and ρ_A is autoregressive components of the productivity shock.

The first order conditions are:

$$W_t = MC_t (1-\alpha) \frac{Y_t}{L_t} \tag{2.8}$$

$$R_t = MC_t \alpha \frac{Y_t}{K_t} \tag{2.9}$$

where MC is marginal cost.

In the second step, the wholesale firm maximizes its profit by choosing the price of its good j. The wholesale firm chooses how much to produce in each period, but following a rule *a la Calvo* (Calvo, 1983) that says they fail to choose the price of their good in all periods. At each period t, a fraction $0 < 1 - \theta < 1$ of firms are randomly selected and allowed to choose the price of their good for period t, $P_{j,t}^*$. The remaining firms (the ratio θ of firms) keeps the price of the previous period for the product.

The wholesale firm has a probability θ to keep the price of the previous period for the good and the probability $(1 - \theta)$ to choose the price optimally. Once fixing the price 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. This firm should take into account these probabilities when choosing the price of its own good in it capacity to perform this adjustment.

Thus, the problem of the firm able to adjust the price of the good is:

$$\max E_t \sum_{i=0}^{\infty} (\beta\theta)^i \left[P_{j,t}^* Y_{j,t} - Y_{j,t} MC_{j,t} \right] \qquad (2.10)$$

where θ is the factor of rigidity in the adjustment of prices and $P_{j,t}^*$ is the optimal price set by the firm with the ability to adjust the price of your product. Equation (2.10) is the discounted profit of the firm during the period which the price $P_{j,t}^*$ is in progress.

Arriving at the following first order condition:

$$P_{j,t}^* = \left(\frac{\varphi}{\varphi - 1} \right) E_t \sum_{i=0}^{\infty} (\beta\theta)^i MC_{j,t} \qquad (2.11)$$

Combining the pricing rule of equation (2.11), and the assumption that all firms with the ability to adjust define equal value and that firms without this ability retains the same price, the overall price level is obtained by the equation:

$$P_t = \left[\theta P_{t-1}^{1-\varphi} + (1-\theta) P_t^{*1-\varphi} \right]^{\frac{1}{1-\varphi}} \qquad (2.2.12)$$

2.3 Government

The government sector in this work is divided into three subsectors: Fiscal Authority, Social Security, and the Monetary Authority.

2.3.1 Fiscal Authority

The government collects taxes and issues bonds to finance its spending on goods and services. The result of the pension system is transferred to the rest of the government. So if social security shows a deficit (or surplus), this is financed (or appropriated) for the remainder of the government. Therefore, the change in public debt is given by the following rule:

$$\frac{B_{t+1}}{R_t^B} - B_t = P_t G_t - BAL_t - TAX_t \qquad (3.1)$$

To account for the fact that the focal fiscal variable in Brazil is the (net-of-interest) primary balance, we introduce a rule for the primary surplus that responds to business cycle conditions and to the deviations of the public debt-to-GDP ratio from its steady-state:

$$\frac{SP_t}{SP_{SS}} = \left(\frac{SP_{t-1}}{SP_{SS}} \right)^{\eta SP} \left[\left(\frac{B_{Y,t}}{B_{Y,SS}} \right)^{\xi SP,B} \left[\left(\frac{G_{Y,t-1}}{G_{Y,SS}} \right)^{\xi SP,Y} \right] \right]^{1-\eta SP} \qquad (3.2)$$

where SP_{SS} is the primary surplus target, $SP_t = \dfrac{TAX_t - P_t G_t}{Y_t P_t}$ is the nominal level of the primary surplus, $B_{Y,t} = \dfrac{B_t}{Y_{t-1} P_{t-1}}$ is the nominal level of the public bonds and $G_{Y,t} = \dfrac{Y_t}{Y_{t-1}}$ is the

gross rate of output growth. ηSP is smoothing parameter of the primary surplus, $(\xi SP, B)$ and $(\xi SP, Y)$ are the sensitivities of the primary surplus in relation to the public bonds and to the product, respectively.

And tax revenue is obtained by the following equation:

$$TAX_t = \tau_C P_t (C_t + I_t) + \tau_l \phi_t^l W_t L_t + \tau_k \phi_t^k (R_t - \delta) K_t \tag{3.3}$$

2.3.2 Social Security

Social security is defined as a system of simple allocation, i.e., it is not capitalized (*pay-as-you-go*). The pension balance is the difference between the total collected with the social security contributions of active workers, $\tau_p W_t L_t$, and the total payment of benefits to inactive employees (retirees), PEN. Justified this way of modeling social security to highlight the relevant of this institution in the public budget.

