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FISCAL POLICY MACROECONOMETRICS: AN APPLICATION FOR BRAZIL

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Carlos Marchionatti

FISCAL POLICY MACROECONOMETRICS: AN APPLICATION FOR BRASIL

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FISCAL POLICY MACROECONOMETRICS: AN APPLICATION FOR BRAZIL

Dissertation Thesis presented as a requirement for the approval of the Master's Degree title of the Graduate Program in Development Economics of the Business School of the Pontifical Catholic University of Rio Grande do Sul.

Advisor: Prof. Gustavo Inácio de Moraes

Porto Alegre
February 2017

ABSTRACT

Fiscal Policy is on debate nowadays. Its impacts on GDP growth, inflation, interest and real exchange rate brought insights by the works of Alesina (2010) and Cavalcanti and Vereda (2010 and 2015). This work aims to extend the fiscal policy shocks via government spending used in Cavalcanti and Vereda's (2015) DSGE model into different levels: federal, state and city levels. SVARs for the Brazilian economy presented new parameters for all the three levels of the DSGE model proposed. The results presented showed that although there is a temporary increase on GDP level, an expansionary fiscal policy via government spending leads to higher inflation, higher interest rates, appreciated real exchange rate and starts a recession.

Keywords: Fiscal Policy, Brazil, SVAR models, DSGE models.

RESUMO

Política fiscal está em debate nos dias atuais. Seus impactos no crescimento do PIB, inflação, juros e taxa real de câmbio trouxeram informações pelos artigos de Alesina (2010) e Cavalcanti e Vereda (2010 e 2015). Este trabalho vista extender os choques de política fiscal via gastos do governo usados no DSGE de Cavalcanti e Vereda (2015) em três diferentes níveis: federal, estadual e municipal. SVAR para a economia brasileira apresentaram novos parâmetros para as três esferas do DSGE proposto. Os resultados mostraram que, apesar de haver um aumento temporário no PIB, uma política fiscal expansionista via aumento dos gastos públicos acarreta maior inflação, maiores juros, taxa de câmbio real apreciada e inicia uma recessão.

Palavras-chave: Política fiscal, Brasil, modelos SVAR, modelos DSGE.

SUMMARY

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1 INTRODUCTION

Public debt and its sustainability, primarily affected by government expenditure, are topics debated nowadays. In the view of public finance, fiscal policy shocks may conduct to increases in GDP level or start a recession. Since the work of Keynes (1936), fiscal policy received a new position for economics, and decades of discussion led to innumerous ways to conduct taxation and government expenditure.

As well as worldwide, with the all-time high stock of debt, Brazil recently had a boom in the level of debt in percentage of its GDP. Many economists, financial analysts and other professionals argued that this was the most important ingredient that led Brazil to a two-year recession, getting the level of per capita GDP back to that of the last decade of the new century (2000).

The purpose of this work is to extend the analysis of fiscal policy into federal and two subnational levels: state and city ones. This way, this work analyzes the impacts of the Brazilian fiscal policy on macroeconomic variables, especially GDP level, inflation, interest rates and real exchange rate. Is this really the macroeconomic component that makes Brazil face its greatest particular recession, even more intense than the Brazilian depression when Keynes wrote his famous book of the general theory back in the 1930's?

To achieve this general objective, time series methods, such as Vector Autoregressive and Vector Error Correction Models, and mathematical models, such as the Dynamic Stochastic General Equilibrium Models were used to estimate the impacts of an increase in government expenditure on the Brazilian economy. The specific objectives were to estimate Structural VARs models to create recent parameters of the Brazilian economy and use them into the model of Cavalcanti and Vereda (2015), extending the DSGE model into three different macroeconomic levels: federal, state and city levels.

After this introduction, there will be an overview of worldwide debt, the Brazilian situation and different ways to conduct fiscal policy (heterodox and orthodox ones) in chapter two, as well as a brief introduction to macroeconometrics. In chapter three, there will be an exposition of the methods used to measure fiscal shocks on the economy, such as VARs, VECs and DSGE Models. Some examples of these models will be presented, especially for macroeconomic analysis and for Brazil. In chapter four, the results of the estimations will be shown, and, finally, there will be a conclusion in chapter five.

2 DEBT

2.1 A WORLDWIDE OVERVIEW

In this chapter, we will discuss the debate about levels of public and private debt, the Brazilian debt and the current macroeconomic situation, expectations for the future, optimal fiscal policy and its differences from other types of fiscal policies, including a simple exercise.

2.1.1 Debt debate: Private and Public debt linkages and Fiscal Policy Benefits

Debt is a worldwide debated topic for Economics. According to the Fiscal Monitor Report of the International Monetary Fund (IMF, page 1, 2016), the current debt levels are 225 percent of world GDP, an all-time high state, about 152 trillion of dollars in 2016 (IMF, page 20, 2016). Most of this debt, around two-thirds, consists of liabilities from the private sector. This fact reinforces the need of deleveraging in some countries, since it has implications upon growth and financial stability, slowing down the development of the world.

The Fiscal Monitor Report tries to answer the questions about how high global private and public debt is, and if fiscal policy can help with private sector deleveraging and how. Including emerging markets, as well as low-income countries, it expands the coverage of previous studies, and it proves private debt is high in the entire world, for emerging, low-income and advanced economies. High private debt increases the likelihood of financial crisis and hampers economic growth, while borrowers do not have conditions to maintain the normal level of consumption and investment (IMF, page 1, 2016). But, having this in view, how public debt relate to this phenomenon ?

Empirical analysis, according to the Fiscal Monitor (IMF, page 2, 2016), shows that fiscal policy can reduce the depth and duration of a financial crisis, associated to a private debt overhang, which it is observable in several countries, and, in the case of this study, especially in Brazil. However, the ability of a government to be a stabilizer depends on its fiscal position prior to the crisis (IMF, page 2, 2016).

Several emerging market economies had a big boom in debt since the global financial crisis, not only Brazil. According to the IMF (page 4, 2016), China is included in this selected group, and, with Brazil, corresponds to 60 percent of the output of emerging market economies.

So, Brazil is not facing this private debt overhang alone, which is observable among other countries. But why is private debt overhang so dangerous? The next section explains it.

Private debt impacts on public fiscal policy when the Government uses its balance sheet to cover deficits from banks and other institutions (IMF, page 11, 2016). In Brazil, the National Treasury usually covers public banks and big state companies such as Bank of Brazil and Petrobras. On the other hand, high private debt can increase the risk of a country and lowers the rank of credit sovereign debt of the nation. This fact was noticed in Greece many years ago, when the global crisis happened.

Still, fiscal policy can have, during recessions, a positive effect for a small period. Keynes stated that in his famous book "The General Theory of Employment, Interest and Money". Fiscal policy increases demand and can improve recovery since it is countercyclical and its multipliers are likely to be high (IMF, page 12, 2016). This happened especially in Brazil, when it experienced rapid private credit growth and the public balance sheet were weak (high debt level) in the years from 2011 to 2014.

Moreover, fiscal policy has two kinds of interventions, direct and indirect: i) the direct one helps households and firms to access credit at reduced costs and to introduce incentives to restructure debt; and, ii) the indirect one, restructuring and recapitalizing banks. These two interventions have the objective to ensure that deleveraging is orderly, which is economically healthy for a country.

Then, there are three types of actions that fiscal policy, in a strong position (sustainable debt/GDP level), may take and can affect an economy (IMF, page 13, 2016). The first one is a targeted intervention, as it is a subsidized government loan to the private sector in cases where the credit channel is not working. Secondly and thirdly, government consumption and public investment expanding aggregate demand. These three types of intervention may orderly deleverage an economy, recovering the conditions for a suitable growth when the private debt is extremely high. Although fiscal policy is very efficient, is does not work at its maximum capacity if not used wisely with other policies and without some features, as timing and sequencing. The monetary policy must be in order with the fiscal one to reach full effect upon the economy and crowding-out effect can reduce the fiscal expansion power.

Also, considering the role of fiscal policy during recessions periods, there is evidence that entering a financial recession, which is when private credit leverages artificially and it is at an excessive level, a weak fiscal position (high debt/GDP level) exacerbates both the depth and the duration of the recession, especially in emerging economies, as the Latin American ones (Brazil, Argentina, Bolivia).

For those cases (financial recession in emerging markets), fiscal policy tends to be procyclical, since they cut government spending to lower public debt, which is exactly what is happening in Brazil[1] (IMF, page 24, 2016). Thus, when private credit surges, public debt deepens and extends the financial recession, which is worse than a normal recession (when there is a negative demand or supply shock, or even bad expectations guide the economy), according to a study of the IMF (page 24, 2016). Also, the losses of the emerging markets are the double of the advanced economies after five years.

As to how government spending works in recessions, there is a difference between the advanced economies, since it increases initially, and for the emerging markets cited above. For the emerging markets, it falls rapidly: "These results suggest that fiscal policy tends to be procyclical when fiscal buffers are limited prior to the crisis, especially in emerging market economies" (IMF, page 25, 2016), according to the IMF's economists.

The second point is the negative impact of the fiscal policy on the monetary policy, as the IMF points (page 13, 2016). In the last years, the National Bank of Economic and Social Development (BNDES, in Portuguese), moved to the private sector more than 500 billion Brazilian Reais (R$) (CBB, 2017). This fact weakens monetary policy since the interest rates (SELIC) do not act on private consumption and investment for big companies subsidized by the BNDES via public income. Many sectors keep investing and consuming regardless of what the monetary policy is. Now, in 2017, it is being changed by another method of measure, when the loans will be quantified by the yield of the National Treasury's bonds, which will be the inflation (IPCA) plus the real interest rate of the economy.

But why does private debt impact so negatively on economic growth? The reason is very simple. When a household or a firm expands its debt over its capacity to create income, they cannot consume, invest nor borrow anymore. According to the IMF (page 9, 2016)

> "highly indebted borrowers will sooner or later decrease their consumption and investment as they are unable to service their debt and can no longer borrow".

Also, if the credit overhang adjustment is postponed, the private sector becomes very sensitive to shocks. If it is the case, an abrupt increase on interest rates level due to the increased risk of lending can thus worsen the private sector position this way.

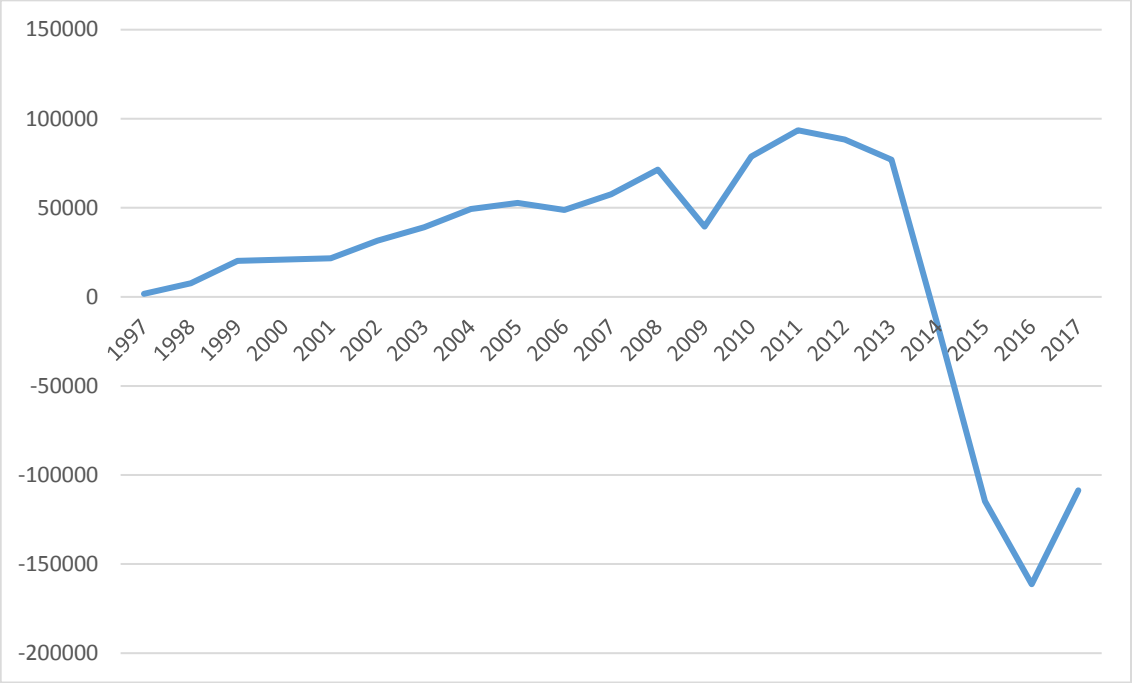
[1] As we can see, many graphs of the IMF's Fiscal Monitor of 2016 show that an increase in private debt, sustained or not by public credit from public banks' balance sheets (the case of Brazil), leads to a deepening of the recession. For example, this is the case of graphs in figure 1.8, on page 8 of the study.

2.2 DEBT IN BRAZIL

2.2.1 Brazilian debt situation in the last years

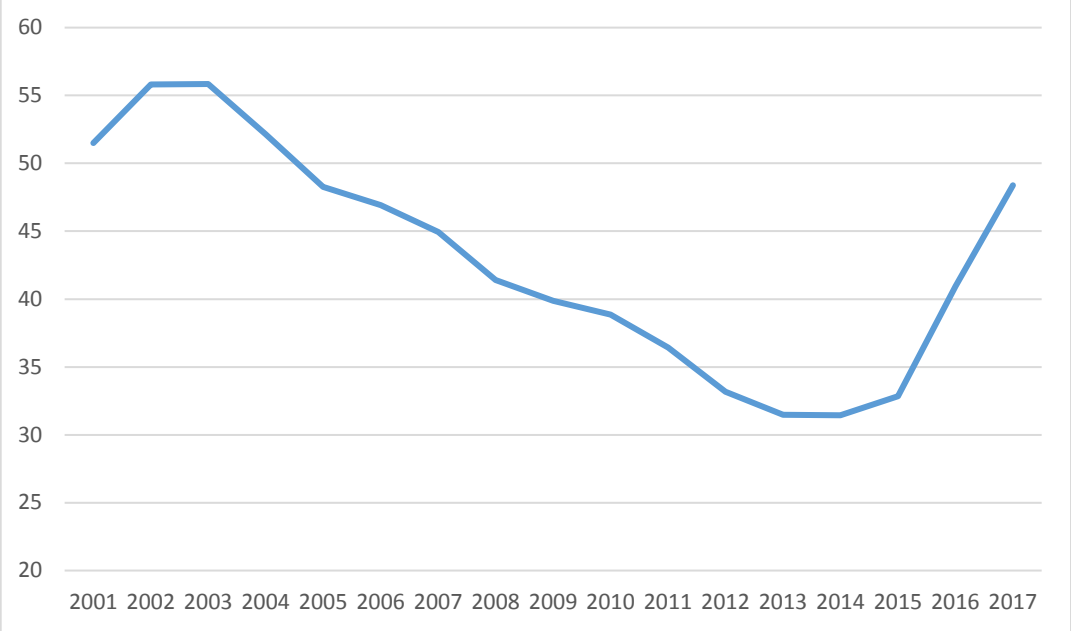
What happened in the beginning of the crisis in Brazil, in 2014, was not a healthy fiscal position since the primary result became increasingly smaller, and, at the end of the year, it became a deficit (CBB, SGS, 2017). In the end of 2016, the primary deficit was even bigger, and the financial market expects it to become a surplus again only from 2008 on.

Graph 1: Monthly Primary Result of Brazil in Billions of Reais: 1997-2017



Source: Central Bank of Brazil (2017).

Graph 2: Net Public Debt (% of GDP)



Source: Central Bank of Brazil (2017).

