Public Expenses Limit Rule (PEC 55/241) and Brazilian Public Debt Sustainability: Scenario Analysis Trough DSGE Model

Áydano Ribeiro Leite

Mestre em economia pela UFPB e Doutor em economia aplicada pela UFBA. Atualmente é Professor Adjunto do departamento de economia da Universidade Regional do Cariri (URCA);

Cássio da Nóbrega Bessaria

Mestre em economia pela UFPB e Doutor em economia pelo PIMES/UFPE. Atualmente é professor adjunto do departamento de economia da UFPB e do PPGE/UFPB;

André Luis Mota dos Santos

Mestre e Doutor pelo IE/UNICAMP. Atualmente é professor adjunto do departamento de economia da UFBA e do PPGE/UFBA;

Fernando Fernandes Neto

Mestre em Processos Industriais pelo Instituto de Pesquisas Tecnológicas do Estado de São Paulo e Doutor em Engenharia de Sistemas pela Escola Politécnica da Universidade de São Paulo. Atualmente faz estágio de Pós Doutorado na FEA/USP.

ÁREA 4-Macroeconomia, Economia Monetária e Finanças

Public Expenses Limit Rule (PEC 55/241) and Brazilian Public Debt Sustainability: Scenario Analysis Trough DSGE Model

RESUMO

O objetivo central deste artigo foi analisar sob diferentes cenários, a trajetória da dívida pública considerando que o governo segue uma regra para o teto dos gastos correntes. A modelagem está baseada em um modelo Dinâmico Estocástico de Equilíbrio Geral (DSGE), calibrado para a economia brasileira. Testaram-se as respostas das variáveis de interesse em dois cenários distintos, assumindo o cumprimento ou não da nova regra fiscal por parte do governo. Assim, nas simulações em que o governo não cumpriu o teto, considerando que os gastos superaram em 3% a meta definida pela regra, o resultado primário caiu de forma significativa e a dívida do governo cresceu persistentemente ao longo do tempo, mesmo diante dos choques positivos de produtividade e sobre os tributos. Por outro lado, para os cenários onde o governo cumpriu a regra do teto, a responsabilidade fiscal foi capaz de corrigir o desequilíbrio em suas contas, tanto diante do choque de produtividade, como também, frente aos choques fiscais sobre os tributos. Em suma, os resultados apontam que um ajuste fiscal, por meio de uma regra que controle os gastos, tem efeito relevante sobre a sustentabilidade da dívida do governo.

Palavras-chave: Trajetória da dívida. Regra fiscal. Teto dos gastos. DSGE.

ABSTRACT

The main goal of this work is to analyze the public debt trajectory under different fiscal scenarios, where government does or does not follow a rule that limits public expenses, within the structure of a Stochastic Dynamic General Equilibrium Model (DSGE) calibrated for Brazilian economy. The variables responses were tested in simulations on which government did not comply with the public expenses limit rule and spent 3% beyond the rule's limit and in a scenario where it spent 3% below the rule's limit. When the fiscal authority spent below the rule, the fiscal posture was able to correct fiscal unbalance in face of taxes or productivity shocks. Otherwise, when government did not follow the rule, it was unable to equilibrate fiscal budget even under positive shocks. The results point out that a fiscal adjustment through a rule that controls expenditures would have a relevant effect on the sustainability of government debt.

Keywords: Debt trajectory. Fiscal rule. Expenses limit. DSGE.

Classificação JEL: E62, E63, H60

1.INTRODUCTION

Current macroeconomic debate in Brazil has been focused on questions related to fiscal unbalance. Since the rapid growth of public debt between 2014 and 2017 we have seen a consensus between economists that the use of fiscal instruments based on prefixed rules can be a solution. On this sense, in 2016, the federal government approved a bill (PEC 55/241[1]) indexing the growth of public expenses in one year to the inflation rate of past year.

The fall in Brazilian government revenues started in 2011 added to the continuous growth on public primary spending, that presented a growth average of 5% between 1997 and 2015, are indispensable to comprehend the recent deterioration on Brazilian fiscal balance. If in the beginning of XXI century we could observe a comfortable fiscal situation, with a primary surplus of 2% in 2000, in 2014 the situation were drastically different, with a primary deficit of 3%. As a direct effect, gross public debt GDP/ratio jumped from 51.5% in 2013 to 74.2% in 2017[2].

As a way to correct this explosive debt path, Temer Administration presented a constitutional amendment (EC/95), approved in 2016, objectifying the establishment of a new fiscal rule. This rule, represented in final instance by the PEC 95/241, contains a set of particular characteristics as:

> (i) Some expenses are excluded form the proposal, as the case of constitutional transfers to federation states and municipalities, FUNDEB complementation, electoral justice expenses and also state companies capital increase; (ii) expenses on public health and education are adjusted by previous period inflation rate; (iii) the expenses limit is dividual for each government sector, in case of on sector bypass the limit, this sector is prevented to realize public employee selections and give a wage raise to its employees. HORTA (2016, p. 286)[3]

Different economists have evaluated the impacts of fiscal rules in Brazilian economy, and we highlight the works of Souza Junior and Santos (2017), Cavalcanti and Vereda (2014) and Saraiva *et. al.* (2017).

Souza Junior and Santos (2017) made a series of simulations under different scenarios on which, one of the scenarios, include the public expenses limit rule (PEC 95/241). They could observe that the medium-term effect of the rule is a primary surplus generation, and as consequence, in the long run it would consistently affect the public debt reduction.

Cavalcanti and Vereda (2014) using a DSGE model, observes the impacts of different fiscal rules on Brazilian case. From a set of public expenses data, including and splitting expenses as goods and services, government investments, welfare expanses and expenses on public workers' salaries, they could notice that when a fiscal rule is applied on one of those types of expenditure, there is no significant positive short-term effect on the GDP. However, there is a positive medium-term effect on the GDP, where they assume that the public investment multiplier, under the rule adopted by them, is greater than one.

Other work on the subject, which searches for alternative fiscal rules on Brazilian economy, is Santos (2017) where the author structured a DSGE model including government capital and an exogenous risk shock on government bonds. He tested three different scenarios: i) with a primary surplus rule; ii) a rule to limit primary expenses in proportion with GDP; iii) a rule similar to PEC 95/241. Santos (2017) found that (iii) has a positive effect on GDP and aggregated consumption level stabilization.

---

[1] The bill establishes a new fiscal regime whereas the Expenses Limit Rule is going to be valid for twenty years, but it can be modified since the tenth year.

[2] Those numbers do not consider the Brazilian international reserves, what means that the net debt proportion are significantly lower than that presented.

[3] In the original: *(i)* Algumas despesas são excluídas da proposta como é o caso das transferências constitucionais a estados e municípios, complementação do FUNDEB, gastos com a justiça eleitoral e àqueles ligados à ampliação do capital de empresas estatais; *(ii)* Para as áreas da saúde e educação, estes são corrigidos pela inflação do período anterior e;*(iii)*O limite de gasto é individualizado por poder, e em caso da extrapolação destes limites, o poder fica impedido da realização de concurso público, conceder aumento salarial e contratar pessoal. HORTA (2016, p. 286).

Saraiva *et. al*. (2017) intents, through a calibrated DSGE model, to analyze the effects of PEC 95/241 on population welfare levels on different scenarios. Paper results indicates a non-significant effect of the rule on welfare. Otherwise, if the rule relaxes the limit in which concerns public investment, superior gains on welfare can be achieved.

On this research, we aim to analyze the public debt path in two different fiscal scenarios associating the public expenses limit rule to exogenous shocks of productivity and taxes. The modeled scenarios are going to be part of a low fiscal dominance regime[4] and tested within the structure of DSGE model. The theoretical basis of our work is the model developed by De Resende and Rebei (2008), which allowed us to incorporate an intertemporal optimization problem to the fiscal policy rule. This research empirical strategy consists in a parametric calibration method, the emulated model adherence test, and the responses function behavior to productivity and taxes shocks in two different scenarios: the first associated with the enforcement of public expenses limit rule; and the second with the no enforcement.

This paper contains this brief introduction, four sections and a short conclusion. If, on the first section of this paper we discuss the fiscal rule in Brazil, in the second, we expose our theoretical model to present, in the third and fourth section the method and the results.