Thus,

$$BAL_t = \tau_p \phi_t^l W_t L_t - PEN \tag{3.4}$$

2.3.3 Monetary Authority

The Central Bank of Brazil appears in this work following a simple Taylor rule (1993) with the dual goal of output growth and maintenance of price stability:

$$\frac{R_t^B}{R_{SS}^B} = \left(\frac{R_{t-1}^B}{R_{SS}^B} \right)^\eta \left[\left(\frac{Y_t}{Y_{SS}} \right)^{\xi RY} \left[\left(\frac{\pi_t}{\pi_{SS}} \right)^{\xi R\pi} \right] \right]^{1-\eta} \tag{3.5}$$

where ξRY and $\xi R\pi$ are the sensitivities of the basic interest rate in relation to the product and to the inflation rate, respectively, and η is smoothing parameter. The gross inflation rate is defined as:

$$\pi_t = \frac{P_t}{P_{t-1}} \tag{3.6}$$

2.4 Equilibrium Condition of Goods Market

To complete the model it is necessary to use the equilibrium condition in the goods market. Wherein aggregate production is demanded by households and and Government:

$$Y_t = C_t + I_t + G_t \tag{4.1}$$

3 CALIBRATION

Once solved the structural model, next step is to obtain the values of the parameters. For this purpose, there are two possibilities: estimating the model using some econometric technique, or using up the calibration. The latter procedure is to somehow calculate the

parameter values arbitrarily through available data or by using values from other works. This technique is the option used by the majority of the works of this type of economic literature.

The main calibration procedure adopted here is to obtain the values of parameters from other relevant DSGE work in the literature. Cavalcanti and Vereda (2010) analyzed the dynamic properties of a DSGE model for Brazil under alternative parameterizations. Therefore, they identified "allowable ranges" of values for some of the key parameters in the literature. Using the results of these authors, it was decided to use the parameters in common between the two studies, which were the discount fator ; the rate of capital depreciation; the coefficient of relative risk aversion; and the marginal disutility of labor. From Carvalho and Valli (2010) were obtained: smoothing parameter of the primary surplus; sensitivities of the primary surplus in relation to the public bonds and to the product, and, respectively.

The parameters related to taxation were obtained from Araújo and Ferreira (1999). An aliquot of social security contributions was calibrated from Cavalcanti and Silva (2010). For the other parameters related to the government, the smoothing parameter, the sensitivity of the basic interest rate on the product and on the inflation rate were obtained from Castro et al (2011). The share of consumption of non-Ricardian agents (inactive workers) in aggregate consumption and the parameter characterizing the benefit payments were calibrated from Giambiagi and Além (2008).

Finally, the parameters related to the structure of the firms were calibrated from two studies. The share of capital in output was obtained from Kanczuk (2002) while the index of price stickiness and the elasticity of substitution between intermediate goods was obtained from Lim and McNelis (2008). Table 1 summarizes the calibration parameters.

4 RESULTS

This section addresses the dynamic properties of the model. For this purpose, it will be shown that the variance decomposition and impulse-response functions are a result of shocks to the tax rates on labor income and capital income. This type of analysis is able to tell which variables have a more important behavior for idealized study. The simulations of the model were run on the Dynare platform.

4.1 Model Validation: Second Moment Comparisons with Data

The summary statistics such as first and second moments have been standard for researchers to use to validate models in the literature on DSGE models, especially in the RBC tradition. As the Bayes factors are used to assess the relative fit amongst a number of competing models, the question of comparing the moments is: can the models correctly predict population moments, such as the variables' volatility or their correlation, i.e. to assess the absolute fit of a model to macroeconomic data.

For the simulation and computation of moments, Dynare assumes that the shocks follow a normal distribution. In a stochastic set-up, shocks are only allowed to be temporary. A permanent shock cannot be accommodated because of the need to stationarize the model. Also the expectations of future shocks in a stochastic model must be zero. But in Dynare we can make the effect of the shock propagate slowly throughout the economy by specifying the shock's process and introducing a "latent shock variable", that affects the model's true exogenous variable, which is itself an AR(1).

In a stochastic framework, these exogenous variables take random values in each period. In Dynare, these random values follow a normal distribution with zero mean, but we can (and have to) specify the variability of these shocks. So setting period=500 when simulating the model specifies that the model is simulated over 500 periods, where Dynare computes the path of variables over a 500 period horizon by solving all the equations for every period, and

this can be used to compute the (empirical) moments of the simulated variables (i.e. simulated model solutions).

Table 1 : Model Parameters Calibrated Source: Prepared by the author.