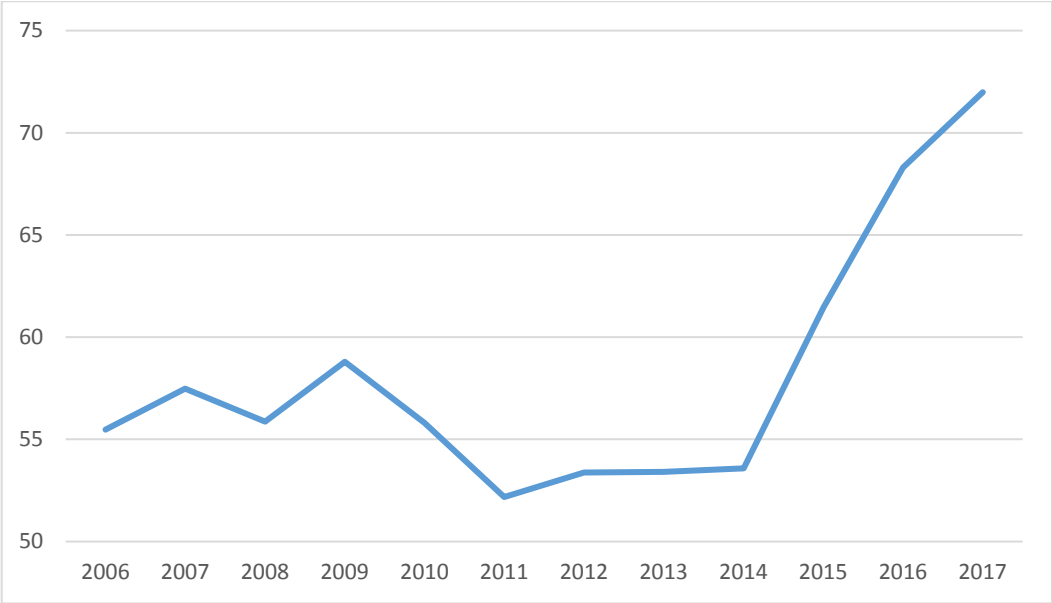
Although this Report (2016) emphasizes advanced economies, the box 1.3 of the Fiscal Monitor of the IMF brings a brief introduction about the recent past and the present years of the Brazilian debt history:

> "Private and public debt in Brazil have increased since the mid-2000s, fueled by a credit boom and procyclical fiscal policy. The sharp deceleration in credit growth in 2015 has exacerbated the country's economic recession, but weaknesses in the public-sector balance sheet limit the country's ability to cushion the impact of private deleveraging". (IMF, page 26, 2016)

Levels of private debt in Brazil are comparable to those of other emerging market economies, such as China. However, its pace of increase is far higher than those of these other countries, being the double of its peers'.

Moreover, credit growth turned to be negative in 2016, but debt rations kept increasing because of the recession (debt/GDP level). Analyzing the last decade, the Brazilian fiscal policy had been expansionary, with decreasing primary results in the period between 2007-2014. The result is a 30 percent higher debt in relation to other emerging markets, around 73 percent of the GDP in 2016 (IMF, page 26, 2016). Big public banks and the big oil and gas company of the country Petrobras were used to fulfill public policy objective, worsening the financial position of Brazil even more.

Graph 3: Gross Public Debt in Brazil in % of GDP – 2006/2017



Source: Central Bank of Brazil (2017).

2.2.2 Future of the Brazilian fiscal policy: The expenditure ceiling

The Ministry of Finance of Brazil decided to reform the fiscal policy to a new regime. In 2016[2], it was set that the government expenditure would only grow according to the index that must be according to the federal target for inflation or in between its bands, which has the name of IPCA. It is the equivalent of the CPI of the United States, and covers the population which has a monthly income from 1 to 40 minimum wages.

The reason for this choice is to stop the increase of debt-to-GDP ratio in the recent years. Many analysists predict that debt/GDP level may grow to nearly 90 % in the end of 2017, totally unsustainable, which reduced Brazil's investment grade and increased country risk, leading to higher interest rates and fewer investments. The results are known.

There is an acrimonious debate between Classic and Keynesian economists around the nation. Heterodox economists from UNICAMP and UFRJ, federal universities in the field of economics state there are other main factors which have led to this recession. Moreover, they state it would be positive to increase fiscal expenditure to avoid a deepening of the crisis. This dissertation hypothesis tries to show that this policy would be even worse for the country.

22 http://www.fazenda.gov.br/centrais-de-conteudos/apresentacoes/2016/2016-08-16_apresentacao_marcos-mendes_cae.pdf/view.

Moreover, it tries to follow the New Neo-Classical Synthesis which will be explained below by the book of Scarth (2012).[3]

2.3 THEORY OF FISCAL POLICY

2.3.1 Budget Deficits and Fiscal Policy

We now turn to the macroeconomic aspects of debt from a governmental perspective only, focusing on their macroeconomic consequences. Budget deficits is a topic where more and more researchers (IMF, 2017) and government reports, such as the Brazilian one, are studying since the last big financial crisis, where almost no inflation existed (and many countries used a total expansionary monetary policy not let prices fall (deflation)), and which is the topic of the moment for Brazil and of this dissertation thesis.

Scarth (page 156, 2012) begins the chapter stating that government debt accumulated in many countries around the world, in absolute terms and as a proportion of the country`s GDP in the last decades. As Keynes explained in his famous book, which is the birth of Macroeconomics, a fiscal expansion is positive during a recession, to stabilize the GDP growth, and, in booms, it must be used to create surpluses to keep the debt level stable or declining, far from increasing over the long term (which is what threatens many governments, or some economists at least) (KEYNES, 1936). Constant government debts may originate many problems for the macroeconomic wealth of a country, such as credibility loss, higher real interest rates for pay the country risk, less private investments (crowding-out), bad expectations for the future, unemployment, inflation and so forth[4]. A brief contextualization of the difference of a tight primary deficit and an overall budget deficit and their consequences will be analyzed in the next paragraphs.

Since the last decades, governments used fiscal policy to stabilize GDP growth, since economist from different school of thoughts “condoned deficit spending during these periods” (SCARTH, page 156, 2012). However, governments did not listen to the other half of the story, where there should be a surplus during the boom to stabilize the debt ratio in proportion to the

[3] In the following link, it can be downloaded the presentation of the special advisor of the Minister of Finance, elaborated in the end of 2016 (http://www.fazenda.gov.br/centrais-de-conteudos/apresentacoes/2016/2016-08-16_apresentacao_marcos-mendes_cae.pdf/view).

[4] On a Monetarist view, using micro-foundations, the efficiency of the public choice purchases must be equal or higher than the private return. As we see, this is very difficult to happen. After all, “Who are the angels?”. A memorable quote of Professor Friedman in the year of 1962 during an interview.

GDP. Thus, debt level increased over time and hence some policy should be proposed. One stated it would be better to have constant primary deficits, leaving government expenditure minus taxes over GDP ((g-t)/Y) as exogenous, while the overall deficit was kept endogenous. This means the government decided how much to spend and hoped GDP growth would be higher than the spending on interest rates, which would be very difficult for a Brazilian scenario, since Brazil had the highest real interest rates in the world in 2016. One more reason why the debt-GDP level in Brazil keeps rising is because there is no primary surplus (the next diagram proposes an exercise of how to keep debt level constant with a primary surplus despite having a higher interest than the GDP growth).

On the other hand, it is possible to set a target of the overall budget deficit (d), leaving it as exogenous, while government expenditure minus taxes over GDP was kept endogenous. This means that stability is assured if the nominal growth rate of GDP is positive, because government expenditure will grow just like the nominal GDP. In this case, debt level does not explode and the payment of interest rates do not increase debt level. Mathematically, bonds (b) would be equal to real deficit (D/PY) divided by change in GDP over time plus inflation: $b = \frac{d}{n+\pi}$ (1). The following equation, which is real deficit equals to government expenditure minus taxes minus the interest paid for the bonds, would have both sides equal: $d = g - t - ib$ (2). This is a perfect scenario where debt/GDP does not grow, and all the harms of a non-sustained debt growth is prevented. In other words, real deficit or surplus needs to be equal to bonds times inflation and GDP growth, avoiding a constant increase of the level debt/GDP which probably leads probably to a recession, as it happened in Brazil during 2014-2017.

By another point of view, it is harmful as well to stabilize GDP growth using budget deficits in the recession period, as many authors state such as Helliwell (1971) and Smyth (1974). Their studies emphasize that although in the beginning of the recession it may decrease it, an expansionary fiscal policy can slow down the recovery of the economy welfare. Although these authors have theory behind their hypothesis, their findings are not micro-based. This way, Scarth (page 161) brings a more up-to-date review of this hypothesis building micro-based equations. Using these equations, Scarth finds that there really is a trade-off between a lower beginning negative impact and a higher speed recovery.

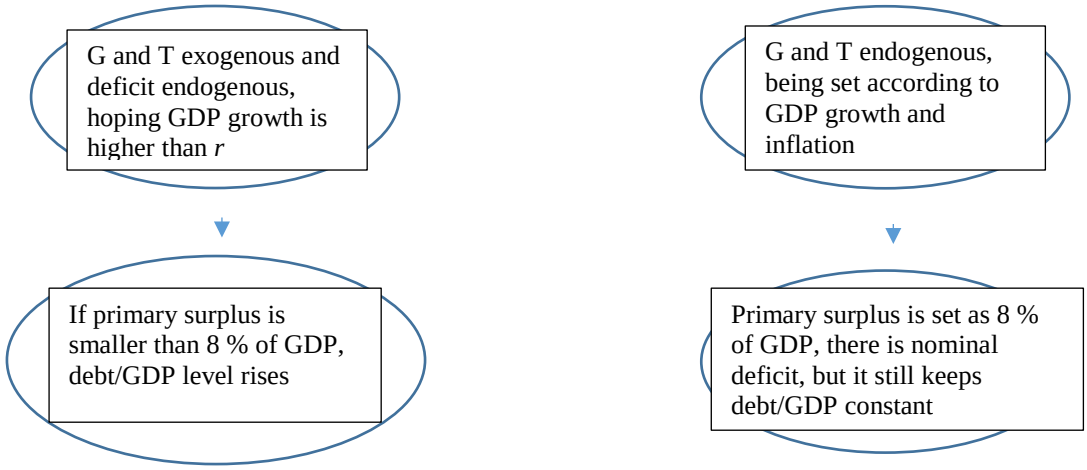
In short, talking about only the fiscal side of the macroeconomy, which is the central theme of this Thesis, Scarth claims that a rigid annual budget balance seems to be more of a stabilizer than a Keynesian policy, which may increase government expenditure when recession

hits. This conclusion is aligned to the New Neo-Classical Synthesis, approached worldwide by many countries. Nevertheless, not in Brazil since in the recent years.

2.3.2 A simple exercise: How to keep Debt/GDP level constant

Suppose inflation is 4 % each year and nominal interest rates (SELIC) are 14 % each year as well. Real interest rates (*r*) (around) 10 %. GDP growth is 2 % each year. What are the alternatives by setting the fiscal policy variables (G, T and budget deficit *n*)? What is the primary surplus needed to offset this difference between real interest rates and GDP growth to maintain debt level in 100 % of GDP (Debt and GDP are 100)? Since this difference would lead to an increase in the Debt/GDP level. Two scenarios emerge.

Illustration 1: A Simple Exercise



In the first case, G and T are exogenous. There is no discernment as to what can happen to debt level. The nominal deficit will be set independently of inflation and GDP growth. In the second scenario, the nominal deficit will be set according to inflation and GDP growth, so there would be a primary surplus of 8 % of GDP, offsetting the difference between real interest rates and GDP growth. This exercise is an adaptation of a question of the National Association of Graduate Programs of Economics of Brazil exam, which was held in 2014.

3 AN INTRODUCTION TO MACROECONOMETRICS

In this section, there will be a proper overview about the Vector Autoregressive (VAR) and Real Business Cycles approaches (RBC), which is the base of the Dynamic Stochastic General Equilibrium (DSGE) models. An example of VAR will be analyzed, as well as examples of real DSGE models for the Brazilian economy. New-Classical and New-Keynesian differences will be highlighted and some equations that will be used in chapter 4 will be shown.

3.1 MACROECONOMETRICS IN THE PAST

This section will introduce the methods to estimate the impacts of shocks on macroeconomic variables. In the beginning of the studies about measuring macroeconomic shocks, there was an approach called the "Cowles Commission", which used to quantify the effects of monetary policy mechanism by evaluating effects in the exogenous variables in the system on the endogenous ones, as Favero (2001, p. 88) claims. The "variables controlled by the monetary policy-maker (the instruments of monetary policy) *were* taken as exogenous, while macroeconomic variables, which represent the final goal of the policy-maker, *were* assumed to be endogenous" (FAVERO, 2001, p. 88). The main objective of this approach was to modify the exogenous variables to see what would happen to the endogenous ones, i.e., what would happen to GDP growth if interest rates were changed. The model is as follows:

$$A\begin{pmatrix} Y_{t-1} \\ M_{t-1} \end{pmatrix} = C_1(L)\begin{pmatrix} Y_{t-1} \\ M_{t-1} \end{pmatrix} + C_2(L)\begin{pmatrix} \overline{M}_t \end{pmatrix}\begin{pmatrix} e_t^Y \\ e_t^Y \end{pmatrix} \quad (3)$$

Where Y represents the vector of macroeconomic variables of interest (it could be the first lag of unemployment and interest rates), while M is the vector of monetary variables determined by the interaction between the monetary policy-maker and the economy, according to Favero (2001, p. 88). Also, $\overline{M}$ represents a sub-vector of the monetary policy, which the author assumes to be exogenous because it is fully controlled by the policy-maker (in the case of Brazil, it would be the National Treasury).

Thus, this is the basic framework the Cowles Commission approaches, but why did that fail? There are many reasons. Firstly, when the famous critiques came in 1970, as Pesaran and Smith (1995) stated: "[This type of model] did not represent the data, did not represent the

theory, were ineffective for practical purposes of forecasting and policy evaluation…" As they claimed, it seems the model is not that appropriate for its means.

After that, three schools arose, with different types of empirical research: The London School of Economics (LSE), the Vector Auto Regression (VAR) and the Intertemporal-Optimization-Real Business Cycle approaches. Section 3.1 will cover about VAR models, providing some examples, while 3.3 will explain Real Business Cycles (RBC) and how they became a DSGE model. For both sections, it will be observable how they are superior to other macroeconometric models of the past.

3.2 VAR APPROACH

3.2.1 VAR Approach: Some examples

According to Favero (2001, p. 96), the VAR approach goes beyond the LSE approach, because it questions the potential of macroeconometric modeling for simulation and econometric policy valuation. Hence, the VAR approach shares some identical factor with the LSE, as the diagnosis of the problem of the Cowles Approach, and its potential as well.

There are three relevant steps for the VAR approach, which are the following since Cristiano, Eichenbaum and Evans (1998): the first is about how monetary policy shocks are identified in actual economies; the second is about how the response of relevant economic variables to monetary shocks happens, and, lastly, how to perform the same experiment in the model economies to compare actual and model-based responses, as well as an evaluation and a selection criterion for theoretical models.

We will now focus on a simple monetary VAR, which contains only two endogenous variables and a constant as an exogenous one, which are taken from the book Applied Econometric Time Series of Enders (2010). For now, there is no restriction, so it is a reduced form VAR, not a Structural one (SVAR). This simple VAR has two series, consumer price index, whose nomenclature in Brazil is IPCA, and the federal bonds interest rate target, the SELIC rate, set by the Open Market Committee (COPOM) of Brazil, which is the same as the Federal Open Market Committee (FOMC) in the USA. The purpose of this VAR is to test the hypothesis of successfully target inflation.

First, it is needed to know if the series are stationary. Several types of unit root tests can be conducted, and ADF and Philips-Perron are the most relevant. When they are stationary, we

can truly see if they impact on the other one, if one helps to predict the other, cause it and so on and so on. Hence, it is not a spurious regression. They can be in level (I(0)) or differentiated once or twice. This VAR could quantify the effect of interest on inflation and vice-versa. For example, how much a shock of one standard deviation impacts on them. This is their impulse-response. If the p-value of the of their t-test is significant to predict each other, this is said they "Granger-cause" each other. For example, higher interest decreases inflation rates. Let us turn to this bivariate VAR:

$$y_t = b_{10} + b_{12}z_t + a_{11}y_{t-1} + a_{12}z_{t-1} + e_{yt} \quad (4)$$
$$z_t = b_{20} + b_{21}y_t + a_{21}y_{t-1} + a_{22}z_{t-1} + e_{zt} \quad (5)$$

Yt is inflation; Zt is interest: each one impacts on the other, they have noises (errors) and both are autoregressive of order 1 (AR(1)), which means most of their composition is from their first past value. When present interest rises, inflation decreases, hence $b_{12} < 0$. On the other hand, when inflation rises, interest must increase to maintain inflation stable along with the inflation targeting, hence $b_{21} > 0$. This is the basic framework of the Taylor Rule.

Also, if the two series cointegrate, it means they have a long-run relationship. This is because their errors of the short run can be "corrected" in order to keep the information of their long run relation, which means they are related to each other. Whatever is changing, is changing both. This allows the Vector Error-Correction to exist, which is an enhanced VAR, since there is no need to differentiate the series and the constant terms are still in the model. The variance-decomposition will be improved, which means more of the model will be explained by its decomposition, since more of both series explains their relationship. Impulse-response improves their performance and forecasting is also enhanced severely.

The second VAR is a simple fiscal policy application. It assesses if an expansionary fiscal policy, increasing the nominal deficit of the country, expands GDP in some horizon or not, and what happens to the SELIC rate. GDP is often trend stationary. SELIC may not have unit root as well many times. So, VAR can be run in levels, improving the estimation of the parameters which will be used in the DSGE. A parameter is, for example, when *b* is 0.05. It means 1 billion expenditures of the federal government increase 0.05 % of GDP growth. This will be exemplified in chapter 4.