2.THEORETICAL MODEL

The theoretical model structure assumes the hypothesis of a closed economy with three sectors and is based on propositions of Smets and Wouters (2003) and Galí *et.al.*(2007). Not only, the benchmark of the model general structure is the theoretical proposal of De Resende; Rebei (2008).

2.1 Representative Consumer

The optimization problem involves the maximization of intertemporal consumer utility taking in account the level of consumptionc_t, the demand of real money balances $\frac{m_t}{p_t}$ and the worked hours h_t. Therefore, the representative consumer utility function follows the structure:

$$Max\ E_t \sum_{t=0}^{\infty} \beta^t \left[\log(c_t) + \gamma \frac{\psi_m}{\psi_m - 1} \left(\frac{m_t}{p_t} \right)^{\frac{\psi_m - 1}{\psi_m}} + \eta \log(1 - h_t) \right] \qquad (1)$$

Subject to the following budget restriction:

$$(1 + \tau_t^c) c_t + x_t + CAC_t + \frac{m_t}{p_t} + \frac{b_t}{p_t} \geq (1 - \tau_t) \left[w_t h_t + r_t k_{t-1} + \frac{D_t}{p_t} \right] + \tau_t \delta k_t + \frac{m_{t-1}}{p_{t-1} \pi_t} + \frac{b_{t-1}}{p_{t-1} \pi_t} i_{t-1} \quad (2)$$

On the restriction (2) τ_t^c is the tax rate on consumption, whereas τ_t is the tax rate on factors income. The nominal part of government bonds is represented byb_t, where the economy nominal interest rate, which represents the bonds yields, is given byi_{t-1}. About the factors income, r_t mesures the capital profitability and w_t represent the real wages by hour. Not the less, the families are the proprietors of the firms, and so,

[4] What define a dominance regime is the *k* values. So, when $\kappa = 1$ we have a perfect monetary dominance and monetary authority total Independence. In this paper we define $\kappa = 0{,}93$ which indicates a low fiscal dominance regime compatible with a relatively independent central bank and a active monetary policy.

receive nominal dividendsD_t. To complete the budget restriction, we added a convex adjustment cost $CAC_t = \left(\frac{\phi_k}{2}\right)\left(\frac{I_t}{k_{t-1}} - \delta\right)^2 k_{t-1}$ to the capital stock, where $\phi_k > 0$.

2.2 The firms

2.2.1 Final goods firms

Following the structure as defined by De Resende e Rebei (2008), the model adopted assumes two kinds of firms: The first is a final goods firm, which aggregates intermediate goods in the process of production and acts at a perfectly competitive market[5], with one homogeneous good y_t. The second is a continuous set of firms indexed by $j \in [0,1]$ which produces intermediate goods in a monopolistically competitive market.

From Dixit-Stiglitz (1997) standard aggregation, we have that the firms which produces final goods y_t combine intermediate goods $y_{j,t}$ according to the following production function:

$$y_t \equiv \left(\int_0^1 y_{j,t}^{\frac{\theta-1}{\theta}} dj\right)^{\frac{\theta}{\theta-1}} \quad (3)$$

Given the nominal prices of final and intermediate goods as p_t e $p_{j,t}$, the profit maximization problem of the final good firm can be represented as:

$$\max_{y_{j,t}} p_t y_t - \int_0^1 p_{j,t} y_{j,t} dj \quad (4)$$

Solving the function (3) we obtain the first order condition:

$$y_{j,t} = \left(\frac{p_{j,t}}{p_t}\right)^{-\theta} y_t \quad (5)$$

As (5) represents the demand for different intermediate good, we shall substitute it on function (3). So, we get that the final good price will be determined by the following pricing rule:

$$p_t = \left(\int_0^1 (p_{j,t})^{1-\theta} dj\right)^{\frac{1}{1-\theta}} \quad (6)$$

2.2.2 Intermediate Goods Firms

In order to produce the intermediate good j, the firm combines two inputs: labor and capital. In this sense, if we assume a competitive market of production factors, the Cobb-Douglas function is going to be given as:

$$y_{j,t} = A_t k_{j,t-1}^{\alpha} h_{j,t}^{1-\alpha} \quad (7)$$

$k_{j,t-1}$ is the capital stock used by the firm, while the services obtained from labor force are represented by $h_{j,t}$. More, the productive shock on (7) will follow an autoregressive process AR (1), where $A_t = \rho_A ln(A_{t-1}) + \varepsilon_t$, with $\rho_A \in (0,1)$ e $\varepsilon_t \; i.i.d. \backsim N(0, \sigma_A^2)$.

Following the rule defined by De Resende and Rebei (2008), we introduced a nominal price rigidity *a la* Calvo (1983). With this, the firm will always when possible re-optimize the goods price at

[5] Como se assume uma estrutura de mercado de concorrência perfeita na produção dos bens finais, então, têm-se um bem agregado (Cesta de Bens) e as firmas deste setor são idênticas.

moment *t* in order to maximize future dividends discounted sum. The profit maximization problem can be descript as:

$$Max\ E_t \sum_{t=0}^{\infty} (\beta\mu)^t \left(\frac{\lambda_t}{\lambda_0}\right)\left(\frac{D_t(j)}{p_t}\right) \qquad (8)$$

Subject to the production function (7) and also the following functions:

$$D_t(j) = p_t(j)y_t(j) - [p_t w_t h_t(j) + r_t k_{t-1}(j)] \qquad (9)$$

$$p_{t+n}(j) = p_t(j), \qquad \forall n \geq 0, \qquad (10)$$

On maximization problem (8), $\left(\beta \frac{\lambda_t}{\lambda_0}\right)$ is the stochastic discount factor to evaluate the Family profits on instant *t*.

2.3 The Government

Further the use of a long-term fiscal policy rule based De Resende; Rebei (2008), we introduced into the model a fiscal rule which limits the primary expenditure as a intertemporal resources restriction:

$$(1+\pi_{t-1})g_{t-1} + \frac{B_{t-1}}{p_t}(i_{t-1}-1) = \tau_t^c c_t + \tau_t[w_t h_t + r_t k_{t-1} + d_t] - \tau_t \delta K_t + \frac{(B_t - B_{t-1})}{p_t} + \frac{(M_t - M_{t-1})}{p_t} \qquad (11)$$

As can be seeing, term $(1+\pi_{t-1})g_{t-1}$ is the public primary expenses limit rule equation and takes in account the subordination of government current expenditure growth at time *t* from inflation rate in $t-1$. Also, $\frac{B_{t-1}}{p_t}(i_{t-1}-1)$ is the financial expenditure with public debt average interest rate and $\frac{(B_t - B_{t-1})}{p_t}$ and $\frac{(M_t - M_{t-1})}{p_t}$ are the revenues corresponding to bond and money issue in between the two periods.

Excluding the debt interest expenses restriction and financial revenues, the primary surplus and seigniorage at moment *t* can be defined as:

$$s_t^{\chi} = \tau_t^c c_t + \tau_t[w_t N_t + r_t K_{t-1} + d_t] - \tau_t \delta K_t - g_t \qquad (12)$$

$$s_t^m = \frac{(M_t - M_{t-1})}{p_t} \qquad (13)$$

Otherwise, the public level indebt dynamic in successive periods of time will follow the structure:

$$d_{G,t} = \sum_{s=t}^{\infty} \frac{g_t - T_t}{\prod_{i=t}^{s}(1+i_t)} \qquad (14)$$

Where primary surplus is given by $g_t - T_t$ and i_i is the economy interest rate. As we assumed that fiscal authority follows a expenses limit rule and chases a primary surplus in all infinity periods, govern intertemporal utility function can be:

$$U = E_t\left[\sum_{s=t}^{\infty}\beta^t\left(s_t^{\chi} - (1+\lambda_T)(1+\pi_{t-1})g_{t-1}\right)\right] \qquad (15)$$

Where $\beta^t \in (0,1)$ represents the intertemporal discount factor and $g_t = (1+\lambda_T)(1+\pi_{t-1})g_{t-1}$ are the government primary expenditure limited by the adopted rule. According with Alper *et. al.* (2006), the use of this type of utility function comes from the assumption that the government behavior is rational and rigid when it comes to political and economy decisions.