PARAMETERS	VALUE	SOURCE
β	0,985	Cavalcanti and Vereda (2010)
δ	0,025	Cavalcanti and Vereda (2010)
σ	2	Cavalcanti and Vereda (2010)
ψ	1,5	Cavalcanti and Vereda (2010)
τ_C	0,1594	Araújo and Ferreira (1999)
τ_k	0,0813	Araújo and Ferreira (1999)
τ_l	0,1730	Araújo and Ferreira (1999)
τ_p	0,105	Cavalcanti and Silva (2010)
η	0,79	Castro et al (2011)
$\xi_{R,Y}$	0,16	Castro et al (2011)
$\xi_{R,\pi}$	2,43	Castro et al (2011)
ϖ	0,39	Giambiagi and Além (2008)
PEN	0,094	Giambiagi and Além (2008)
α	0,39	Kanczuc (2002)
θ	0,85	Lim and McNelis (2008)
φ	6	Lim and McNelis (2008)
ηSP	0.55	Carvalho and Valli (2010)
$\xi_{SP,B}$	0.038	Carvalho and Valli (2010)
$\xi_{SP,Y}$	0.017	Carvalho and Valli (2010)
ρ_A	0,9	Authors
ρ_{SC}	0,9	Authors
ρ_{SL}	0,9	Authors
ρ_l	0,9	Authors
ρ_k	0,9	Authors

Source: Prepared by the author.

Table 2 presents the results of the standard deviations of the model and the real data as a percentage of the standard deviation of the product. Notice that the consumption, investment and labor showed similar variations between the model and the data. While government spending presented very different results. Results in line with those obtained by the RBC tradition. (Hansen, 1985).

Table 2 : Standard deviation as % of output. Source: Prepared by the author.

VARIABLES	MODEL	DATA
Y	100,00%	100,00%
C	68,51%	72,22%
I	450,24%	447,85%
G	1269,32%	198,67%
L	136,14%	132,36%

Source: Prepared by the author.

4.2 Variance Decomposition

Table 3 presents the variance decomposition of the errors of the simulations of the endogenous variables (columns) in relation to exogenous shocks (rows). Note that the shock in the tax rate on income labor was the one yielding best result, with significant values for product, consumption, investment, labor, wage, basic interest rate, and inflation rate (Table 2). In other words, by affecting the price of hours worked[3] this shock renders leisure relatively more expensive and it causes active workers to work more (substitution effect). The result of this increase is a greater aggregate supply. A boom in the production possibilities increases the aggregate demand, so consumption grows. This tax reduction reduces the marginal cost which brings the inflation rate down, thereby leading the Central Bank to cut the basic interest rate.

Table 3 : Variance Decomposition (in percent). Source: Prepared by the author.

	ε_l	ε_k
Y	77,18	22,82
C	88,39	11,61
CR	88,55	11,45
CNR	91	9
I	67,85	32,15
G	84,62	15,38
K	60,25	39,75
L	70	30
R	55,76	44,24
R^B	81,3	18,7
W	73,39	26,61
B	83,68	16,32
TAX	58,62	41,38
BAL	55,25	44,75
π	87,92	12,08

Source: Prepared by the author.

On the other hand, the shock to the tax rate on capital income (▨) displayed rather relatively disappointing results. It demonstrates that this shock barely explained the changes in capital, which affect the poor performance of product. In other words, the tax reduction on capital was not able to increase the disposable income enough to create conditions that stimulated the main macroeconomic variables. Tax reduction on labor income played an important role in increasing the capital stock. Other variables were explained approximately equally between the two tax reductions. Briefly, the analysis of variance decomposition showed that tax reduction on labor income was more efficient in almost all results of the macroeconomic variables.

4.3 Impulse-response analysis

Figure 1 shows the impulse response functions[4] for the two shocks under study in this work[5]. The shocks are in the stochastic components of the tax rates. Note that these two

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[3] With a lower tax on labor income, disposable income increases.
[4] The impulse response graph estimates responses to shocks in each of the endogenous variables. These responses are obtained as follows: initially, all variables must be in their steady state levels. At some time t = 0, an endogenous variable takes a value equal to its steady-state level over an increase (impulse) in size equal to one standard deviation, and are calculated as all variables evolve after that.

shocks return to their steady-state level in about 40 periods (quarters). The behavior of both functions presents similar results for some variables, while for others the behavior is clearly differs.

The results of tax reduction in the tax rate on capital income will be analyzed. Among the most noteworthy results, it is worth highlighting the weak effect of this tax reduction on fostering on growth of output . On the demand side, it should be noted that nothing changed significantly. Also, there is a perceived neutrality concerning the labor market in that neither the level of wages nor labor supply are amended with this shock.