3.3 DSGE MODELS

The Dynamic Stochastic General Equilibrium (DSGE) models are a modern tool for macroeconomic analysis of the new century (2000^{th}). Diffused around the world through many research and financial institutions as well as many central banks of the current main economies, DSGE models have some attributes that may overcome other macroeconometric tools in the medium run. Based on microeconomic foundations, its theorical power to explain the macroeconomic interactions is very attractive.

In the words of Villaverde (2009), "DSGE models have become one of the cornerstones of modern macroeconomics. The combination of rich structural models, novel solution algorithms, and powerful simulation techniques […] created the *New Macroeconometrics*". For example, in the field of monetary policy, DSGE models showed that the management of economic expectations can stabilize inflation more effectively than actual changes in the policy rate (in the case of Brazil, the SELIC rate) (SBORDONE, et al., 2010). Also, this result is consistent with the fact that many central banks are focusing to anticipate their moves to the market, through their announcements of monetary policy and inflation targeting.

Although there are many studies of DSGE models applied for monetary economics, as the Stochastic Analytical Model with a Bayesian Approach (SAMBA) of the CBB and the Federal Reserve Bank of New York (FRBNY) DSGE model, this dissertation will focus on fiscal policy analysis, since the current situation of Brazil is demanding a debate between government expenditure and public debt stability with their impacts over real GDP growth rate.

Fortunately, DSGE models are also useful for fiscal analysis, and they have the same assumption they do for monetary policy. According to Sbordone et al. (2010), "a key advantage of DSGE models is that they share core assumptions on the behavior of households and firms, which makes them easily scalable to include details that are relevant to address the question at hand". Thus, we can see it is usable for fiscal analysis as well.

3.3.1 Real-Business-Cycles

The DSGE model was not created without a history. Many facts came by to add features to this tool of macroeconomic policy analysis. Since the beginning, a big question was why the economy has up and downs… why does it fluctuate so much and why? From it, a theory emerged, which is named the Real-Business-Cycle (RBC). "Real" because only two factors cause a real change in output: technological and fiscal shocks, which will be fairly explained.

After that, there was an improvement for a set of economists, introducing rigidity to prices in the short-run, a New Keynesian assumption[5]. For the New Classicals, RBC models were set in a dynamic and stochastic perspective, focusing on rational expectations, which will be explained further. This way, the DSGE models were born.

The RBC tries to explain why there are so many short run variations in aggregate output and employment. Sometimes, output is falling rapidly, while unemployment goes up. Other times, the output has a boom and unemployment falls intensely. For example, in Brazil, between 2004-2007, the output growth was increasing, while unemployment was low. However, after the budget crisis in 2014, Brazil faced a big depression, and many economists stated it was the most severe since 1930. This way, the main goal of the RBC is to understand the causes of aggregate fluctuations.

Firstly, it is important to cite that there is no pattern for economic growth. As Romer states (page 191, 2012), growing is not simply regular, and indeed there are many trends going on. In the next graph, it is possible to see how the GDP fluctuated in Brazil in the last decades.

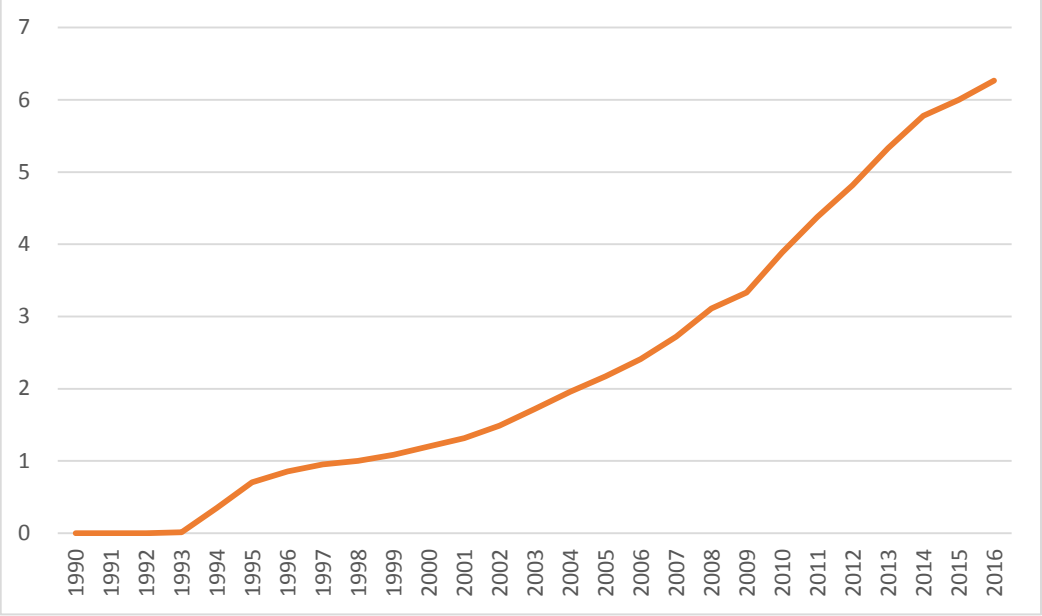
Secondly, all the components of output behave very unevenly along the years. For example, consumption falls much less than investment in residences, and even less than investments in inventories. On the other hand, "consumer purchases of nondurables and services, government purchases and net exports are relatively stable (ROMER, page 191, 2012).

As a third point, Romer (2012) claims that there is no symmetry in output movements. Although growth is distributed symmetrically around its mean, it seems to behave differently when it is above or below its usual path. This means when output is growing, it lasts for long periods. When it is below its path, it takes brief periods.

At last, the magnitude of fluctuations over time is not deterministic. Sometimes a recession may last longer than others; sometimes a prospering growth may last longer than others. We can see it in the graph of GDP growth in Brazil below. From 2003 to 2008, GDP growth lasted more than from 2010 to 2012, for example. Obviously, the opposite happens as well, and hence we can see the Okun's Law effect, when a percentage of output falls and unemployment rises too.

[5] This DSGE will focus on rational expectations and will not consider nominal rigidity completely. Hence, it is a New Classical DSGE (Lucas, 1972).

Graph 4: GDP in Brazil 1990-2017 (Trillions of Reais)



Source: Central Bank of Brazil (2017).

About variables, some have a pattern and others do not. For example, in the US, according to Romer (2012, page 193), for the last decades, inflation and money stock (M2) appear to have no clear pattern on the one hand. On the other hand, real wage falls slightly in recessions, as well as nominal and real interests, which fall too but not in the same proportion.

3.3.2 Improving the Ramnsey Model

Now, after some facts about aggregate fluctuation have been explained, some of the theory behind it must also be clarified. If it only takes a Walrasian model to describe economic fluctuations, without externalities, missing markets, asymmetric information, or other imperfections, the Ramsey model (a basic macroeconomic model of growth) would be perfect to explain macroeconomics. However, this is not the way it appears to behave, since the economy does not converge to a balanced growth path and continues to rise smoothly after that always. There are recessions and big booms.

Thus, two types of disturbances were introduced: technological and fiscal shocks. Think about a software developed by some company with which economists input data and it runs the best model to predict and analyze whatever is needed. It could provoke an economic boom perhaps, because it would change the production function. This is a technological shock.

Secondly, fiscal shocks, according Romer (2012, page 194), change the "quantity of available goods to the private sector for a given level of production". These two types of shocks are real, which means they are not monetary nor nominal. They really change the economy. Therefore, this macroeconomic model is named Real-Business-Cycle (RBC).

Also, another change was introduced: change in the employment level. Other models assume the employment level is exogenous, meaning it grows smoothly and it is always constant. However, the RBC model states the employment level is the intersection between labor supply and labor demand, because households decide not only whether they consume but also on how much they work. So, RBC introduces shocks (fiscal and technological) and employment changes. Is this enough to create a DSGE model? The next sections will provide an answer.

3.3.3 RBC assumptions and Beyond

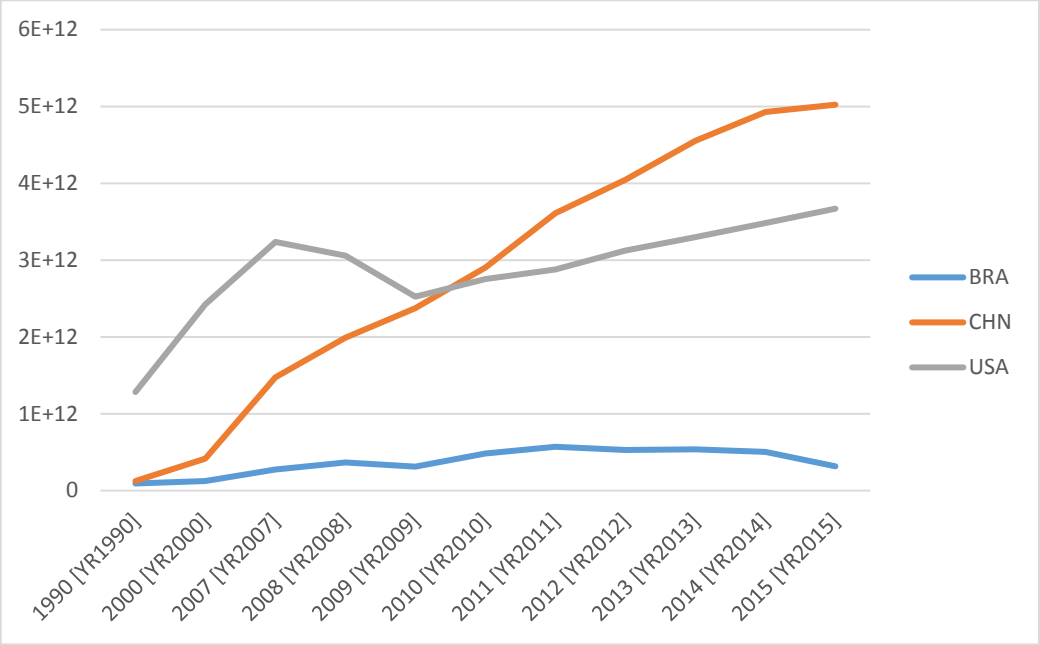
It would be interesting if an economist set an extended Walrasian model to a RBC model to predict economic fluctuations fairly. However, it is possible to notice in the literature that RBC models only do a poor job explaining macroeconomics (the end of this chapter explains why). Although it is not a DSGE, it aims to be a general equilibrium based on microeconomic foundations and has "specification of the underlying shocks that explain, both quantitatively and qualitatively, the main features of macroeconomic fluctuations" (ROMER, page 194, 2012).

Nominal rigidity, which is accepted by a set of economists worldwide, is not part of this model. Therefore, Romer claims that RBC is not a full calibrated DSGE model, a New Keynesian explanation. However, for the New Classics, price rigidity can be dropped or taken partially. This dissertation will try to apply the New Classical approach for a DSGE model, focusing on the agents' expectations.

First, RBC begins describing a normal production function, where $Y_t = {K_t}^{\propto}(AL_t)^{1-\propto}$, a classical production function of many textbooks, named "Cobb-Douglas Production Function". Alpha is between 0 and 1. K_{t+1} equals K plus investment minus its depreciation, when I is Y minus consumption and government expenditure. Real wages and real interest rates are sets of the marginal product of labor and capital, respectively. A discussion why the Brazilian real interest rates are so high and real wages low in relation to other countries can

perhaps be explained by this fact. Brazilian productivity and capital investment[6] are well below industrialized countries', such as the Unites States and Europe, and emerging countries as well, such as China and Russia (WB, 2017).

Graph 5: Difference between Brazilian, American and Chinese stock of capital – 1990/2015



Source: World Bank Data (2017).

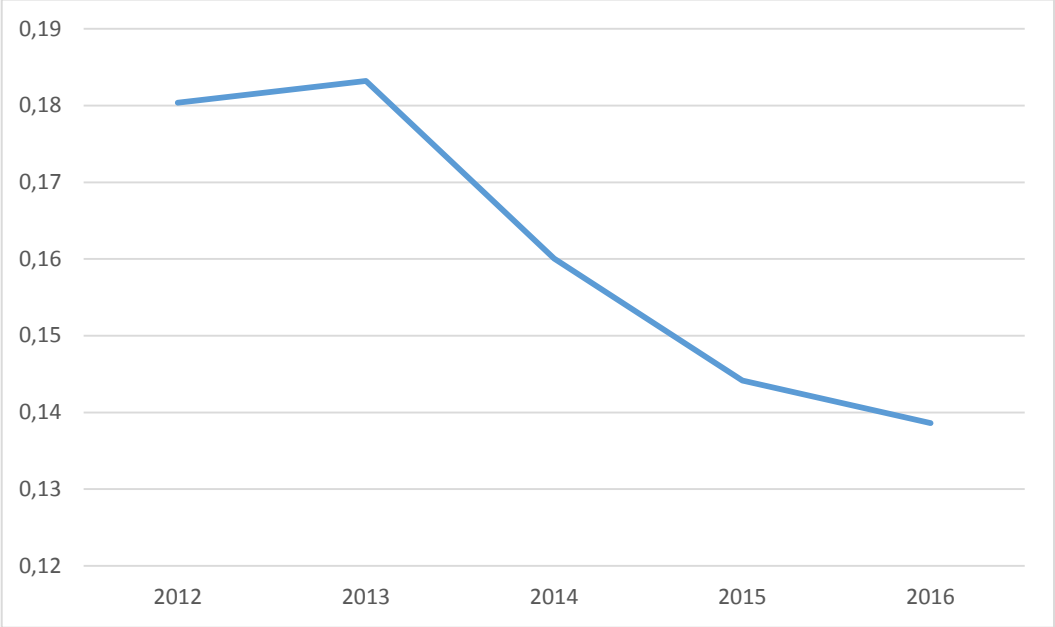
Another point is that the Brazilian aggregate supply is very inelastic even in the short run: entrepreneurs have several bureaucracies and tax difficulties to start new productive investments (new companies), so the supply side is very restricted. This in fact, a demand-pull inflation, as small as it can be, can yield a slight or severe inflation procedure. Also, inertial inflation in Brazil is a fact which can be analyzed in the Quarterly Inflation Report of the CBB (March of 2017, page 35). To counterbalance this, the neutral interest rate (the rate that does not overheat the economy and leads to maximum employment rate) needs to be far higher than international levels, around 4.5 % a year.[7]

[6] At Carvalho et al. (page 36, 2007), chapter 3 explains why a small capital stock may set higher values for the natural real interest rates. When capital stock is tiny, any improvement has a high marginal product. To offset this, natural interest rate must be high.

[7] This can be seen simply by subtracting from the nominal interest rate (SELIC) the inflation expectation for the next 12 months. Many economists, as Schwartsman, show this in their speeches about monetary policy. This data can be found in the SGS of the CBB (2017). Also, even if monetary policy is not the focus of the DSGE in discussion, it certainly has linkages to fiscal policy. This will be fairly explained in the sequence.

Also, as a saving rate perspective, Brazil tends to save less than a world level in percentage of GDP. The investment level is financed by the current account deficit, or foreign saving rate. In a Solow Model perspective, Brazil should grow more and faster if it expands its saving rate. Even for heterodox economists, a continuously fiscal expansion could not be done, since the Balance of Payments condition is related to a foreign restriction.

Graph 6: Saving Rate in % of GDP – 2012/2016



Source: Brazilian Institute of Geography and Statistics (IBGE), 2017.

Another feature of RBC models includes leisure in the utility function and randomness of technological and government purchases shocks, which are, according to Romer (page 197, 2012), “the two most important differences between RBC models and the Ramsey model”. For simplicity, the equation that shows the relation between consumption and leisure is the following:

$$\frac{c_t}{1-l_t} = \frac{w_t}{b} \quad (6)$$

Which shows the household’s behavior.

Another point is that households face uncertainty about rates of return and future wages. Their choices of consumption (c) and labor supply (l) depend on technological and

government purchase shocks. Here, RBC differs because uncertainty relates to “consumption in the current period to expectations concerning interest rates and consumption in the next period”, while the Ramsey model represents an equation “relating present consumption to the interest rate and *c* a short time later by the Euler equation” (ROMER, page 199, 2012).