However, we also assume that the government will spend as much as he can in between the rule limits. So the optimization problem will have a convex restriction as:

$$g_t \geq (1+\pi_{t-1})g_{t-1} \qquad (16)$$

With restriction (16) the government expenditure intertemporal optimization problem, can be represented by the following Lagrangean:

$$\begin{aligned} L = \tau_t^c + \tau_t[w_t N_t + r_t K_{t-1}] - \tau_t \delta K_t - (1+\lambda_T)(1+\pi_{t-1})g_{t-1} \\ + \Lambda\big((1+\lambda_T)(1+\pi_{t-1})g_{t-1} \\ - (1+\pi_{t-1})g_{t-1}\big) \end{aligned} \qquad (17)$$

Where Λ is the Lagrange multiplier. Solving the problem related to g_{t-1}, we have:

$$\frac{\partial L}{\partial g_{t-1}} = -(1+\lambda_T)(1+\pi_{t-1}) + \Lambda\big((1+\lambda_T)(1+\pi_{t-1}) - (1+\pi_{t-1})\big) = 0;$$

$$\lambda_T = \frac{1}{\Lambda - 1} \qquad (18)$$

From (18), is notable that a government decision of expenses expansion aim to stimulate the economy can bring adverse effects on fiscal variables behavior. Deriving the same problem in relation to Λ, we get:

$$\frac{\partial L}{\partial \Lambda} = (1+\lambda_T)(1+\pi_{t-1})g_{t-1} - (1+\pi_{t-1})g_{t-1} = 0;$$

$$\lambda_T = 0 \qquad (19)$$

With the government problem defined from condition (19) we can make some considerations: from utility function (15), when $\lambda_T = 0$, trivial solution is the same as the function of expenses rule, being this the parametric value that maximizes utility and the economy path in absence of exogenous shocks.

As we already know government budget restriction (11), taxes on consumption and income, respectively τ_t^c e τ_t will follow a stochastic process AR (1) gave by the ratio between the logarithms of them in relation to stationary values defined by:

$$log\left(\frac{\tau_t^c}{\tau_{ss}^c}\right) = \rho_{\tau^c} log\left(\frac{\tau_{t-1}^c}{\tau_{ss}^c}\right) + \varepsilon_{\tau^c,t}\ ; \qquad (20)$$

$$log\left(\frac{\tau_t}{\tau_{ss}}\right) = \rho_{\tau} log\left(\frac{\tau_{t-1}}{\tau_{ss}}\right) + \varepsilon_{\tau_t,t}\ ; \qquad (21)$$

On this dynamic, solving the government budget restriction and combining it with a non-Ponzi condition[6] where: $\lim_{n\to\infty} \frac{B_{t+n}}{P_{t+n}R_t^n} = 0$,we have the present value of government intertemporal budget restriction:

$$\frac{B_{t-1}}{p_{t-1}\pi_t} i_{t-1} = \sum_{n=0}^{\infty} \frac{s_{t+n}^{\chi}}{R_t^n} + \sum_{n=0}^{\infty} \frac{s_{t+n}^{m}}{R_t^n} \qquad (22)$$

If the government follows a long-term fiscal policy rule, given a initial debt level B_{-1} plus a price sequence$\{i_{t-1}, w_t, r_t, p_t\}_{t=0}^{\infty}$, the fiscal policy in $\kappa \in [0,1]$ can be established from the sequence $\{g_t, \tau_t^c, \tau_t, B_t\}_{t=0}^{\infty}$, for all $t \geq 0$, where:

$$\chi_t = \kappa i_{t-1} \frac{B_{t-1}}{p_{t-1}\pi_t}, \qquad \forall t \geq 0 \qquad (23)$$

On policy rule (23) the present primary surplus value is adjusted in all periods in the necessary amount to finance the constant fraction κ of the government debt. Respecting the budget intertemporal restriction:

$$\mathcal{S}_t = (1-\kappa) i_{t-1} \frac{B_{t-1}}{p_{t-1}\pi_t}, \qquad \forall t \geq 0 \qquad (24)$$

On (24), $(1-\kappa)$ represents the debt share that will be backed up by the segnoriage revenues discounted value.

Lastly, the model symmetric competitive equilibrium results on the following identity:

$$Y_t = c_t + x_t + g_t + \left(\frac{\phi_k}{2}\right)\left(\frac{I_t}{k_{t-1}} - \delta\right)^2 k_{t-1} \qquad (25)$$

As on stationary state all real variables are constants, we can define the following relation to inflation:

$$\pi = \frac{1}{1-(1-\kappa)\left(\frac{1}{\beta}-1\right)\left(\frac{b}{m}\right)} \qquad (26)$$

On equation (26), the inflation rate is a function of κ and β. According to De Resende; Rebei (2008), κ values near to 1 indicates a low level of fiscal dominance and relative independence to the monetary authority.

3. RESULTS ANALYSIS

3.1 Structure Parameters Calibration

In this work the chosen strategy was one involving parameters calibrations derived from the past decades Brazilian economy structural changes. According to Cavalcanti and Vereda (2014), depending on the model complexity can be harder to estimate and comprehend the model structural parameters. On this way, we adopt as references to calibrate the parameter SAMBA[7] model as developed by Castro *et. al.* (2015), and also the parameter on De Resende e Rebei (2008) and Ornellas (2011) papers. Between the

[6] The budget restriction present value is backed up by the non-waste of revenues hypothesis.
[7] SAMBA means *Stochastic Analytical Model with Bayesian Approach*, and is the name of a Brazilian Central Bank model, used as a decision basis.

calibrated parameters, disposed on Tables 1 and 2, intertemporal discount factor β presents a value slightly lower than 1[8], a economy interest rate of approximately 8.5% p.a. and a inflation target of 4.5% p.a.

Table 1- Calibrate Parameters Values

Fixed Parameter	Model Description	Values	References
β	Intertemporal Discount Factor	0,989	Castro *et.al.* (2015)
γ	Preference Parameter	$5{,}91\text{x}10^{-6}$	De Resende e Rebei (2008)
η	Labour offer substitution elasticity	2,046	Ornellas (2011)
α	Capital Share	0,485	Castro *et.al.* (2015)
δ	Depreciation Rate of Capital	0,015	Castro *et.al.* (2015)
ϕ_k	Capital Adjustment Cost	6,599	Ornellas (2011)
θ	Goods Substitution Elasticity	8,00	Basu (1995)
ψ	Money Demand Elasticity	0,25	De Resende e Rebei (2008)
μ	*Calvo's* Parameter for Price Rigidity	0,74	Castro *et.al.* (2015)
κ	Monetary Dominance Parameter	0,93	Defined from Equation (26)
	Variable Parameter		
λ_T	Public Expenses Limit Rule Parameter		$\lambda_T \leq 0$; Rule Enforcement. $\lambda_T > 0$; Rule Non-Enforcement.
	Stochastic Parameters		
ρ_A	Technological Shock Coefficient	0,91	Castro *et.al.* (2015)
ρ_{τ^c}	Consumption Taxes Shock Coefficient	0,8	De Resende e Rebei (2008)
ρ_τ	Income Taxes Shock Coefficient	0,8	De Resende e Rebei (2008)

Source: Authors Elaboration, 2018

The α parameter express proportion between capital income and economy aggregated income, and had its value calibrated according to Castro *et. al.* (2015). Furthermore, the capital depreciation factor was adjusted to 0.015 quarterly, coming close to Bonelli and Fonseca (1998) and Fernandes Neto (2014) estimates. At the same time, capital adjustment cost parameter had its value placed as 6.59, following the Ornellas (2011) estimates. This value is slightly different from the Smets and Wouters (2003) and Christoffel *et. al.* (2008), when corresponding values are 5.9 and 5.8.

Calvo rigidity parameter was assumed at 0.74, what implies an adjustment probability of 0.26. This value converges with Carvalho and Valli (2010) estimates that were found at 0.738 and also the values commonly found on international literature, as in the works of Smets and Woulters (2003) and Galí *et. al.* (2007).

The persistency parameters related to exogenous shocks, as in example the productive shock persistency[9] had been settled according to Castro *et. al.* (2015). At the same time, the taxes shock persistency had been defined following the estimates of De Resende and Rebei (2008).

[8] The intertemporal discount parameter value is smaller than 1, indicating that the agent discounts the future.
[9] The estimations corresponding values to the coefficient were in most studies defined between [0,60;0,98].

Lastly, we highlight the two most important parameter in calibration process: the first is κ, in wich the fixed value was 0.93, what according to equation (26) configures a low fiscal dominance regime. The second is the parameter related to the government expenses limit rule, and was calibrated from the fiscal authority desire of accomplish or not the expenses limit rule. On this sense, when government follows the rule $\lambda_T \leq 0$, when it doesn't $\lambda_T > 0$ and the optimum point is when $\lambda_T = 0$.