Regarding the fiscal side, public debt increases in the same proportion as the decrease in government revenues (TAX). In other words, the main impact on the fiscal front is a reduction of government participation in the economy. Consequently, the stock of capital responds positively to the tax reduction on capital income. However, this effect does not suffice to stimulate product, probably due to the low influence on aggregate demand variables.

Considering the returns with greater relevance between the two tax reductions proposed, this work found a better result for the tax reduction on labor income. The significant output growth was accompanied by consumption growth, a fall in government revenues (TAX), and a rise in both the stock of public debt and in input factor quantities (capital and labor).

Another relevant effect is the fall in the inflation rate, which brings about an interest rate cut by the Central Bank. Among these results, it bears stressing a surprising event. This shock has a greater positive effect on capital stock than that to capital income (also noticed in the variance decomposition). Briefly, using the displacement of any variable as a measure, the result attained by the tax reduction on labor income is much higher that than the one accomplished by reduction in the capital income tax.

4.4 Keynesian multipliers

In order to complete this discussion on the better tax reduction, we seek to identify the Keynesian multiplier for each of the two proposed in this study. The multiplier is calculated in the same way as in the "old Keynesian" tradition, ▨, in simple terms, we obtain the gray area in Figures 2 and 3[6].

The multiplier for the shock to the tax reduction on labor income yielded a value of 0,2603, which means that for every R$ 1 billion in this tax cut increases GDP in R$ 0.2603 billion. This result is close to the value found to the United States 0,2 and 0,3[7] (Elmendorf and Furman, 2008). On the other hand, the shock to the tax reduction on capital income, even though on impact it had positive effects, the net accumulated outcome was nearly nil.

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[5] $\varepsilon_l = 1$ and $\varepsilon_k = 1$.

[6] Cumulative Multiplier ▨

[7] These values are related with the way interest rates are adjusted based on a Taylor rule. For rebates: low: 20 percent of rebate spent; high: 50 percent spent.
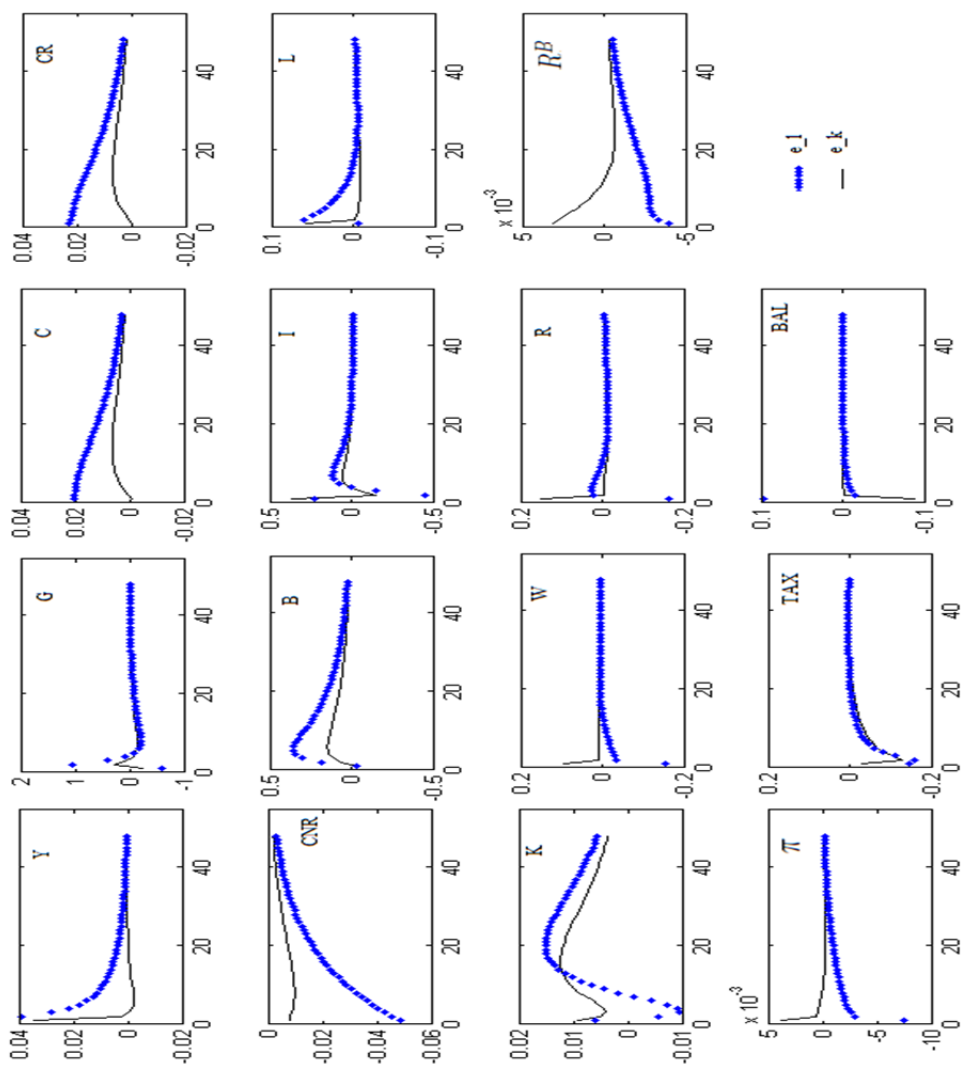
Figure 1 : Impulse-response functions for shocks in the taxes on labor income and capital income.
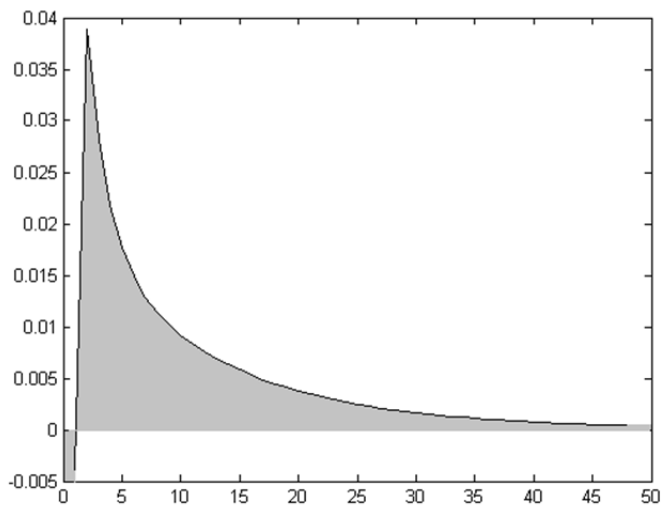**Source:** Prepared by the author.