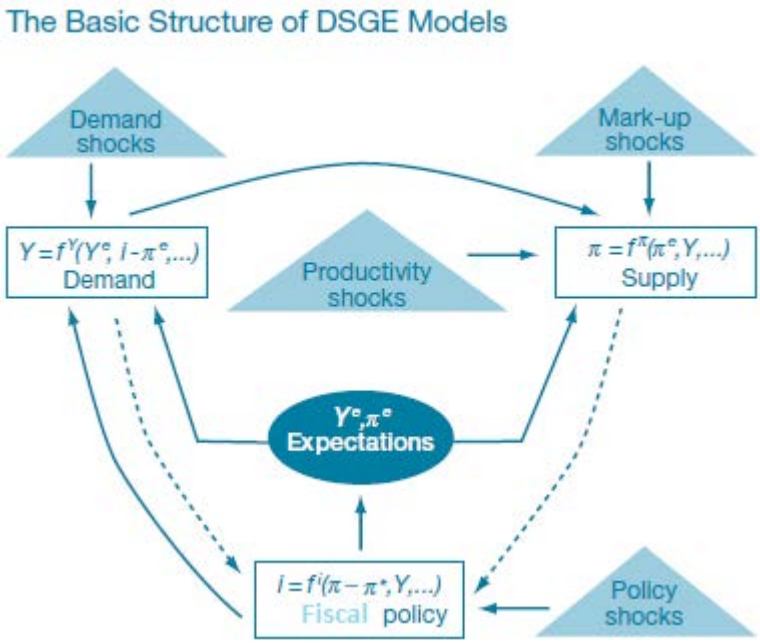
In final words, this model is an example of an economy whose technological and government purchase shocks drive macroeconomic fluctuations, where there are no market failures, and, if fiscal policy is used to stabilize the economy, it would only reduce welfare. So, it is possible to see that RBC models need to be improved, becoming a calibrated DSGE model. Romer (page 211, 2012) shows the effects of technology shocks and changes in government purchases in the model too. For example, if technology increased 1 per cent positively, and capital stock is constant, labor supply would rise by 0.35 percent, consumption would rise 0.38 percent and output would increase 0.90 percent, since $K^{1/3}(AL)^{2/3}$.

Having in mind a change in the fiscal policy, in response to a 1 percent shock, output would increase by 0.02, but it would fall later below normal, to -0.004 percent 7 quarters ahead.

3.3.4 Structure of DSGE models by macroeconomic assumptions

For now, it would be interesting to talk a little bit about how are the DSGE models’ structure is. As Sbordone et al. (2010) states for the monetary policy, it would run the same way, but with the difference that it would switch monetary shocks to fiscal shocks. For example, it would switch a decrease in the SELIC rate or in the reserve requirements to an increase in government expenditure, both enhancing the demand compound in the economy analyzed. So, the basic framework is the following:

Illustration 3: Structure of a DSGE Model



Source: Sbordone et al. (2010). Edited.

Also, there is a point that will be highlighted about this type of macroeconomic model: DSGEs incorporate the expectations about the future outcomes, and these expectations about what is going to happen make things really happen (or have substantial influence on them)! For example, if the government states there will be an increase in the expenditure, the agents may think inflation will rise 1 %. This expectation can really increase inflation in 1 %, even if the increase in the demand by the new shock did not cause a 1 % increase in the actual growth of general prices.

For fiscal parameters, most of the papers recently claimed the fiscal policy shocks would be an autoregressive 1 – AR(1), not depending, thus, of any other variable in the model (it is endogenous), as Cavalcanti (2011) states. The government expenditure or the primary surplus is determined by the public debt path, along with the output (Y) path.

3.3.4.1 New-Classical Assumptions: Expectations emphasizing and clear markets

The basic assumption of this school of thought is that the individuals maximize utility based on the expectation formalized rationally with the information they have. This changes the output level when there are differences between price levels and expected price levels. Expectations and the agents' maximizing utility function is the topic of the next paragraphs.

The Lucas Supply Curve is also present in the literature and has strong implications, which it will be formalized in the next section.

Rational expectations are the basic feature of a DSGE model: in short, they are the way agents take decisions, using all the information they have about the economy, making them rational. More formally, according to Scarth (page 51, 2009), the basic idea of rational expectations is a simple fixed-price fixed-interest-rate income-expenditure model. The relationships are $Y_t = C_t + G$, $C_t = cY^e{}_t$, $Y_t^e = Y_{t-1}$ and $Y_t^e = E_{t-1}(Y_t)$. The first equations mean that output equals consumption and autonomous spending, and consumption is a coefficient times expected value of Y. The last equations are the rational expectations themselves, where *e* is the mathematical expectation that the agents forecast.

A more sophisticated equation for rational expectations is the equation (3.8) of Scarth (page 53, 2009), where rational expectations are $p_t^e = E_{t-1}(p_t)$, which calculates "the mathematical expectation of price". The time subscript of *E* denotes the shocks agents expect. Agents and the monetary authority (Central Bank) forecast the current and future shocks knowing the previous ones. They also know other variables, such the structure of the economy and its equations and slope coefficients. Eliminating interest rates and expected price variables, the system results in two simple equations, which are:

$$y_t = v_t \quad (7)$$

$$p_t = \emptyset y_t + u_t \quad (8)$$

And their variances are the following equations:

$$var(y) = \sigma_v^2 \quad (9)$$

$$var(p) = \emptyset^2 \sigma_v^2 + \sigma_u^2 \quad (10)$$

These equations show that the log of real output (change of output) is just a supply shock. The log of real prices (change in prices) is a demand shock and a part of the real output change. The variances have zero means, are constant and not serial correlated. Since the variances are not functions of the monetary authority, monetary policy is ineffective. Scarth gives an explanation, stating "the central bank must set its instrument variable (r) before the

current shocks are known, just as the private agents must commit to setting their nominal variables, before the current shocks are known". This means the monetary authority cannot do anything for the private agents "that they cannot do for themselves" (page 54, 2009).

However, there is another model where monetary policy matters, when the central bank waits until the current shock is known to set the interest rate. The equation would be $r_t = \bar{r} + y(p_t - 0)$. The difference to the equation that turned real interest rates ineffective is that r_t depends now on the value of price, not the expected value of price (the central bank waits for the shock to set interest rates). This way, changes in the real output and price level are different from those above, and *y* begins to be affected by demand shocks as well. A new coefficient emerges: it means the elasticity of price-level targeting policy. When it is bigger, resulting in an aggressive price-level targeting, on the one hand demand shocks have a smaller effect on real output, but, on the other hand, it makes supply shocks have a larger effect on *y*. Scarth completes that "the monetary authority faces a permanent volatility trade-off, even though it does not face a permanent trade-of between the average level of real output and inflation (or the price level) (page 55, 2009).

Although there is not a permanent trade-off between inflation and output growth, the monetary authority should not ignore the volatility effects of monetary policy. For example, using the same case in Scarth's book, when a negative demand shock hits the economy, shifting aggregate demand to the left, hence dropping prices, the central bank can reverse this effect by pushing aggregate demand back to the right, stabilizing prices and the volatility of output. However, when there is a supply shock, things become harder. If aggregate supply shifts left, price level rises, and real activity falls. The monetary authority can minimize this effect pushing the demand curve to the left, lowering demand components and pushing prices back to their original levels. But it only makes the output fall to be more accentuated, and, this way, a volatility trade-off in the short run arises[8].

[8] The next section of Scarth's book describes an extended model of Rational Expectations, where it involves yesterday's expectations of today and today's expectations of tomorrow. So, it is an enhanced analysis. For now, we will consider the basic model only for simplicity, since this dissertation is a simple DSGE model for Brazil and a simple VAR.

3.3.4.2 Micro-Foundations of the New-Classical framework: Household's behavior, firm's behavior and Lucas Supply Curve

The Classical model explains itself using some micro-foundations, describing the willingness of the firms to maximize profit and the setting of real wage to be the marginal product of labor. However, there is no micro-foundation setting to describe the use of another factor input, which is capital (K). This lack of microeconomics for macro models, when they needed best explanations to formalize them and to set their parameters, as well as to change them during the time paths, came by in the 1970s. From this period, Robert Lucas made a critique for traditional macroeconomics models, that is best known as "The Lucas Critique".

As Scarth's states (page 64, 2012), "Economics is often defined as the subject that explores the implications of constrained maximization". So, all macro models should have these types of constraints, since households and firms change their behavior when there are changes in the policy regime or in the economic environment. However, these constraints, generating parameters, should not be trivial, once when they are trivial they do not correspond to reality. Scarth's exemplifies it when he states that when a random β, which describes the interaction of tastes and technology, is primitive[9] since when "one wants to explore the determination of taste, one becomes a psychologist, not an economist, and if one is interested in understating technology, one becomes an engineer, not an economist". Thus, there must be micro-foundations to determine the pillars of modern macro models, which change the parameter in response to a change in the policy regime.

The Lucas Critique warns that it does not make sense to always use some coefficient of a basis scenario into an alternative one, because it may change over time and over policy shocks. Lucas also claims that "[It] outlines precisely how to adjust that parameter to conduct theoretically defensible simulations of alternative policy rules". This will be conducted in this thesis when different shocks under different values of parameters will be tested and used for forecasting.

Robert Lucas also created another feature of the New Classical approach for RBC: The Lucas Supply Curve. In Romer (page 295, 2012), there is plenty of information and details of improvement for macroeconomic models. The purpose of this model is to quantify output in response to differences between the island price (the sector's price *i*) and the total price index

[9] According to Scarth, "primitive" means that it is not based on micro-foundations, so it does no respond to changes in the policy regimes. For example, when there is a fiscal policy shock, the parameters may vary, so the micro-foundations capture the trend and adjust during the time path of the change.

P. Basically, the log P (prices), *p*, is the mean of all islands prices, $\overline{p_i}$. $y = \overline{y_i}$, so, the log of output is the mean of the aggregate output of the sectors/islands. Also, y is the difference of the log of money stock *m* and the log of prices *p*. The more money and prices are constant, the more output. Note that for this equation hold, expectations must be anchored. If people expect *m* to increase, prices would increase as well, and no output movement would be seen.

This leads to another equation: $E[p] = E[m]$, which states that expectation of *p* is the same of expectation of *m*. So, if the expectation of price level is to rise 5 %, it is expected that money stock increase 5 %. This way, it is very simple to understand the Lucas Supply Curve. The final equation is the following, which describes that if money stock is greater than the expectation of its change, output will grow under a certain restriction named *b*, a parameter.

$$y = \frac{b}{1+b}(m - E[m]) \quad (11)$$

3.3.4.3 New-Keynesian Assumptions: Nominal Rigidity

Romer states that a major limitation of the RBC models is the absence of shocks in the monetary policy driving the macroeconomic fluctuations (page 238, 2012). For monetary policy to have real effects, there must be some mechanism which does not change only prices without changing output or real prices. This kind of mechanism is called nominal rigidity of prices or wages. Of course, introducing nominal rigidity into the model changes the microeconomic foundations, as Romer posits about the modern business-cycles models. The goal of this mechanism is to describe how "small nominal adjustments can lead to substantial aggregate nominal rigidity".

The assumptions will be divided into totally fixed prices and partially fixed prices. For the first hypothesis, output is given only by a function of labor, Y = F(L). Government and international trade are outside this model for now. Household behavior is described by $\ln C_t = \ln C_{t+1} - \frac{1}{\theta}\ln[(1 + r_t)\beta]$, where C in consumption, r is real interest rates and β and ∅ are adjustment coefficients. The new Keynesian IS curve is $\ln Y_t = \ln Y_{t+1} - \frac{1}{\theta}\, r_t$, which Romer states its main difference is the ln Y_{t+1} on the right-hand side of the equation. Finally, the equation that describes when money demand increases output and decreases nominal interest rates is the following: $\frac{M_t}{P_t} = Y_t^{\theta/v}\,(\frac{1+i_t}{i_t})^{1/v}$.

The effects of shocks with fixed prices are very simple, since the IS-LM model is still the same in the short run. In a Walrasian model, an increase in the supply of money would result only in inflation. Now, an increase in the supply of money pushes the IS curve down-side, and interest rates fall and output rises.

Looking at the cases of model adjustment with prices and wages rigidities, and a perfect competition in the goods and labor markets, the first one made is the Keyne's model, derived from the General Theory (1936). Case 1 shows nominal wage is unresponsive to current period developments W = $\overline{W}$. It means real wage is above market-clearing level, a non-Walrasian feature which states wages are above the level that equates supply and demand. Real wage is the marginal product of labor (L), a very conventional assumption. The findings of this case failed to find support, since a higher demand would rise prices and real wage would fall, stating a countercyclical fluctuation. The truth is that real wage is very procyclical.

For case 2, we have sticky prices and flexible wages, the opposite of the case, but yet with a competitive labor market 1. The conclusions are different of case 1, because a higher demand increases the effective labor demand, leading to higher real wages. From this case, three conclusions emerged: i) the natural starting point for models are price stickiness rather wage rigidity; ii) there is no necessary connection between nominal rigidity and unemployment and, at last; iii) it is an easy model to use. This case is the only when that there is no unemployment, since employment is the intersection between labor supply and effective labor demand.

For case 3, we now have the same assumptions of case 2 but the real labor market contains imperfections. This makes sense when it is possible to notice output appears to be associated with fluctuations in unemployment (ROMER, page 249, 2012). Somehow, real wages are above the level which equates supply and demand, for example when firms pay more for the employees because of efficiency-wages. The conclusions are the same as in case 2; however, there is unemployment since employment and real wage are set by the intersection of effective labor demand and the real wage function.

In case 4 there is the extension of case 1 created by Keynes (1936), as case 3 extends case 2. Now, along sticky wages and flexible prices, there is an imperfect competition in the goods market. This case emphasizes that fluctuations happen when there is fluctuation in the demand for goods, as case 1 does. However, this is not the reality facing the data. Romer finalizes stating Keynes' original model describes well the supply side of the economy (page 253).

3.3.4.4 Microeconomics of Nominal Rigidity

Focusing on menu costs, here "the goal is to characterize the microeconomic conditions that cause menu costs to lead to significant nominal stickiness in response to a one-time monetary shock" (ROMER, page 267). The assumption is that firms produce only with L in this specific model, where $Y_i = L_i$, and Y is output. Household's utility function is the following $U = C - \frac{1}{\gamma} L^Y$, and $\gamma > 1$. In this model Y = C, and the new demand curve is $Y = \frac{M}{P}$. The best interpretation is that higher prices induce to a smaller Y, a simplification of the IS curve since the focus here is the supply curve.

The implications are that monetary shocks can have real effects on the economy, influencing macroeconomic fluctuations. Simply, by changing the amount of Money (M), depending on what happens to prices, output can grow or not. This is because when producers have market power, they produce less than the optimal amount. Since the demand curve is downward-sloping, it means the marginal product is higher than the marginal revenue product of labor, implying the real wage is less than it should be optimally. Labor supply is below the optimal level and hence optimal output is below its equilibrium level.

Romer complements that imperfect competition has "important implications for fluctuations" (page 273). And an economy in which incomplete nominal adjustment prevails, or nominal rigidity, fluctuates when there are monetary shocks. For example, when a marginal reduction in all prices hits an economy, M/P rises. Thus, aggregate output rises, because firms are selling at prices that exceed marginal costs, rising profits and increasing welfare of households. Of course, higher real wages demand more goods and services, shifting out the demand curve (IS). Another point which influences welfare but does not have a real impact is because households suply the same amount of work and earn more, having a positive effect on welfare, but the owners of firms supply more since they charge less for their products, having a negative impact on welfare[10]. These externalities[11] of price setting under imperfect competition are called "aggregate demand externality", according to Blanchard and Kiyotaki (1987).

[10] In the aggregate level, welfare is not affected by this channel of externality.

[11] There is another type externality of price setting, called "Real Rigidity", focusing on "small responsiveness of profit-maximizing real prices to aggregate output", according to Romer (page 279. 2012). This happens when the firm has a low incentive to adjust its price to its new profit-maximizing price since some fact changed aggregate output. Although this topic is relevant for the New-Keynesian approach, it is not in the scope of this work. To see more details of this phenomenon, section 6.7 of Romer (2012) provides full explanations.

3.2.4.5 The Lucas Imperfect-Information Model

Nominal rigidity or imperfect information, cited in the last section is older than the New-Keynesian version. Lucas (1972) and Phelps (1970) suggested another type of nominal rigidity, when “producers do not observe the aggregate price level perfectly”. Romer explains this fact by giving an explanation: “If a producer does not know the price level, then he or she does not know whether a change in the price of its goods reflects a change in the relative price of the goods or a change in the aggregate price level” (page 292, 2012).

In short, the change in the price of some good may come from a change in the price level or in the relative price of the good. The producer response is to increase output because he or she attributes part of this change to the price level and part of it to the relative price of the product. Thus, this imperfect-information phenomenon, when the change in the price of the good is only a reflection of the change in the price level, leads to a higher production of the firm’s goods, only because the producer does not know that only the inflation rose, not the relative price of the firm.

3.3.5 Differences between DSGE in Real-Business-Cycle and New-Keynesian approaches

In the book of Romer (2012), chapter 7 details the New-Keynesian approach of the DSGE, emphasizing the nominal rigidity on prices, wages, and some frictions. We will look into some equations which are important to the model too. On the other hand, we will show some key equations for the New-Classical DSGE approach, which are similar to the New-Keynesian ones, with the difference of some parameters of frictions.