On Table 2 we present some macroeconomic aggregates calibration reasons. Government GDP/Expenses ratio had been extracted from Fernandes Neto (2014), whom uses a Hodrick-Prescott filter on government consumption and GDP series, which allows him to infer the expenses proportion through smoothed series. Furthermore, government gross indebt level had been fixed expressing the real long-term variable tendency.

Table 2 – Calibration and Proportion of Some Variables at Stationary State

Variable	Model Description	Stationary State Value	References
g/y	Government Expenditure	0,2019	Fernandes Neto (2014)
m/y	Monetary Offer	0,0587	M1/GDP
b/y	Government Debt	0,80	Debt/GDP Ratio Projection
τ^c	Consumption Taxes	0,177	Ornellas (2011)
τ	Income Taxes	0,192	Ornellas (2011)
π_{ss}	Steady State Inflation Rate	0,045	Defined from Equation (26)

Source: Authors Elaboration, 2018

Consumption and income taxes had been calibrated according to Ornellas (2011) definitions, whom uses consumption taxes related to GDB basic prices, and income taxes related to economy production.

3.2 Empirical Model Adherence Test

After parameters calibration, a cyclical analysis of the artificial economy properties is needed. Following Kanczuk (2004), Mussolini and Teles (2012) and Divino *et. al.* (2012) analytical method we used quarterly data from 1999 to 2018, and smoothed then using Holdrick-Prescott filter, meaning to detach the tendency from the cyclical component and then evaluate second moments with the standard deviations and the contemporary correlation components. The considered variables were: (1) Gross Domestic Product (GDP); (2) Consumption; (3) Investment; (4) Government Spending; (5) Government debt/GDP Ratio; (6) Monetary offer; (7) Interest Rate; and (8) Inflation Rate.

So we compare cyclical behavior of the artificial economy and data of real Brazilian Economy responses to productive shock and also the different outcomes from government fiscal posture related to the expenses limit rule. Two different postures were analyzed: in the first speculated scenario, the government does not accomplish the rule, and spent 3% beyond the budget imposition, so $\lambda_T = 0{,}0075$. In the second speculated scenario, the government accomplishes the rule and spent 3% below the budget imposition, and we have $\lambda_T = -0{,}0075$.

On Table 3 we present the moments generated by the artificial economy on both speculated scenarios. The model cyclical behavior and data adherence can be verified from the variables directions related to gross domestic production. On this sense, the observation parts from the contemporary correlation coefficient between each variable and the gross domestic production.

Initially, we can attest that most variables present a pro-cyclical behavior on both real and artificial economy, and we can highlight the variables consumption, investment and monetary stock,

which indicate a good data adherence. Also, the fiscal variables present a pro-cyclical tendency at the same moment that the public debt presents a counter-cyclical behavior in the real economy, this finding is reinforced by Vegh (2015) results, that appoints the pro-cyclical role of government spending.

However, in the simulated scenario 1 where government spends 3% more then allowed by the fiscal rule, the debt signal is inverse, and presents a pro-cyclical behavior. Otherwise, in the simulated scenario 2, when government saves 3% more, the behavior is counter-cyclical.

Table 3 – Real and Artificial economy responses to productive shocks.

Variables	Real Economy			Artificial Economy $\lambda_T = 0{,}0075$			Artificial Economy $\lambda_T = -0{,}0075$		
	Sd(x%)[10]	***Corr(x/Zyt)***[11]	***Direction***	***Sd(x%)***	***Corr(x/Zyt)***	***Direction***	***Sd(x%)***	***Corr(x/Zyt)***	***Direction***
GDP	0,694	1,000	-	0,396	1,000	-	0,553	1,000	-
Consumption	0,494	0,876	Pro-cyclical	0,275	0,927	Pro-cyclical	0,328	0,899	Pro-cyclical
Investiment	1,049	0,830	Pro-cyclical	1,049	0,907	Pro-cyclical	1,587	0,908	Pro-cyclical
Government Expenditure	0,814	0,893	Pro-cyclical	0,294	0,815	Pro-cyclical	0,461	0,754	Pro-cyclical
Debt/GDP	1,8	-0,590	Counter-Cyclical	1,780	0,806	Pro-cyclical	0,724	-0,657	Counter-Cyclical
Monetary Offer (M1)	0,812	0,516	Pro-cyclical	1,079	0,786	Pro-cyclical	0,458	0,808	Pro-cyclical
Interest Rate	0,628	-0,061	Counter-Cyclical	0,039	0,179	Pro-cyclical	0,275	0,468	Pro-cyclical
Inflation Rate	0,893	-0,075	Counter-Cyclical	0,034	0,466	Pro-cyclical	0,080	0,568	Pro-cyclical

Source: Authors Elaboration, 2018

In Table 3 we can see that production, consumption and government spent were more volatile on real economy. Otherwise, the investment volatility was close between the real economy and the scenario 1 artificial economy. From this, we can conclude that artificial economy can consistently reproduce the cyclical behavior of Brazilian economy within the observed period.

The debt volatility pardon also presents a close relation between real economy and simulated scenario 1, when government spends beyond the fiscal rule. From which we can conclude that the government accomplishment of fiscal rule, represented by scenario 2, reduces debt volatility.

3.3 Productivity and fiscal shocks response functions reaction analysis

In this section, we discuss the results from the reaction of response functions when introduced productivity and taxes shocks. In a time horizon of forty quarters, we analyze the scenarios 1 and 2, when government spends beyond the Public Expenses Limit Rule and when government spends below the rule.

[10] Valid Standard Deviation for Table 3.
[11] Refers to the correlation coefficient between each variable and the product, for Table 3.

The goal here is to evaluate the fiscal primary result and the government gross debt trajectories dynamic in different fiscal postures related to exogenous shocks.

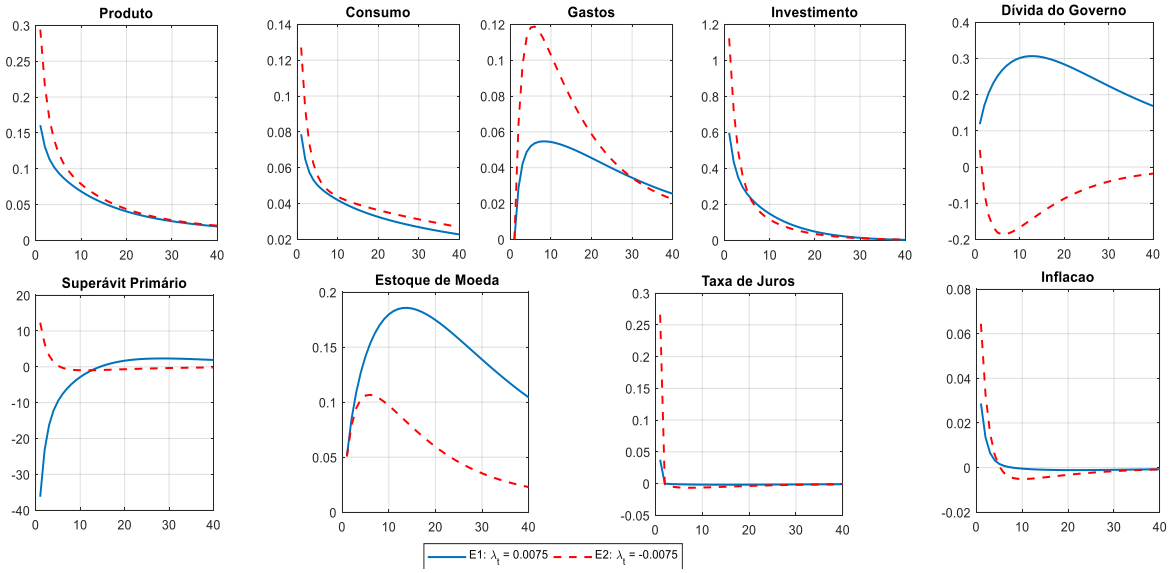
3.3.1 Scenarios with $\lambda_T = 0,0075$ and $\lambda_T = -0,0075$

As we already defined before, in scenario 1 government spends 3% beyond the limit while in scenario 2 it spends 3% bellow. The figures 4, 5 and 6 express the different variables responses when exogenous shocks on productivity and taxes are introduced.