Figure 2 : Keynesian multipliers to shock from the tax rate on labor income.
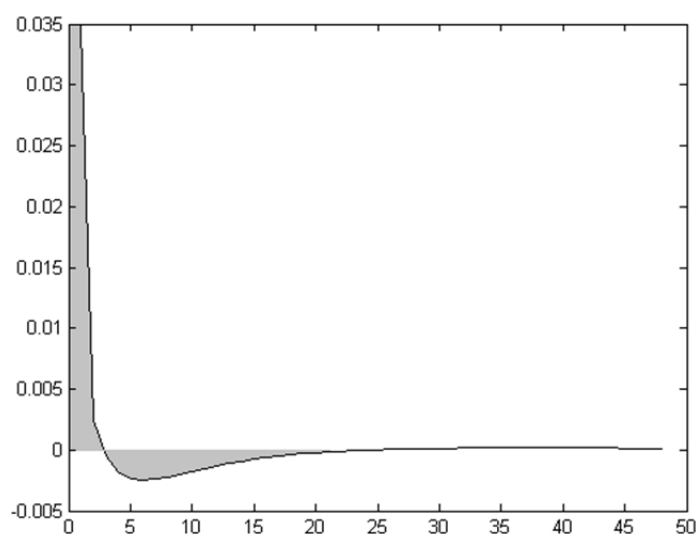**Source:** Prepared by the author.

Figure 3 : Keynesian multipliers to shock from the tax rate on capital income.
Source: Prepared by the author.

5 CONCLUSIONS

This work aimed to contribute to the discussion on tax reforms in Brazil analyzing effects of some given tax reductions on the productive sector through a DSGE model. To achieve this purpose, two different stochastic shocks were taken into consideration, namely, to the tax rates on labor income and on capital income.

The first relevant result found was the low performance of the tax reduction on capital income. This effect was related to the weak stimulus in aggregate demand variables after the shock. The labor market remained neutral with this tax reduction, showing no impact on the wage level and on labor supply.

The main result of these simulations concerns the tax reduction on labor income. Output grew remarkably as a result, and it occurred along with increases in consumption, declines in government revenues, as well as with rises in the quantities of factors of production (capital and labor).

From this description, it is worth noting that performance from the elimination of the tax on labor income was significantly higher than from other tax reduction. If the country undertook such a measure, production and consumption would increase and public finances would improve in a sustaineble fashion.

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