Few equations can demonstrate the big difference between RBC and New-Keynesian DSGE models. Note that all New-Keynesian models have different values for parameters, mostly far from 1, which means there are imperfections and frictions for the economy that may slow down the process of adjustment of the variables. For the RBC, there will be less frictions, hence they will not have the same impact on the final results of the model as the New-Keynesian parameters.

For example, this equation of consumption for the Keynesian approach has a β which represents the discount rate, stating consumption is not clear and has an imperfection. Consider the following New-Keynesian equation for consumption:

$$\sum_{t=0}^{\infty} \beta^t \, [U(C_t) - V(L_t)], 0 < \beta < 1 \text{ (12)}$$

Note that β represents a friction which impacts on consumption and labor as time passes. This equation is from Romer (page 315, 2012).

For firms, a simple New-Keynesian DSGE equation could be the following:

$$R_t = Y_t[\left(\frac{P_{it}}{P_t}\right)^{1-\eta} - (\frac{W_t}{P_t})(\frac{P_{it}}{P_t})^{\eta} \text{] (13)}$$

The η represents a friction, which in the aggregate has an impact on the firm's real profit in period *t*. To clarify, if η is 0, which means total friction, output times the difference of price of the firm's sector divided by aggregate price will be subtracted by wage divided by the aggregate price. On the other hand, if η is high, near 1, there would be a significant difference in the result of the equation. This equation is by Romer (page 317, 2012).

For a New-Classical perspective, price and wage flexibility will rule - the opposite of the New-Keynesian perspective (which is price and wage rigidity). For example, a simple consumption equation would be $c_t = \partial + c_{t-1} + w_t^e + \varepsilon_t$ (14), provided by our perspective. This means consumption at time *t* is simply a sum of autonomous consumption, the past value of consumption (perhaps the consumption of a household has a lot of items he or she consumed last month for example), his or her expectation of income (wage) and an error term, which could respond to an unexpected event or expected (but not often) event like a marriage, graduation and so forth. Note that there is no friction or rigidity. The debate is in the short-run, and it may take time to find a true answer.

3.3.6 DSGE Models for Brazil

Creating a DSGE model for Brazil may be a hard task. According to Costa (2016), we can notice that most of the Brazilian macro series have breaks related to policy regimes and methodological changes, which discontinues the series. Also, emerging market economies have structural shifts, derived by reforms, switches in regimes, high exposure to external cycles and political turnovers. In 2016, Brazil faced all of the above, when there were a fiscal and foresight reforms, an economic regime switch because of changes in the federal economic team, exposure

to political cycles, like the current US foreign policy and, at last, political turnovers such as the impeachment of the first woman president ever in May 2016.

For the broken series, short samples may have missing mean of the long run behavior and it is very difficult to identify deep parameters (COSTA, page, 4, 2016). Costa (2016) also states that "a closer look into Brazilian data can reveal a number of economic questions to consider regarding the recent slopes in the times series […]". Thus, getting the trends of fluctuations needs a structural perspective, in which a DSGE model is efficient when used with a multivariate filter, because they provide exogeneity and consistency, especially with their common application to measure output gap (COSTA, page 4, 2016).

Another point refers to the fact that most DSGE models are meant to explain cyclical fluctuations and are resolved around a steady state (COSTA, page 5, 2016). It means the fluctuations are meant to be stationary, and they need, per Costa (page 5, 2016), a transformation in the preliminary data to be estimated. This is necessary because the model has to be detrended, which occurs because it has many trends, especially in the Brazilian economy.

It is known that "when trends are misspecified, the structural model is also misspecified and parameter estimation is biased" (COSTA, page 5, 2016). This represents that when a set of variables are cointegrated, having a linear long run relation, they need a deterministic trend to be estimated, resulting in a cyclical DSGE model. To analyze policy and forecast using a cyclical DSGE model, four aspects need to be weighed in, and we will see it in the next paragraph (especially in the view of an unstable economy as Brazil's).

i) Economic trend itself: in the example of Costa (page 6, 2016), the main variable is the GDP growth of the last twelve months, because it is a long memory measure. It must be taken in account since the trends may vary a lot, differing through the several kinds of series that exist.

ii) It is hard to explain the shifts of some variables: again, in the case of GDP trend, "real-time revisions of trends brought forth by methodological procedures, either for current or past periods, are highly inappropriate and can hazard the policy calibration" (COSTA, page 6, 2016). Costa (2016) states stability is highly desirable as well, because they are very likely to need an HP filter or a demeaning process to erase uncertainties in the short run (page 6).

iii) Technical content to trace and explain revisions: trends will occur, and they must be "consistent and integrated with real business cycles (RBC)". So, for policy-making, there must be ability to forecast trends, because, without the trend dynamics "that sustain their procedures", it becomes impossible to make a

accurate forecast in critical periods and very difficult in the other periods (COSTA, page 7, 2016).

iv) At last, ability to learn about the current stance of economic activity: the written paragraph by Costa (page 7, 2016) explains why it is needed:

> "Once GDP data series are calculated on a quarterly basis and the release is delayed by months, univariate methods cannot work until a new data series becomes available, although current information set contains useful assistance to outline stances for trends and cycles. Structural detrending methods can present yet comparative advantages at this point".

Finally, after all these mentions about Costa (2016), the author turns to the methods to create a DSGE model "by using a one-step filtering, [which] cares about nonstationary in raw data", providing a "internally-consistent trend-cycle decomposition […]". Again, as many papers claim, there is no unique method to detrend cycles in the DSGE approach, and micro-foundations are the main way to quantify the short run connections (COSTA, page 7, 2016).

The DSGE model presented by Costa (2016) is a simple close-economy, similar to the one that will be created for the Brazilian fiscal policy in this thesis, and is meant to explain the Brazilian prices in relation to the output measure. The principal challenge is to detrend GDP growth which has many breaks since methodological techniques change with frequency. Again, the author makes an application to measure potential output and a contribution of the debate about monetary policy.

3.3.7 A DSGE model for Brazil: An Example of Monetary and Financial DSGE

According to Costa (page 8, 2016), the DSGE model in question "is built to combine short run specifications and structural changes in the balanced growth path". Also, Costa states that only the real structure of the economy drives the long run growth path. Although many features are included in a modern DSGE model, as Costa claims, they will not be part of this model properly: "the idea is to keep the framework as simple as possible (page 8, 2016)".

The model has three types of economic agents (households, firms and the government), and it is a simple closed economy. As this dissertation will approach, the DSGE model in question will be similar to the DSGE model of Costa: an economy with these three types of agents. However, there is a difference: the dissertation DSGE model will be focused on the fiscal policy (again). Back to Costa's paper (2016), there will be four elementary trends, which

are population, technology, labor and capital-specific factor productivities, which will shift with time, when the output growth rate will be determined by the growth rates production factor.

Now, Costa (2016) turns to the micro-foundations of his DSGE model, which will have the supply, demand, aggregation, price and wage setting (which will not be part of the DSGE model of this dissertation), government, market clearing and exogenous processes features. We will take a look at these eight components.

i) Supply: the aggregate production function will describe growth rates, and it will be represented by time-varying elasticity of substitution, permitting different productivity levels of capital and labor. There will be the rule of diminishing returns and a CES function will drive the elasticity of the parameters. The author claims that "a generalized production function broadens the possibilities of the model to catch some of the recent economic developments in Brazil", so the model will be fitted to the Brazilian macroeconomy (COSTA, page 9, 2016).

ii) Demand: the demand will be driven by a population N at time t which will grow at the rate g at time t and will choose consumption and supply of labor according to $\varepsilon^{\infty}{}_{t=0} = \beta_t U(c_t, I_t)$ and will drift over time. As Costa claims, the β will be a time-varying variable and "intends to catch permanent changes in the long run interest rate", as it happens in the Brazilian economy.

iii) Now, it comes to the aggregation: some part of the population, who does not work, is considered as an assumption. To enrich this idea, Costa (page 12, 2016) proposes "single linear specifications" to "account for short run changes in participation and employment rate". Moreover, Costa (2016) finally sums up per capita labor supply.

iv) Price and wage setting: here, Costa (page 12, 2016) assumes nominal rigidity in prices and wages, a new Keynesian assumption. Notice that our DSGE model will have a different assumption, when at any time given, even in the short run, there will be no price rigidity. Costa explains the dynamics of the monopolistic competition and pricing factors, when the goods pass from firms to households by a standard Dixit-Stiglitz aggregator. Also, Costa explains how prices are updated, when there is a long run factor for inflation and past inflations rates. The long run inflation would be the mean between inflation target and expected inflation 24 months ahead. For simplicity, we will focus on other parts of DGSE model.

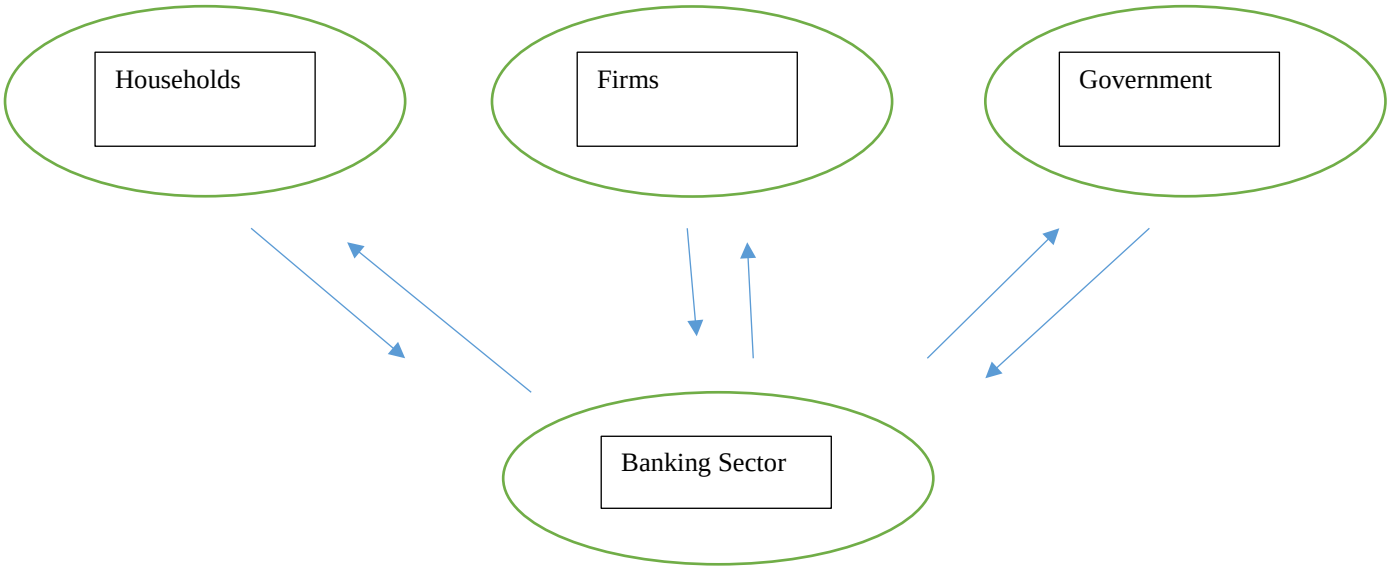
v) Government: Costa (page 13, 2016) now explains the two types of government interventions, a fiscal side and a monetary side. Our dissertation will focus on the

fiscal part, but will not leave the monetary policy even partially. For the monetary policy, there is a central bank that sets the nominal interest rate, according to other variables such as CPI inflation, inflation target, output gap and so on. On the fiscal side, "the government does three things: consumes a fraction of the private output, levies lump sum taxes on households, and issues debt b_t paying interest" (COSTA, page 13, 2016). Primary surplus is well defined as the difference between the taxes and government expenditure. There are other factors that seem to be close to our DSGE model, and will be clearly explained in the third chapter. For now, the main feature is that Costa's model is Ricardian, as ours will be, considering the rational expectations.

vi) After that, there is the market clearing: on Costa's model, aggregate supply is defined with price rigidity: for our model, this assumption will not hold. On the demand side, Costa states GDP will hold as the sum of $C_t + I_t + G_t$. Then, market clearing would be the GDP equals to Y at time t and labor demand would be equal to labor supply, a known measure for centuries.

vii) Exogenous Processes: Costa (pages 14 and 15, 2016) claims that trends can be easily modeled within a DSGE model. This is true, and there are some details that will be explained. For example, two types of exogenous processes exist. The first one is composed by a drifting and an autoregressive process component. The equation is $X_t = X_t^{trend} X_t^{cycle}$. On the other hand, this is not as simple as it appears to be. Cycle and trend are composed by autoregressive patterns and they are this way so the variables are consistent with the Brazilian style, when interest rates drift many times as well as the inflation target, "as many Brazilian economists have argued in recent years (COSTA, page 15, 2016).

Illustration 4: Dynamics of a simple Economy



Source: COSTA (2016).

Costa's theoretical model is like Carvalho and Castro's (2016) DSGE model, with some differences. For example, there is a banking sector along with other sectors, as well as it is an open-economy. Conversely, they are both equal when the public sector is divided in two parts: a monetary authority and a fiscal authority. It is possible to notice this on page 19 of Carvalho and Castro (2016).

Moving on, we see Carvalho and Castro introduce the financial system, as cited above about the banking sector, and all its components. Briefly, it is compounded by the "Retail Money Market Fund", the "Balance of Payments and Foreign Capital Flows", now introducing both open-economy and financial system together, and, again, the "Banking Sector".

Taking a brief view about the banking and foreign sectors, Carvalho and Castro (page 11, 2016) explain how the retail money market fund (RMMF) behaves. This fund intermediates the saver's financial investment, without transaction costs. The authors assume this idea for simplicity, when it is very difficult to quantify all transaction costs. Also, the many types of elements for the portfolio aim to maximize the total nominal return according to an extent equation which shows the interactions between them. The elements are bank deposits (D), government bonds, and bonds in the international market. The equation shows the return of the domestic bonds against the return of international savings in the next period (t+1).

The banking sector of Carvalho and Castro (page 13, 2016) presents the following idea: "assess[ing] the impact of macroprudential policy instrument not only on bank rates (prices) but also on quantities, through shifts in the composition of bank's balance sheets". Therefore,

this banking sector gets funds from deposits branches and extends credit to households, entrepreneurs and export firms, through lending branches.

The balance of payments (BoP) of Carvalho and Castro (page 12, 2016) shows the interaction with foreign capital flows as well. It extends the analysis in addition to exports, imports, the BoP includes Foreign Direct Investment (FDI), foreign portfolio investment (FPI), foreign exchange reserve flows, and, at last, unilateral transfers (UTL), completing the current account and the BoP.

3.3.8 A Fiscal Policy DSGE Model: Cavalcanti and Vereda's (2015) DSGE Model for Brazil

Cavalcanti and Vereda (2015) starts their paper highlighting the interest of economists and policy makers to use fiscal policy since monetary instruments were no more effective after the 2008 global financial crisis. According to Pires (2009), Brazil took almost 50 billions of countercyclical measures, or almost 1.5 % of GDP during the crisis. The main findings using the medium size DSGE model, the same used in chapter 4 of this work, were that some fiscal stimulus, such as government spending in contrast to government investments, lead the economy to more inflation, interest and less output growth.

The model represents "the main characteristics of the Brazilian economy" (page 200), and is under rational expectations and firms and individuals who are able to "fix prices and wages due to the market power they possess". Also, there is the presence of individuals excluded from financial and credit markets, that cannot use intertemporal consumption instruments and so are called as Non-Ricardians (Nr), such as other features (page 201).

Back to some considerations about the mathematics of the model, there are some equations to highlight. For monetary policy rule, which will be incremented according to the expansionary fiscal policy in chapter 4 of this work, we have the following formulation:

$$R_t = a_R R_{t-1} + (1 - a_R)\left(a_{pi}(E_t(pi_t + p) - \bar{pi}_t) + a_Y E_t(\bar{Y}_{t+z})\right) + \widehat{E_t^m} \quad (15)$$

This rule, according to Cavalcanti and Vereda (2015), states that monetary policy "depends on an inertial component, on the expected deviation of inflation from target chosen by monetary authorities and on expected deviation from output from its steady-state value". For our work's

monetary rule, Nominal Result parameters impacts on nominal interest rates will be incremented on the equation presented above, which will be shown in chapter 4.

Secondly, output is defined according to the classic IS curve: output equals consumption, investment, government expenditure and capital of the last period minus depreciation. Fiscal policy also follows a constraint, which is the government budget constraint:

$$SP_t = \frac{R_{t-1} Dl_{t-1}}{P_t} - \frac{Dl_t}{Pt} \quad (16)$$

This equation states primary surplus (SP) must be equal to the payment of interest of the last period debt minus this period debt, all divided by current prices (Pt).

After the model presentation, Cavalcanti and Vereda (2015) show the results of fiscal policy shocks in three different scenarios: shock on social transfers to non-ricardians, shock to public sector employment and shock to public investment.