Figure 4 express both scenarios behavior when productive shock is introduced to the model. As standard, the theory appoints that a productive shock impel positive effects on product, consumption and investment. Not only, generates rebounds on fiscal variables improving the public finances as a function of taxes revenues expansion. The response functions corroborate with literature, as the GDP, consumption and investment level reactions are positive to a productive shock, and it is reinforced by the endogenous effect on monetary basis growth.

The interest[12], by its side, positively respond to inflation rate increase and stabilized from fifth period. This relation between inflation and interest rate are similar in all emulated scenarios. According to De Resende and Rebei (2008), this result indicates that indirect endogenous effect dominates exogenous productivity shock. In this case, we understand that the first is a function of monetary expansion while the second refers to technological shock propagation, which results in a net inflation increase.

Figure 4- Response Functions reaction to a productive shock when $\lambda_T = -0,0075$ and $\lambda_T = 0,0075$



Source: Authors Elaboration, 2018

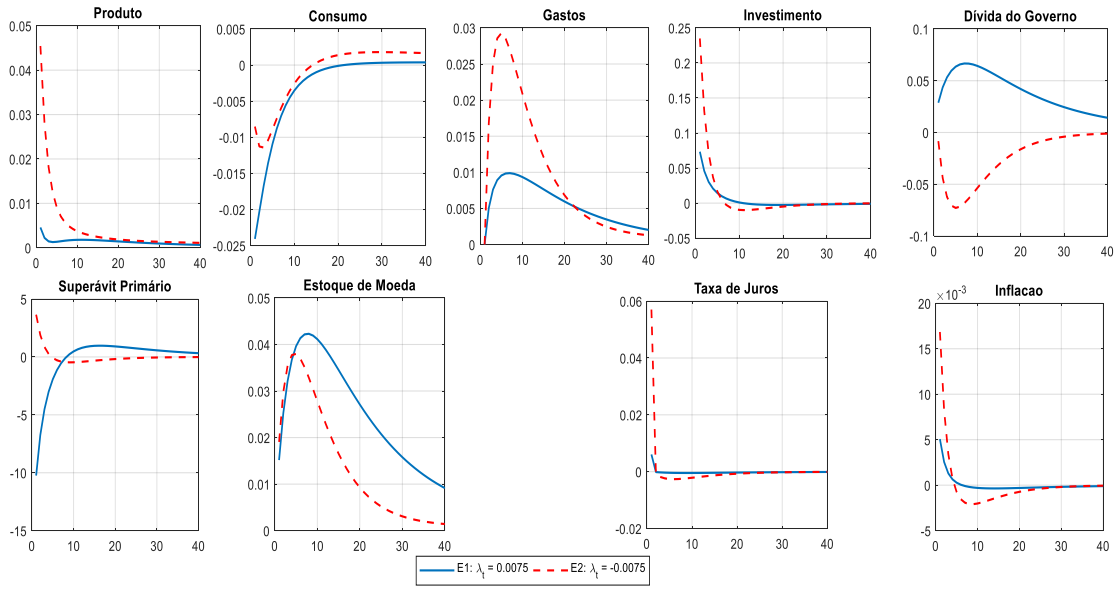
We can see in Figure 4 that in a scenario when public expenses limit rule are not enforced, the variables related to fiscal policy (government primary result and public debt) presents a irregular behavior. We noticed that primary deficit suffers an expressive expansion and stabilizes only on the fifteenth period after the productive shock while the government debt presents a positive response to the shock and starts to fall only from the same period.

On the other hand, when government spend 3% bellow the established by the rule, we visualize a primary surplus with growth in the first five quarters after the shock. Public Debt presents a significant retraction and maintains its trajectory below the steady state level through all the period, showing the importance of fiscal rule respect. Also, in this scenario, when the shock is on consumption taxes and not

[12] As can be noticed the monetary authority posture characterize a low fiscal dominance regime in the simulations. This can be identified as monetary authority assumes a active posture increasing interest in response to inflation.

on productivity taxes, GDP is not negatively affected but presents some volatility and stabilizes above the stationary state only after twelfth period. This GDP expansion dynamics can be explained from the endogenous government expenses growth, which dominates the direct effect of the taxes exogenous shock positively affecting the aggregate demand.

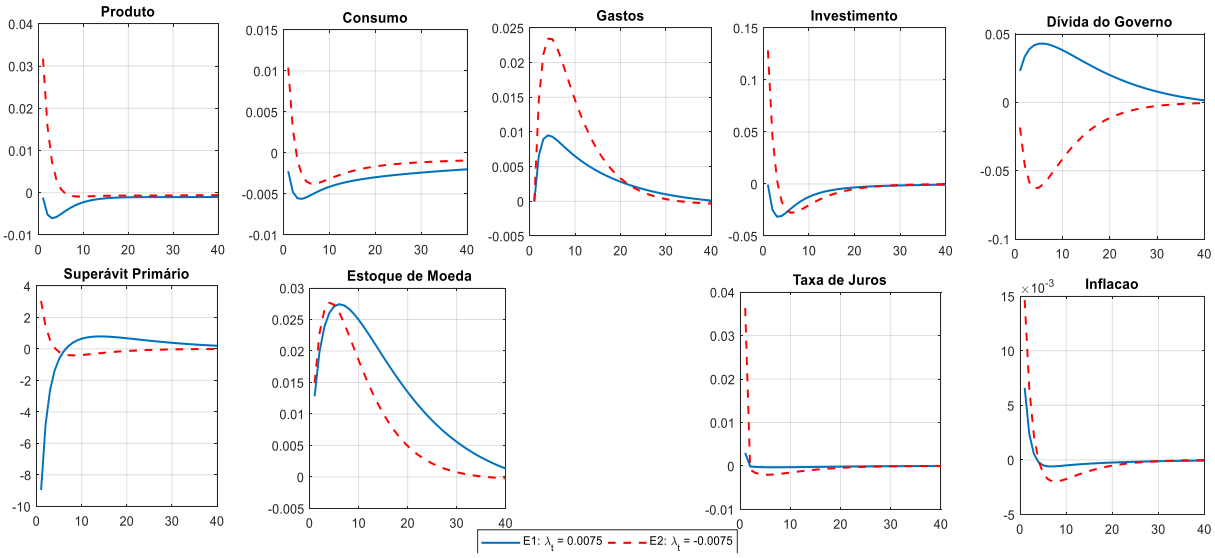
Figure 5- Response Functions reaction to a consumption taxes shock when $\boldsymbol{\lambda_T = -0,0075}$ **and** $\boldsymbol{\lambda_T = 0,0075}$



Source: Authors Elaboration, 2018

On a scenario when the shock corresponds to income and not consumption taxes, we can see on Figure 6 that variables dynamics is modified principally on the scenario 1, where government does not follow the Public Expenses Limit Rule. A drastically investment reduction is followed by a GDP reduction, indicating the effects of productivity and capital profitability retraction. Consumption is also strongly affected, as disposable income is lower, the wealth effective is negative and remains bellow the stationary state through all the period. So, we can conclude that on this scenario the dynamics of this three variables have been negatively affected after the taxes shock on income.

Figure 6- Response Functions reaction to a income taxes shock when $\boldsymbol{\lambda_T = -0,0075}$ **and** $\boldsymbol{\lambda_T = 0,0075}$



Source: Authors Elaboration, 2018

Comparing Figures 5 and 6 and evaluating the fiscal variables dynamics behavior on scenario 1, seems clear to us that on both types of shock we have a deterioration on fiscal balance outlook. As we can see, surplus and debt walks on opposite directions. Contrarily, on scenario 2, where government more than accomplish the expenses limit rule, the primary result increases, the indebt level decreases and the fiscal balance equilibrates. This means that even when we have a taxes expansion, this is not enough to equilibrate public budget if the Public Expenses Limit Rule is not followed. Therefore, in all analyzed scenarios, an adjustment on government budget through an expenses limit rule is a relevant mechanism to the stability and sustainability of the public debt in the long run.

4.CONCLUSION

The present article have as its goal analyze the government debt level trajectory in distinct fiscal scenarios associated to the expenses limit rule and exogenous shocks on taxes and productivity at a low fiscal dominance regime within the structure of a DSGE model.

On model structure we taking in account the nominal prices rigidity hypothesis and considered a set of political rules. In relation to this, we used a long-term fiscal policy rule based on De Resende and Rebei (2008) assuming that some part of the government constant debt has to be backed up by the primary surplus value. Not only, the other part of this debt has to be backed up by seigniorage revenue.

In respect to the theoretical model contribution, this one incorporates some innovation when comparing to the original model, mainly in the government action respect. We include a fiscal policy rule limiting public expenses based on PEC 55/241. Distinctively from De Resende and Rebei (2008) model, the government expenses were assumed as endogenous from the intertemporal optimization problem, in a way that government decision from the utility function were restricted to the new rule based on the parameter $\boldsymbol{\lambda_T}$.

The presented results came from the response functions reaction to each exogenous shock relating them to the different government fiscal posture. In all stochastic shocks the non-respect of public expenses limit rule negatively reflects on fiscal variables. Specifically on this scenario, the reactions show an expressive fall on primary fiscal result and consequently the government indebt growth.

From what we conclude that even with some positive effects derivate from productivity and taxes shocks on fiscal balance, the result point in the direction of a government necessity in accomplish the public expenses limit rule in a way to stabilize the public debt. The use of a limit rule on public expenses shows consistent effects on the indebt level stabilization.

REFERENCES

ALPER. *et al*. The welfare efects of government's preferences over spending and its financing. Economic Modelling, v. 25, n. 1, p. 1-12, 2008.

BRAUN, R.A.Tax disturbances and real economic activity in the postwar United States. Journal of Monetary Economics, v. 33, p. 441-62, 1994.

BASU, S. Intermediate goods and business cycle: Implications for productivy and welfare. The American Economic Review,85(3):512-531, 1995.

BONELLI, R. ; FONSECA, R. Ganhos de produtividade e de eficiência: novos resultados para a economia brasileira. Pesquisa e Planejamento Econômico, v. 28, 1998.

CASTRO,M. R. et al. Samba: Stochastic analytical model with a bayesian approach. Brazilian Review of Econometrics, v. 35, n. 2, p. 103–170, 2015.

CARVALHO, F. A. ; VALLI, M. An estimated DSGE model with government investment and primary surplus rule: the brazilian case. In: ENCONTRO DA SOCIEDADE BRASILEIRA DE ECONOMETRIA – SBE, 32., 2010, Salvador, Bahia. Anais[...] Salvador: SBE, 2010.

CAVALCANTI, M. ; VEREDA, L. Multiplicadores dos gastos públicos: estimativas a partir de um modelo DSGE para o Brasil. Rio de Janeiro: Ipea, 2014. (Texto para discussão, n. 1.588).

CALVO, G. Staggered prices in a utility maximizing framework. Journal of Monetary Economics, North-Holland, v. 12, n. 83, p. 383-398, 1983.

CHRISTOFFEL, K. *et al.* The new area wide model of the Euro area: a micro-founded open economy model for forecasting and policy analysis. Frankfurt: Europe Central Banking. 2008. (Working paper, n. 944).

DE RESENDE, C.; REBEI, N. The welfare implications of fiscal dominance. Ottawa: Bank of Canadá, 2008 (Working papers, 28) 2008.

DIVINO *et al*.Choques monetários e tecnológicos e as flutuações cíclicas na economia brasileira. Economia Aplicada, v. 16, n. 3, p. 501-529, 2012.

DIXIT, A. K. ;STIGLITZ, J. E. Monopolistic competition and optimum product diversity. American Economic Review,v. 67, n. 3, p. 297-308, 1977.

FERNADES NETO, F. Sistemas Dinâmicos Aplicados a Previsão no Setor Energético Brasileiro. 105 f. Dissertação de Mestrado em Processos Industriais- Instituto de Pesquisas Tecnológicas do Estado de São Paulo-IPT/USP, São Paulo, 2014.

GALÍ, J. *et al.* Understanding the effects of government spending on consumption. Journal of the European Economic Association, v. 5, n.1, p. 227–270, 2007.

HORTA. G.T.L. Fiscal rules in Brazil: an analisys of the proposed constitutional amendment 241. Revista do BNDES, n.47 , p. 259-308, 2017.

KANCZUK, F. Juros reais e ciclos reais brasileiros. Revista Brasileira de Economia, v. 56, n. 2, p. 249–267, 2002.

MUSSOLINI, C.C. ; TELES, V.K. Ciclos reais e política fiscal no Brasil. Estudos Econômicos, São Paulo, v. 42, n.1, p. 75-96, 2012.

ORNELLAS, R. ; PORTUGAL, M. S. Fiscal and monetary interaction in Brazil. In: MEETING OF THE BRAZILIAN ECONOMETRIC SOCIETY, 33., 2011, Foz do Iguaçu. Anais[….] Rio de Janeiro: Sociedade Brasileira de Econometria, 2011.

SANTOS, A. S. Regras de política fiscal em um modelo DSGE: uma análise a partir da regra dos gastos fixos e de superávit primário. 83f. 2017. Tese (Doutorado em Economia) - Universidade de Brasília, 2017.

SARAIVA, et.al. Reformas fiscais no Brasil: uma análise da EC/95/2016 (teto dos gastos). Fortaleza: Caen, 2017.

SMETS, F. ; WOUTERS, R. An estimated dynamic stochastic general equilibrium model of the euro area. Journal of the European Economic Association, v. 1, n. 5, 2003.

SOUZA JÚNIOR, J.R.C. ; SANTOS, J. R. ; ALMEIDA, F.E.L. Simulações da trajetória da dívida bruta do governo geral (2017 a 2037). Rio de Janeiro: Ipea, 2017. (Texto para discussão, n. 2303).

VEGH, C. Fiscal policy in emerging markets: procyclicality and graduation. Cambridge: NBER, 2015.

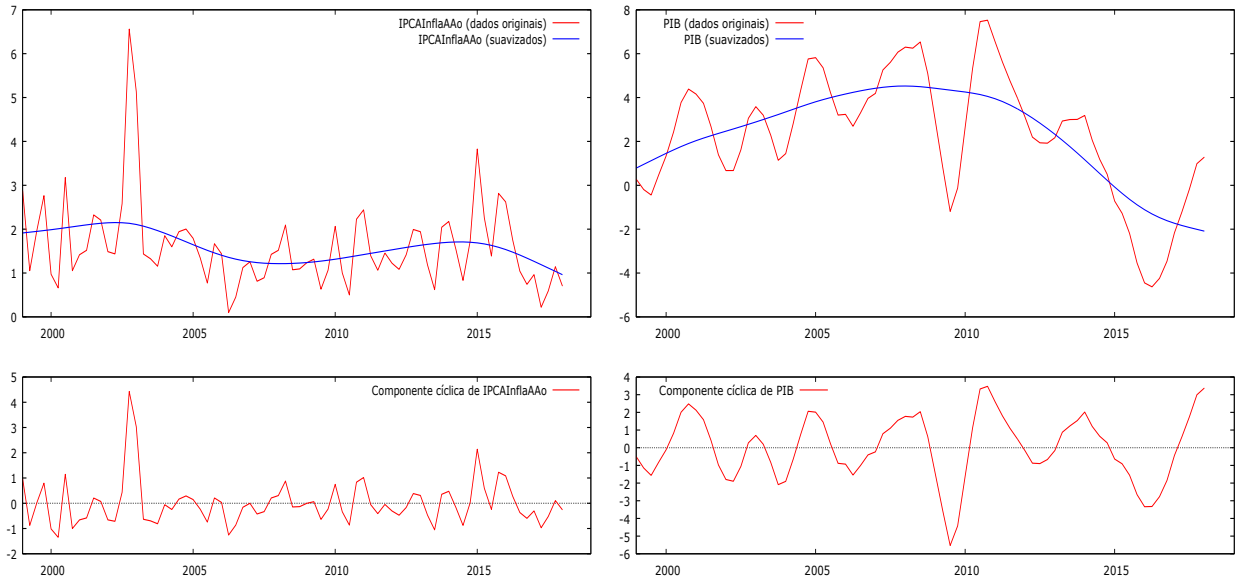
Appendix

Appendix A- Steady State Values

Variable	Descrition	*Steady State Value*
pi_ss	**Inflation Target**	1,009
i_ss	**Interest Rate**	1,020
r_ss	**Capital Income**	0,030
w_ss	**Wage**	5,388
Y_ss	**Output**	2,101
y_ss	**Firm Output**	2,093
h_ss	**Labor Hours**	0,174
k_ss	**Capital Stock**	29,273
x_ss	**Investment**	0,440
g_ss	**Government Expenditure**	0,418
c_ss	**Consumption**	1,240
m_ss	**Money Stock**	0,123
b_ss	**Government Debt**	1,681
stau_ss	**Primary Surplus**	0,348
sm_ss	**Seigniorage**	0,001