The results for shocks to transfers to non-ricardians were very similar to chapter 4 results, which Cavalcanti and Vereda explains in page 2017, as it follows:

> A WM (social transfers) shock leads to an instantaneous 0,85% increase in GDP, with a corresponding impact multiplier slightly below 1. This positive effect is partly explained by the higher income that accrues to non-ricardians, who increase consumption and therefore drive up demand for goods; as a result, production by firms also goes up. Given the positive wealth effect from increased social transfers, non-ricardian labor supply decreases, which drives up their real wage and increases the relative demand for ricardian labor. The higher labor demand by firms is accommodated by an increase in labor supply by ricardian individuals, who try to compensate for expected higher taxation in the future (and thus smooth their consumption path). Note that the higher contemporaneous level of economic activity automatically expands the tax base and generates higher tax revenues for the government, so that there is no immediate need to raise tax rates. However, as production expands and the average real wage rises, marginal costs and inflation go up, which leads to an increase in interest rates by the central bank. The higher production and capital costs drive investment down, and therefore also future capital stock levels. This means that the initial increase in production (and in the tax base) is not sustainable, and that the higher level of government expenditure will have to be met by higher tax rates in the future. In the subsequent quarters, as the interest rate is kept high and the government raises tax rates on capital and labor income, investment moves further down, and so does labor supply by ricardians; non-ricardian consumption also gradually decreases, as a result of lower transfers and higher labor taxation. Consequently, GDP falls and soon finds itself below its steady-state level (from the 3rd quarter after the shock onwards). After one year, the cumulative multiplier of total spending (cumulative deviation of GDP from steady-state divided by the cumulative deviation of total public spending from steady-state) is only 0,47; after three years, it becomes negative.

This quote explains what happened to output, inflation an interest in chapter 4 of this work: in the medium run, output falls below steady-state and inflation and interest goes up, although fiscal shocks on public investment have different and better results. So, expansionary fiscal policy has positive effects in the short run, but negative effects after some quarters. The graphs of chapter 4 will highlight this fact.

4 MODELS FOR BRAZIL

In this section, several Structural VARs will be estimated to parametrize the extended DSGE model by Cavalcanti and Vereda (2015). Also, the extended DSGE model will be presented with graphs as well and there will be forecasting graphs using reduced-form VARs.

4.1 PROPOSED VAR

4.1.1 The Models

The proposed Vector Autoregression (VAR) is a structural model (SVAR) which estimates the fiscal policy parameters for the current proposed DSGE, which will be explained in the next section. There are 9 SVAR/SVECS models in our EViews models. Three at federal level (Central Bank of Brazil and Federal Government), three at state level and three at city level. The purpose of these SVAR/SVEC models is to estimate the parameters/elasticities of key variables for our DSGE model, such as impact of nominal result on GDP (IBC-Br), impact of nominal result on nominal interest rates (SELIC) and impact of nominal result on inflation level (IPCA).

The dataset is from 2003 to June 2017, and its periodicity is monthly, containing 174 observations. The source of the series is from the Time Series System of the Central Bank of Brazil (CBB), which contains data of the own CBB and other institutions such as the Institute of Geography and Statistics of Brazil (IBGE in Portuguese). There are four variables: IBC-Br, which measures GDP of Brazil, IPCA, which is the CPI of Brazil, SELIC, which is the Fed Funds Rate of Brazil, and Nominal Result of the Government, a data of Public Finance, which corresponds to taxes minus spending and the payment of interest rates of the debt level.

For example, if a parameter β is 0,05, which is the impact of nominal result on GDP, it means that an increase of 1 of nominal result (for example, billions) increases GDP by 5 %. The parameters and calibration of the fiscal policy model will be explained in the DSGE section. Every SVAR/SVEC model cointegrated (variables had a long-run relationship). The variables which did not have a long-run relationship with the current nominal result of the government entity in the last 12 months were exchange rate and real average income of population. Since it is the case of a simple DSGE, they were left behind for simplicity.

The elasticities came from the Structural Vector Error Correction Models (SVECMs), since they are more sensitive estimating the shocks of nominal result on these three variables

(IBC-Br, SELIC, IPCA) and presented better results in the t-tests, SCW and AIC. Every SVAR/SVEC model had two endogenous variables, where the second one was always the nominal result of the federation, or states or cities. For example, one SVAR estimated was IBC-Br and Nominal Result as endogenous, and IPCA and SELIC as exogenous. The second one was IPCA and Nominal Result as endogenous, IBC-Br and SELIC as exogenous. The third and last as SELIC and Nominal Result as endogenous, IBC-Br and IPCA as exogenous. The others put as exogenous, as well as the trend dummy variables, configurated the structural performance of the model, since they were not impacted by the endogenous and other exogenous ones. It could be set by the new tab of EViews 10 for Structural VARs or imposing restrictions on the VEC model, but it was easily made by setting them as exo variables.

Almost every impulse response corresponded to economic theory, which led the models to be richer, stating the shocks had the expected behavior. For example, when there is a big deficit in nominal result, interest rates rise according to the increase in default risk, country risk, and so forth. Inflation levels rise as well since the government entity increases its debt level and GDP growth remains stable or decreased, because of the Crowding-Out effect explained in chapter 2 and because of the IS-LM-FX model which describes a small open economy, as Brazil, when there is an expansion of the aggregate demand by a rise in G, pushing IS curve to the right[12].

4.2 PARAMETERS[13]

4.2.1 Federal Parameters

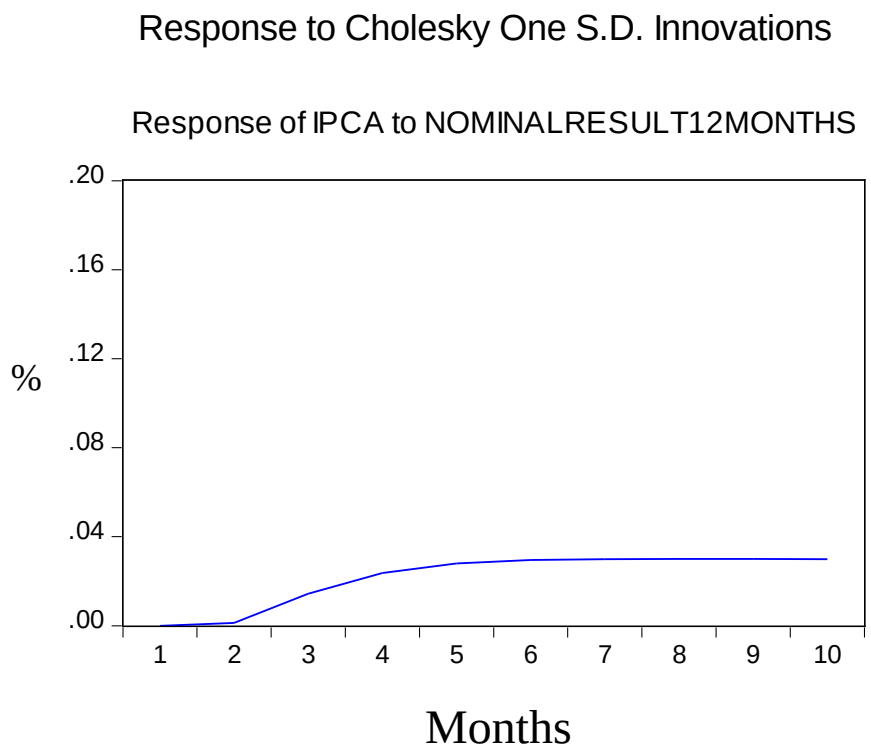
The VEC model for GDP had significant and insignificant parameters. It is not possible to state that the impact of Nominal Result upon GDP is not zero, which means that an increase in the deficit of the government may not impact GDP of Brazil in the long run parameter of the VEC model. On the other hand, SELIC had a significant impact upon a GDP growth of -0.3 (p-value of 0.01) in the short-run (one per cent more of interest decreases the GDP level in almost one third). The main explanator of GDP level is its lagged value in the previous period (p-value of 0.01) in the short run as well.

[12] The nominal interest rate increases since there is a higher demand for the current currency in the country. This way, FX appreciates and the trade balance suffers with fewer exports and more imports, decreasing its surplus or worsening its deficit. This made the IS curve shift back to its original level.
[13] All outputs of the VEC Models will be shown in the apêndix at the end of this work.

For the IPCA, the most significant cointegrating vector of the estimated VECM, which was with constant and trend, indicated a .000187 % (p-value of 0.05) increase in the index in the long run. The impulse response left no doubt about the impact of a constant deficit in the nominal result on inflation. In the long run, one standard deviation (SD) impulse of nominal deficit increased in six months .04 % of the IPCA. In the short-run, basically what explained the current value of inflation is its past value with 1.4 % (p-value of 0.1), an economic activity with 1.7 (p-value of 0.01) and the dummy variable for the IBC-Br with a p-value of 0.1. Nominal Result and SELIC had no significant impact.

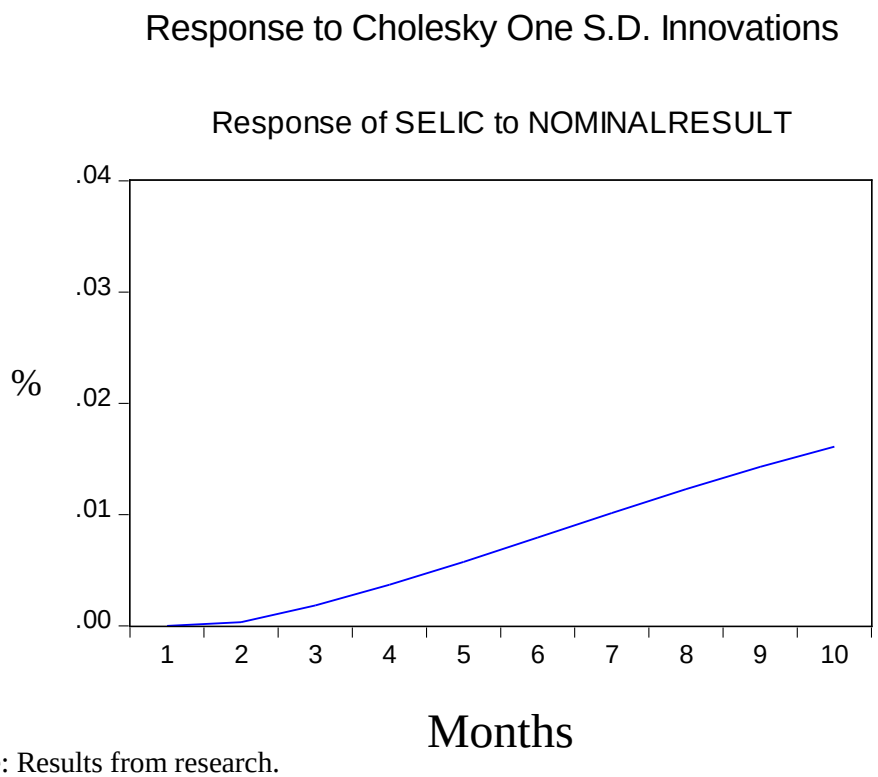
SELIC varied about the same as IPCA in the long run: .000168 % (p-value of 0.05) of increase in the interest rate. Impulse response also varies with a decontrolled deficit. In the short run, both past lags of SELIC explained it quite well, 61 % (p-value of 0.01) for the last period and 19 % (p-value of 0.05) for the second previous one. Inflation was significant as well, with 0.8 % (p-value of 0.1) and the economic activity was 0.045 % (p-value of 0.01). Nominal Result and the dummies variables had no significant impact.

Graph 7: Shock of Nominal Result on IPCA at federal level



Source: Results from research.

Graph 8: Shock of Nominal Result on SELIC at federal level



Source: Results from research.

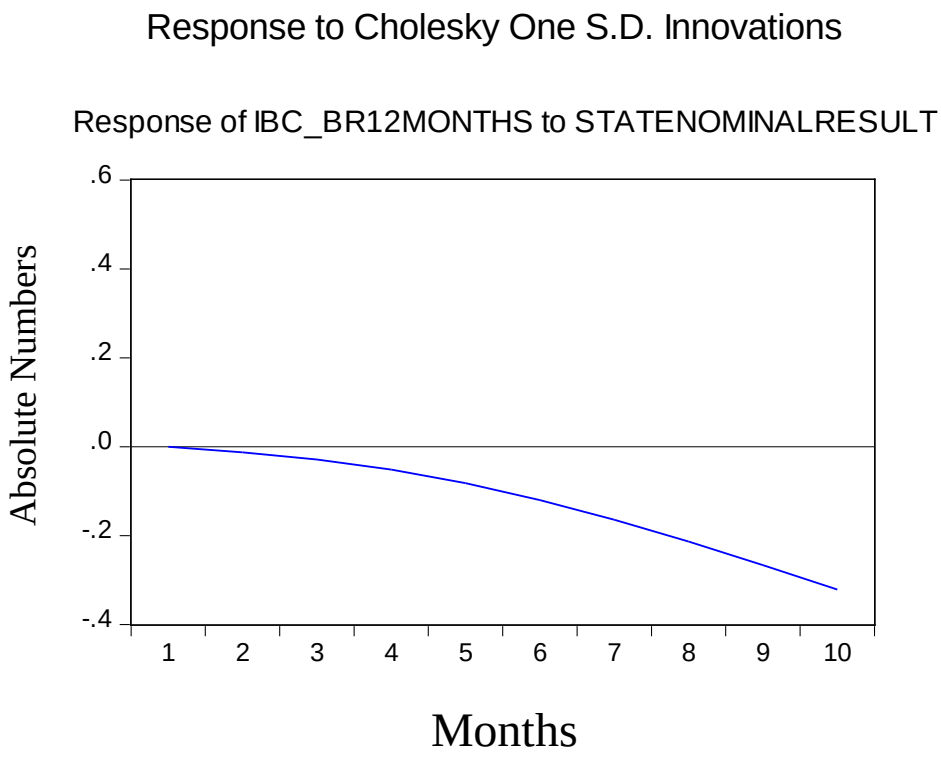
4.2.2 State level Parameters

For the State level, one million of Deficit decreases the IBC-Br in .000218 (p-value of 0.01) points in the long run. In the short run, the past value of IBC-Br, SELIC and IPCA, and the dummy for the state level nominal result were significant: 0.95 for IBC-Br (p-value of 0.01), 0.21 (p-value of 0.01) for SELIC, 0.057 (p-value of 0.1) for IPCA and 0.06 (p-value of 0.05) for the dummy variable of state level nominal result. The dummy variable for IBC-Br and the past values of Nominal Result, as well as the second past value of IBC-Br did not significantly explain the changes in GDP growth.

For inflation, the deficit influences in .000889 % (p-value of 0.01) inflation in the long run. Surprisingly, a state level deficit hikes more inflation than a federal level deficit. In the short run, what explains inflation is its past value, 1.5 % (p-value of 0.10) and economic activity with 0.7 % (p-value of 0.05). The dummy variable for GDP growth was also significant in 0.108 % (p-value of 0.05).

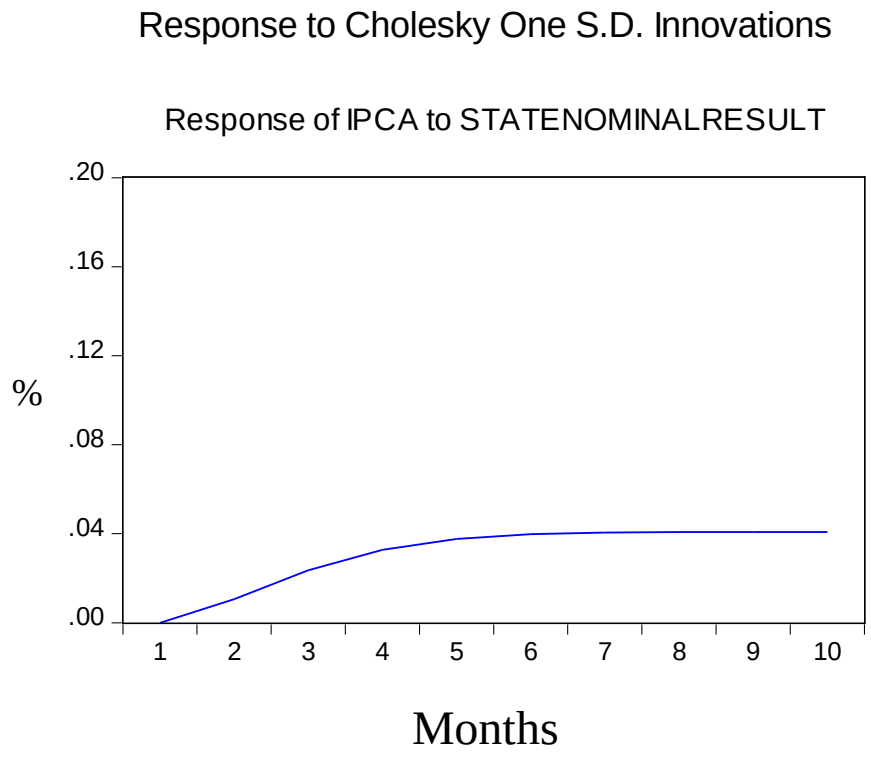
For interest rates, the result is worse: one million of deficit increases the SELIC rate in .0015 % (p-value of 0.01) in the long run. In the short run, SELIC at time minus one and IBC-Br explains significantly the current value of interest. The other variables were not significant.