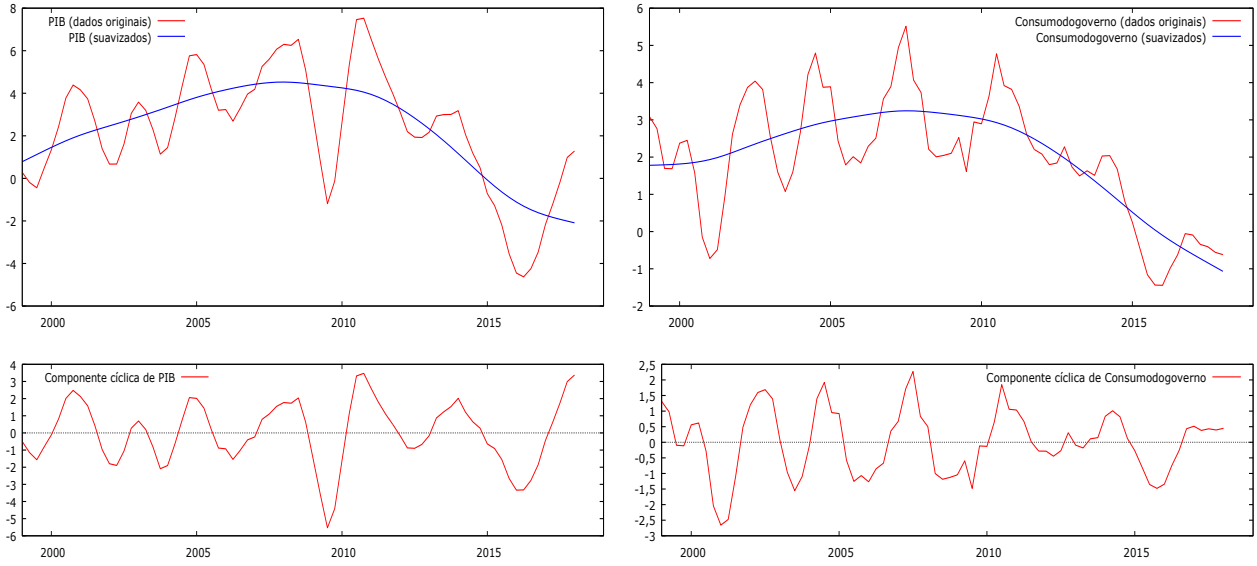
Source: Authors Elaboration, 2018

Appendix B - Cyclic Component / HP Filter- GDP x IPCA



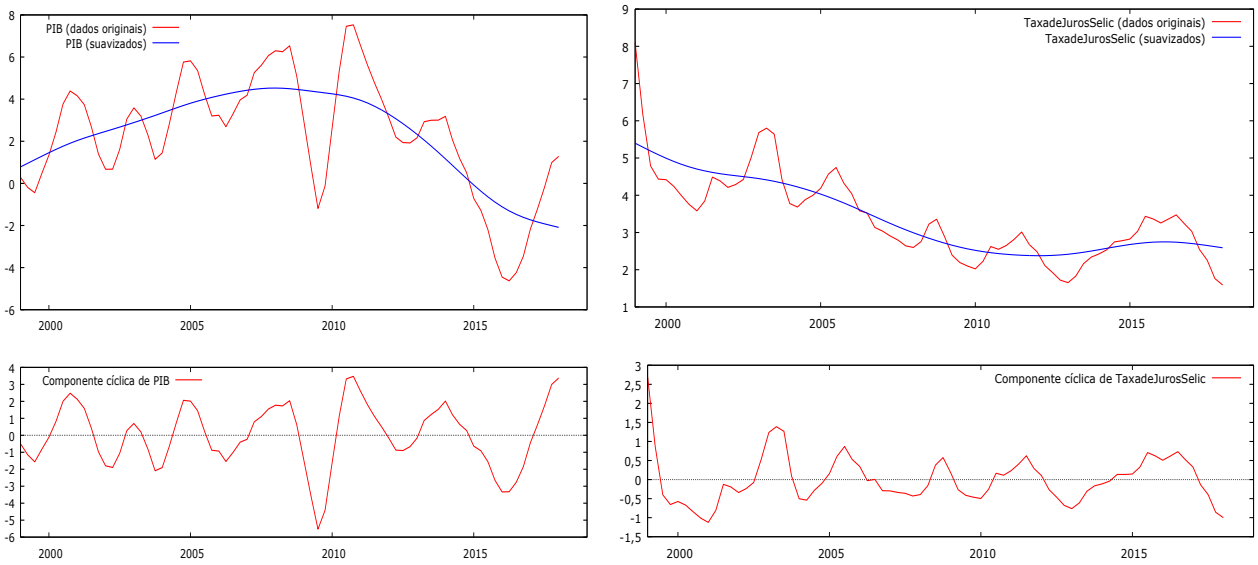
Source: Authors Elaboration, 2018

Appendix C - Cyclic Component / HP Filter - GDP x Government Expenditure



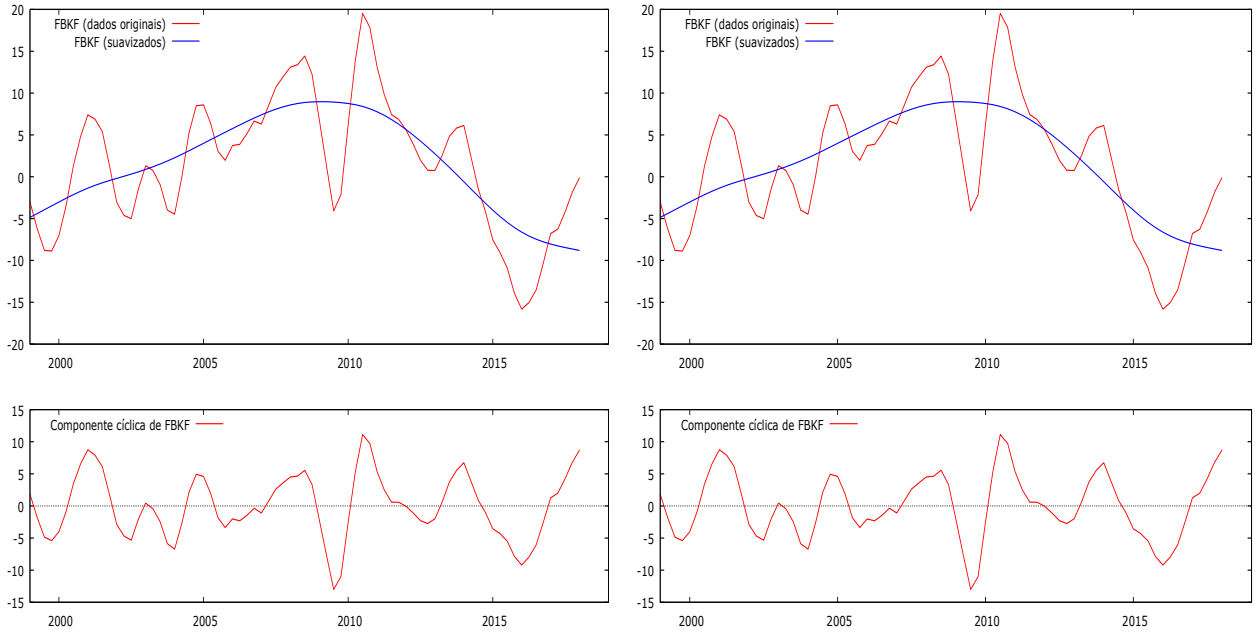
Source: Authors Elaboration, 2018

Appendix D - Cyclic Component / HP Filter - GDP x Interest Rate



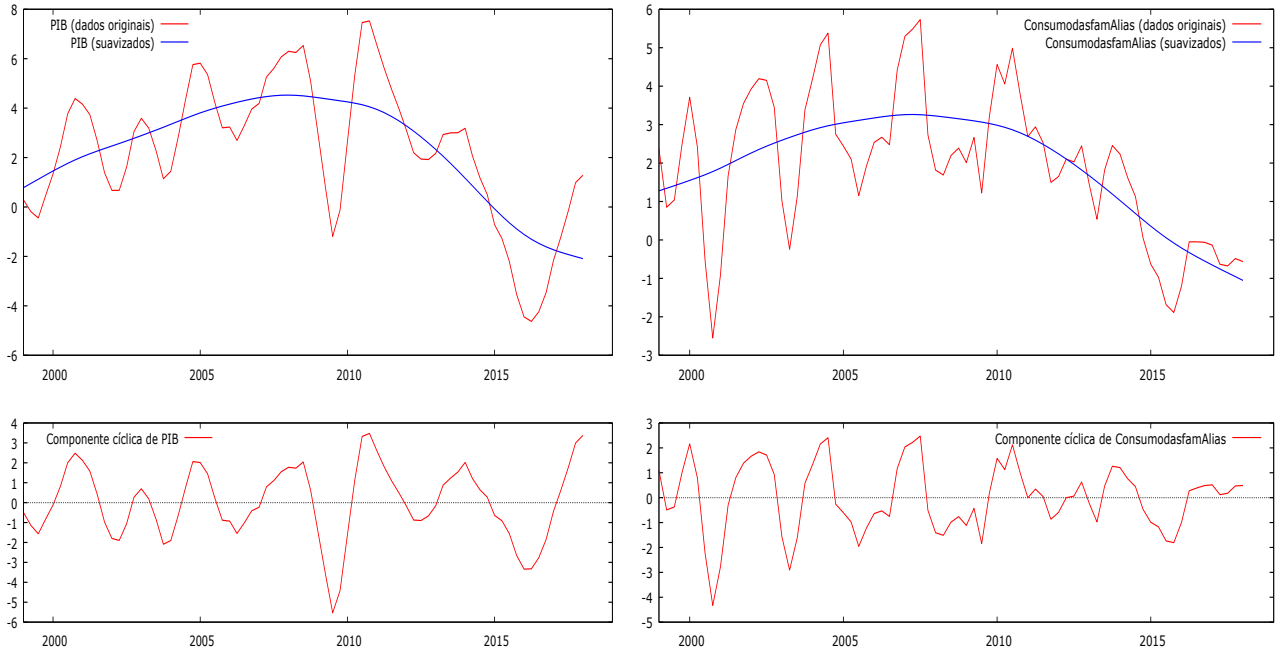
Source: Authors Elaboration, 2018

Appendix E - Cyclic Component / HP Filter - GDP x Investment



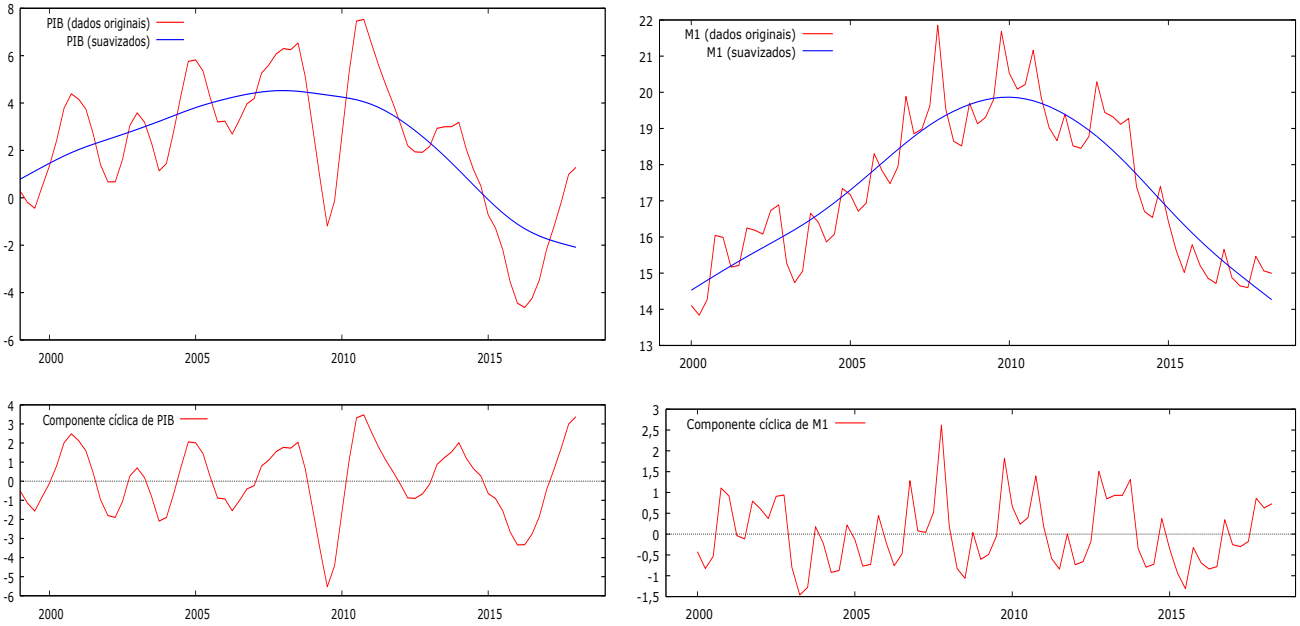
Source: Authors Elaboration, 2018

Appendix F- Cyclic Component / HP Filter - GDP x Consumption



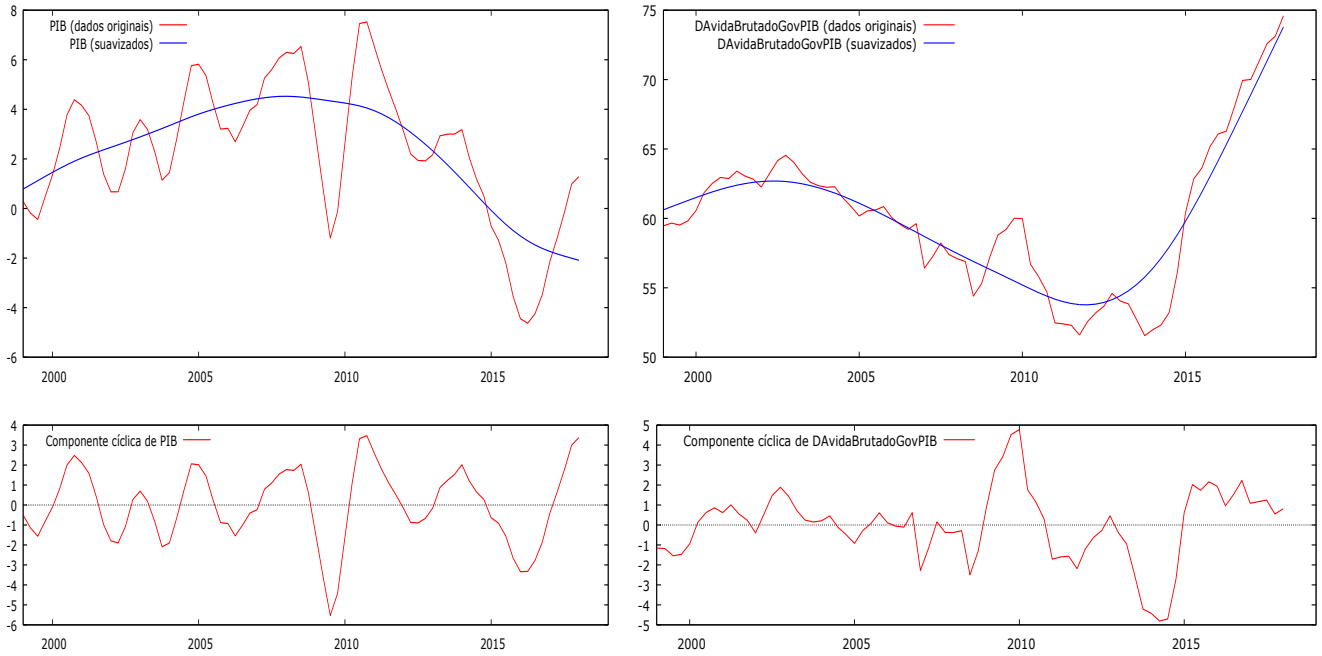
Source: Authors Elaboration, 2018

Appendix G - Cyclic Component / HP Filter - GDP x M1



Source: Authors Elaboration, 2018

Appendix H - Cyclic Component / HP Filter - GDP x Government Debt



Source: Authors Elaboration, 2018