Graphs 9: Shocks of Nominal Result on Output (IBC-Br) at State Level



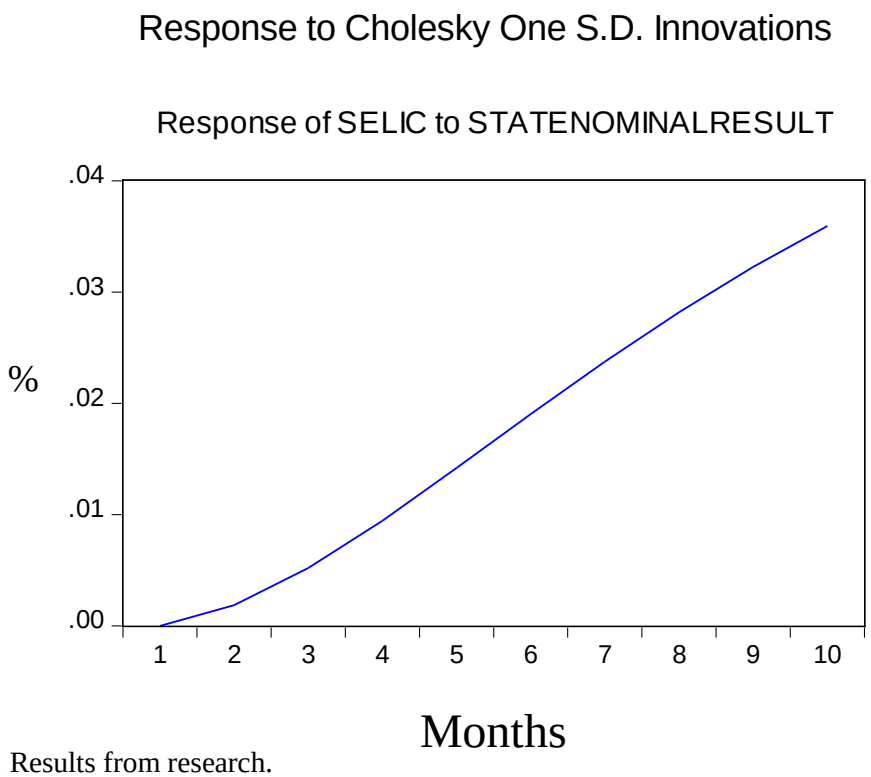
Source: Results from research.

Graph 10: Shocks of Nominal Result on Inflation (IPCA or Brazilian CPI) at State Level



Source: Results from research.

Graph 11: Shocks of Nominal Result on Interest (SELIC) at State Level



Source: Results from research.

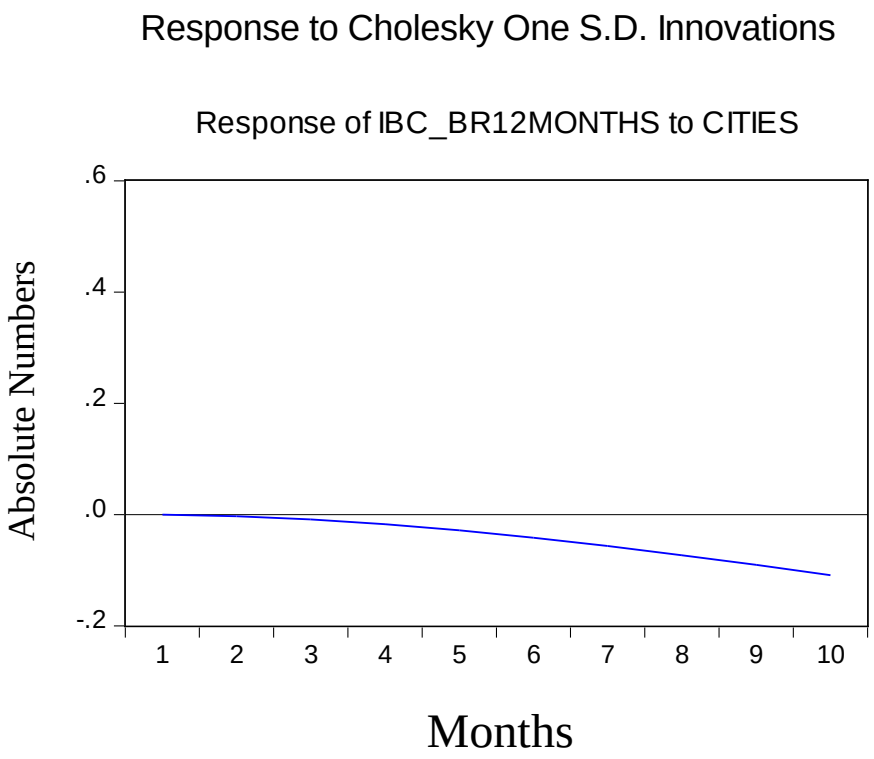
4.2.3 City level Parameters

For the City level, the parameter of Nominal Result did not explain significantly GDP growth in the long run. Everything in the short run, except for the past value of city level Nominal Result explained GPD growth. IBC-Br (t-1) was 0.92 (p-value of 0.01), SELIC was -0.01(0p-value of 0.01), IPCA 0.07 (p-value of 0.05) and the dummies for IBC-Br and city level Nominal Result were -0.10 and -0.17 respectively (both with 0.01 p-value).

Inflation rises .00247 % (p-value of 0.01) with a one million increase of deficit at city level in the short run. The past values of IPCA and Nominal Result of the cities were significant too, with 1.3 % (p-value 0.1) and 0.00355 % (p-value of 0.1) respectively. IBC-Br and the dummies were significant as well, with -0.149 % (p-value of 0.1), 9.9 % (p-value of 0.1) and -1 % (p-value of 0.1).

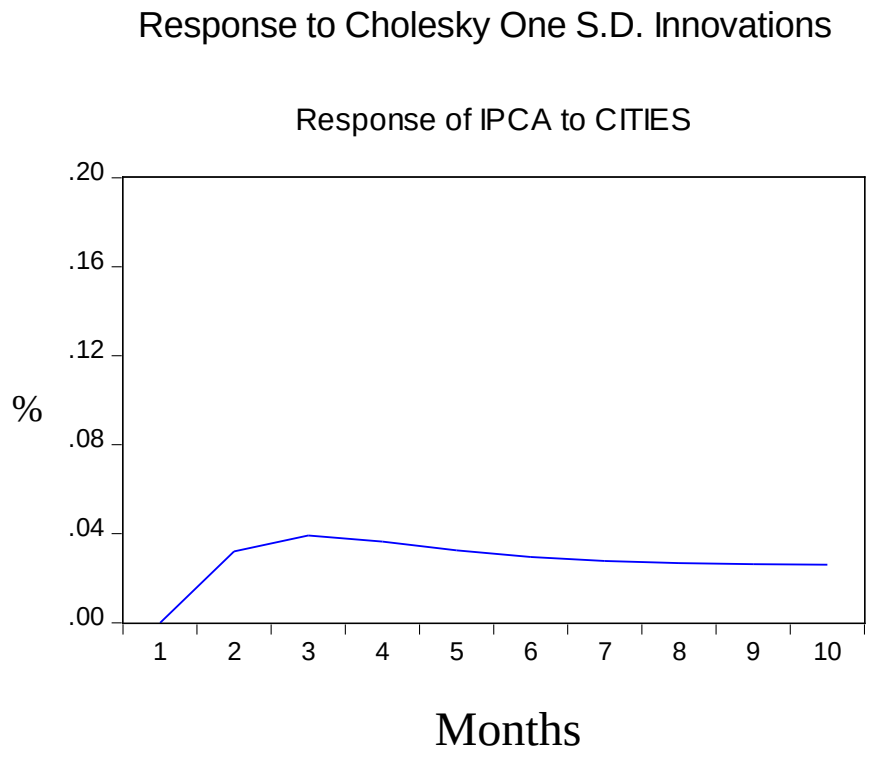
Interest rises 0.0113 % (p-value of 0.1) in the long run with an increase of one million in nominal deficit. In the short run, SELIC (t-1), IBC-Br and the dummy for the cities nominal result were significant, with -0.024 % (p-value of 0.05) and -1.1 (p-value of 0.05) respectively.

Graph 12: Shocks of Nominal Result on Output (IBC-Br) at City Level



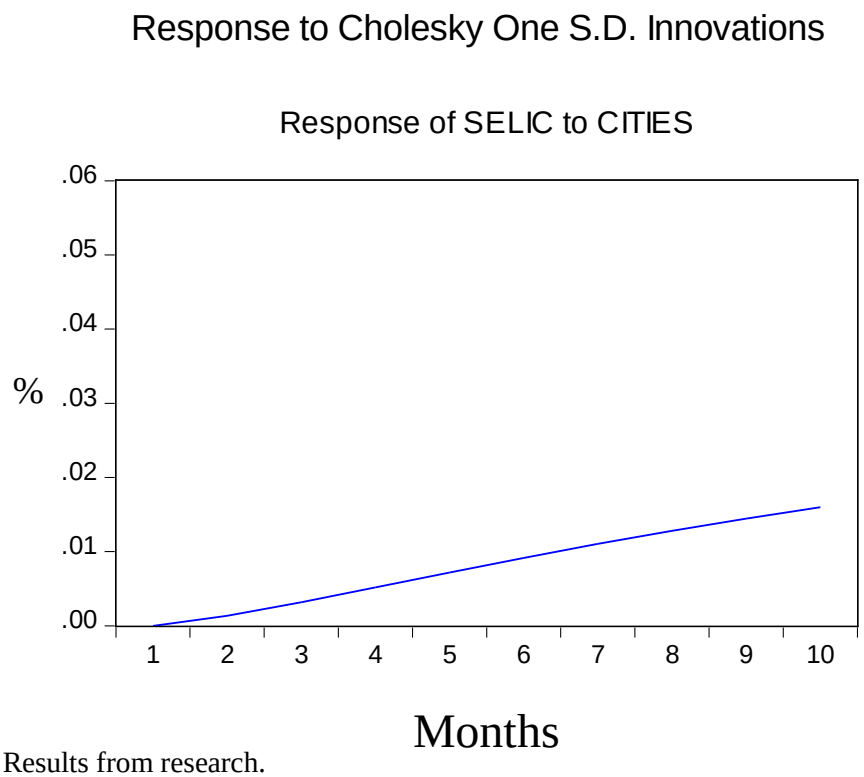
Source: Results from research.

Graph 13: Shocks of Nominal Result on Inflation (IPCA or Brazilian CPI) at City Level



Source: Results from research.

Graph 14: Shocks of Nominal Result on Interest (SELIC) at City Level



Source: Results from research.

Here, nine parameters for the DSGE were estimated at a macroeconomic level. Our model based on the IPEA paper for the Brazilian economy will use them, and two more equations will improve this DSGE. Federal level expenditure changes accordingly to the increase in the number of equations for fiscal policy. It will be explained in the next section.

4.3 EXTENDING CAVALCANTI AND VEREDA'S DSGE MODEL OF THE BRAZILIAN ECONOMY

4.3.1 Equations Modified

There are three equations which had new parameters added, which are the equation of output, inflation and monetary policy rule. Three new parameters and new values for other existing parameters completed the extended DSGE model of Cavalcanti and Vereda (2015). There are three new parameters that represent the impact of Nominal Result on GDP, inflation and interest are called nr_{pib}, nr_{pi} and nr_r. The values are the same as indicated in 4.2.1, 4.2.2 and 4.3.3, which are parameters calculated with the SVARs. Also, there are the parameters

which correspond to the lagged value of output, inflation and interest rates. The last one has two lagged values, which correspond to the two parameters of the SVARs that were significant explaining the behavior of interest rates (SELIC). Finally, there are the impacts endogenous impacts between the variables, which are the impact of interest on output, output on inflation, inflation on interest and output on interest.

The equation for inflation (prices), became the following:

$$p = p_{t-1} + \pi * nr_{pi} + gdp * gdp_{pi} \quad (17)$$

This equation demonstrates that current prices are the prices of the last period plus inflation times Nominal Result impact on inflation. In the end of the equation, there is an increment of the impact of GDP on inflation.

The second modified equation is related to monetary policy. It is the following:

$$nr_r * r = (lag_{r-1} + lag_{r-2}) * r_{t-1} + pi_r * (\pi - \bar{\pi}) + vm + gdp_r * gdp \quad (18)$$

This equation shows that interest times nominal result impact on interest parameter equals two parameters of lagged values for interest times last period interest, plus the deviation of inflation from target times the impact of inflation on interest, plus exo shocks (vm) and, finally, the impact of the GDP parameter on interest times GDP.

The last equation modified is related to output. This is the following:

$$\left(1 + nr_{gdp} - r_{gdp}\right) * gdp = lag_{gdp-1} * gdp_{t-1} + exp - imp + y \quad (19)$$

This equation shows that GDP, times the parameters which measures the impacts of nominal result and interest on GDP, is equal to the lagged parameter of GDP times GDP, plus exports minus imports, plus the closed economy GDP of Brazil (C+I+G). Note here that the impact of interest on GDP is negative, and the impact of nominal result is positive. This explain the right-hand side of the equation, and it is according to economic theory: more interest, less output, and more government spending, more output, in the short run.

After these modifications, a shock of 2 % in government spending via expansionary fiscal policy, which occurred in the last years of 2013-2014 in Brazil, was stochastic simulated in the Dynare program of MATLAB.

4.4 IMPACTS OF GOVERNEMENT EXPENDITURE INCREASE OF 2 %

4.4.1 Federal Level

Now with the nine new parameters, the model was extended into three entities: federal, state and city level. The equations changed slightly, adding the fiscal impact to real interest rate, inflation rate and GDP level. In the MATLAB file it is possible to see the improvements in the equations to explain the endogenous variables as the equations are in 4.3.1.

The impulse response functions of a shock of 0.02[14], or 2 %, in government expenditure showed that at federal level, both in the short and long run for every variable, a deficit increase in nominal result changed the output level worse than in Cavalcanti's (2015) original DSGE in the first eight months. "Worse" here means a deeper recession and a more fluctuating growth path, which is not stable. After eight months, short run makes less significant the impact of nominal result on GDP, but long run parameters still confirm that it is worse for the federal long run model. For both models, as well as for Original one, an expansionary fiscal policy led to a recession.

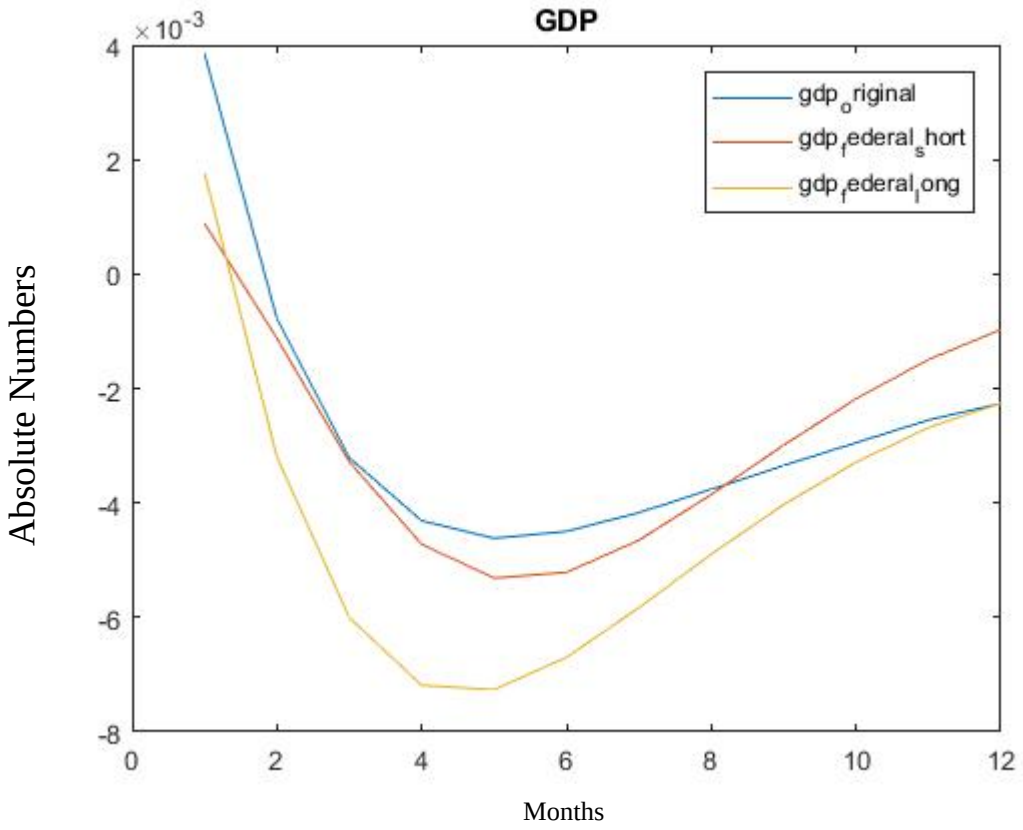
For inflation, the graphs showed different paths having a shock on the deficit result of the government. For the long run model, it has changed the IPCA level more smoothly than in Cavalcanti's (2015) original DSGE. However, for the short run model, the impact was even more negative. This can explain the inflation of 2 digits Brazil had in 2015.

For interest (SELIC), the IRF showed that the result was worse than the original DSGE for the short run parameters, which means higher real interest rates leading to less investment and consumption, driving the economy to a recession as we can see in the first graph above. In the long run, SELIC increased less than the Original model, but it did anyway.

For the Real Exchange Rate, named FX in the graph, in the long run there was an even bigger appreciation of the Brazilian currency. In the short run, it did less than the Original model, but it appreciated until the end of the stochastic simulation of 12 periods (months).

[14] In the graphs, it is the same measurement: $4 * 10^{-3} = 0.004$, or 0.4 %.

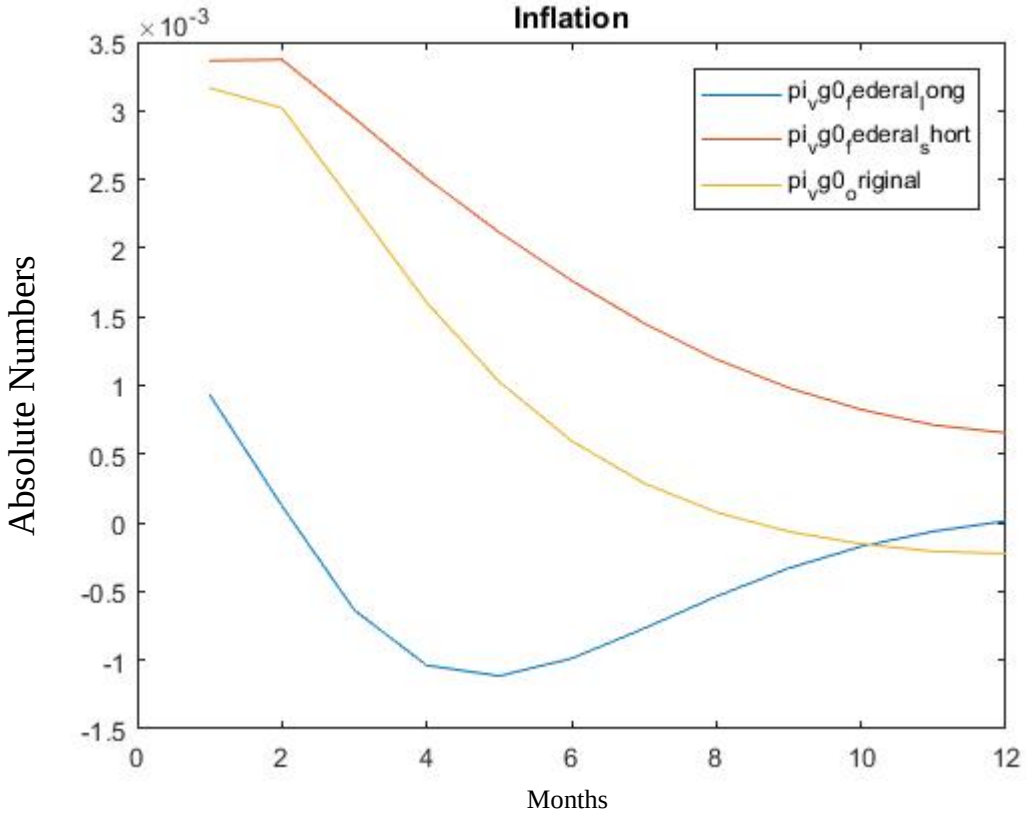
Graph 15: Federal Paths for Output of Brazil[15]



Source: Author's scripts of MATLAB (2017).

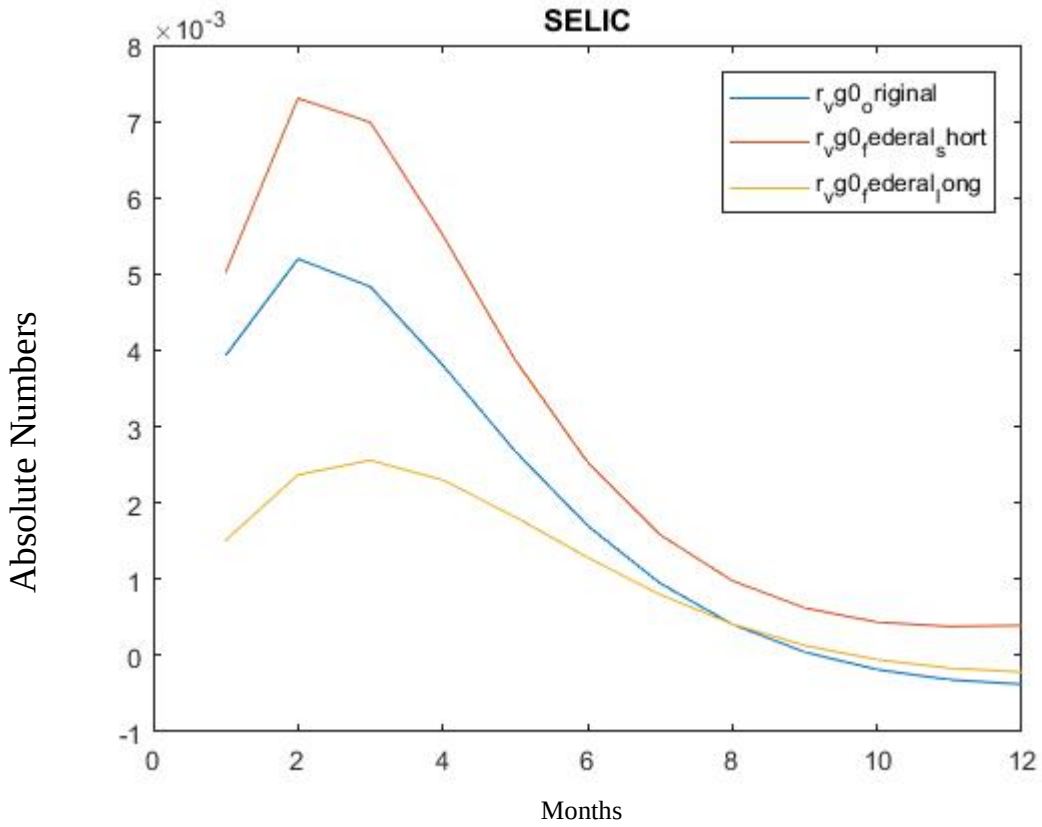
[15] Note: 0.004 means 0.4 % in the graph, since the shock of governement expenditure was of 0.02, or 2 %.

Graph 16: Federal Paths for Inflation (IPCA or Brazilian CPI)



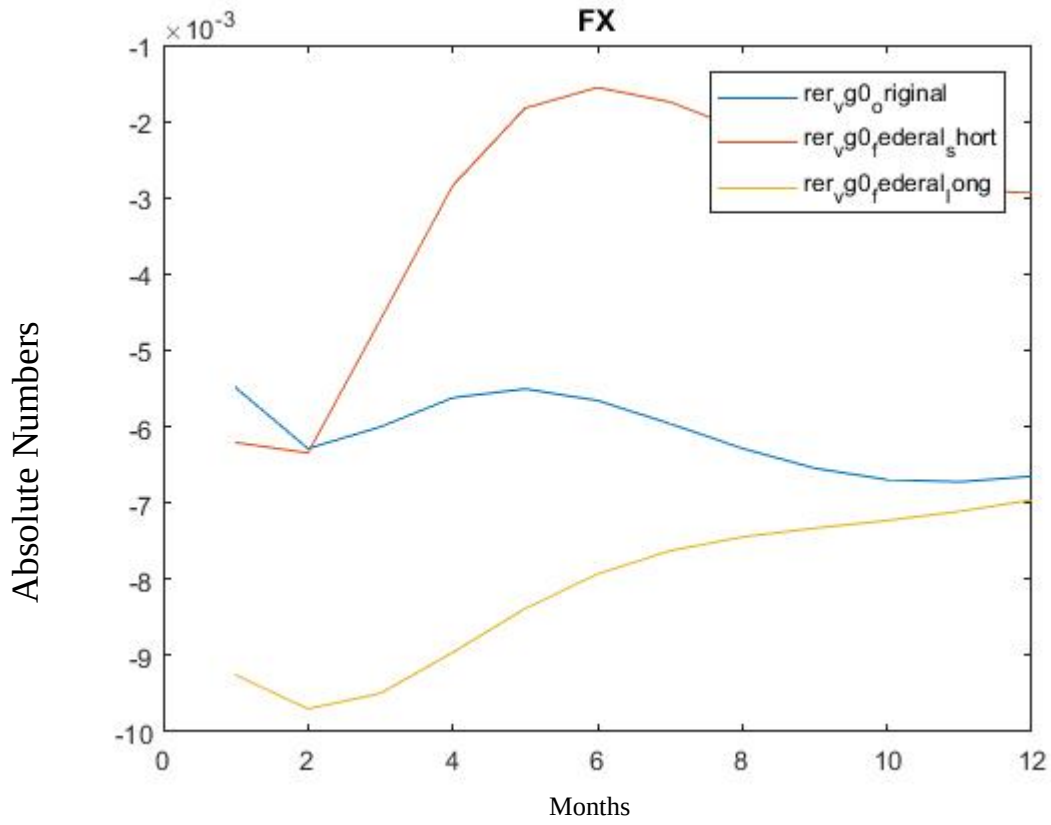
Source: Author's scripts of MATLAB (2017).

Graph 17: Federal Paths for Interest (SELIC)



Source: Author's scripts of MATLAB (2017).

Graph 18: Federal Paths for FX (Brazilian Real to US$)



Source: Author's scripts of MATLAB (2017).

4.4.2 State Level Models

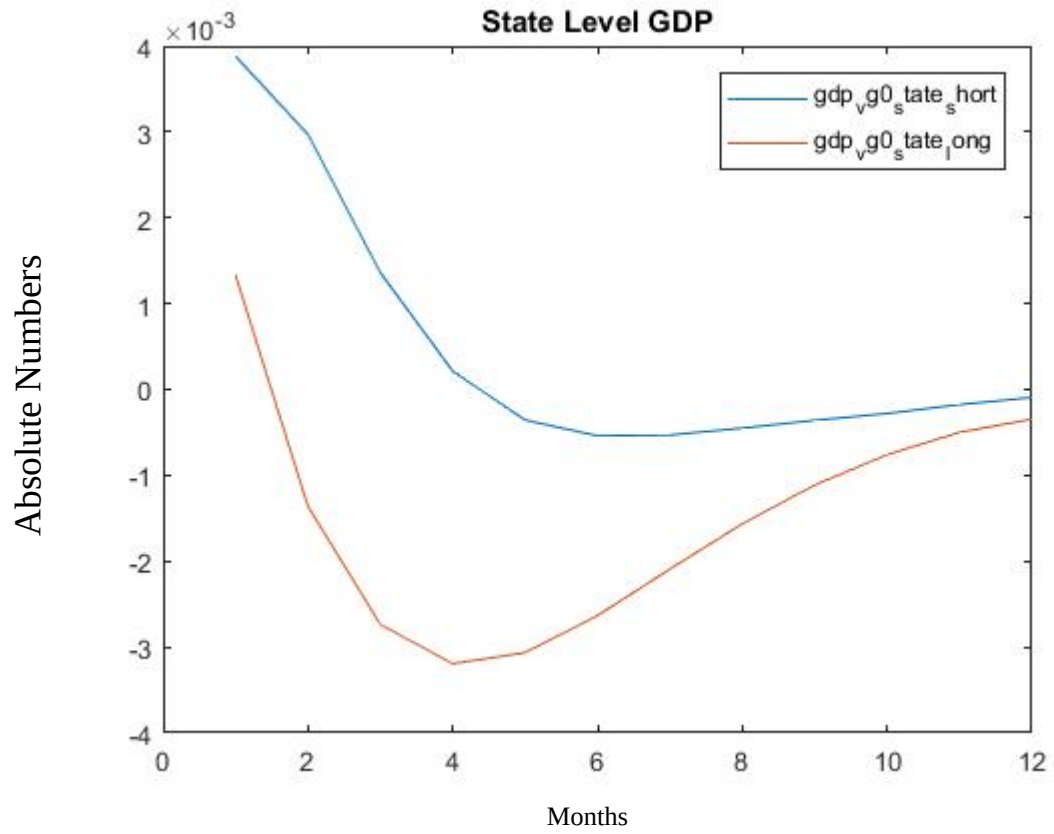
Now, we will analyze the different impacts of fiscal policies on different types of entities. For the State level, GDP responded differently from the short and long run. In the long run there is a recession anyhow. In the short run, there is a boom initialy, but it goes to zero by the end of the shock. A simple IS-LM-FX explains this fact.

For inflation, the short run model exposes the hostile effect of an increase of 2 % in governement expenditure. In the lon run, it remained more stable.

For interest rate, the short run model showed an increase in the SELIC rate, much higher than that in the long run. Much of this is explained because the model has no rigidities. In the lon run, everything which is nominal or monetary stabilizes. However, real terms, as GDP and Real Exchange Rates keep part of the dark effects of decontrolled fiscal policy.

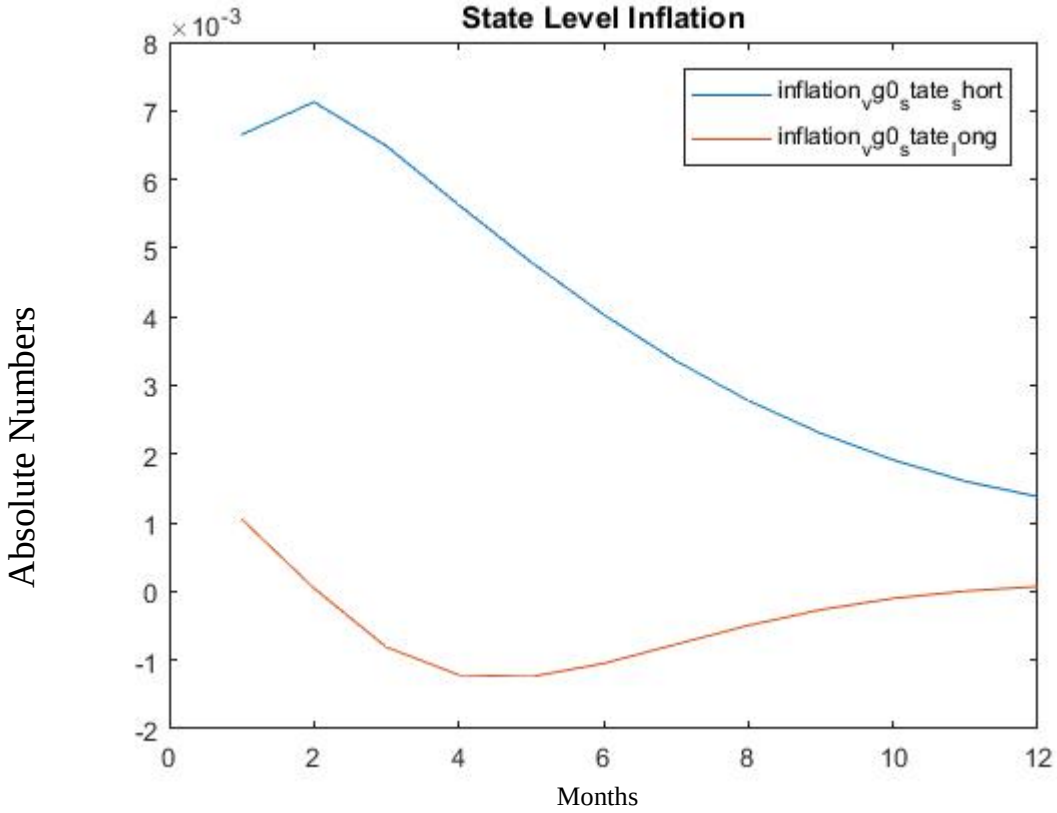
Finally, FX showed again that in the long run real exchange rate kept appreciated in the end of the stochastic simulation. In the short run model, there is a little depreciation which is offset in the subsequent months.

Graph 19: State Paths for Output of Brazil



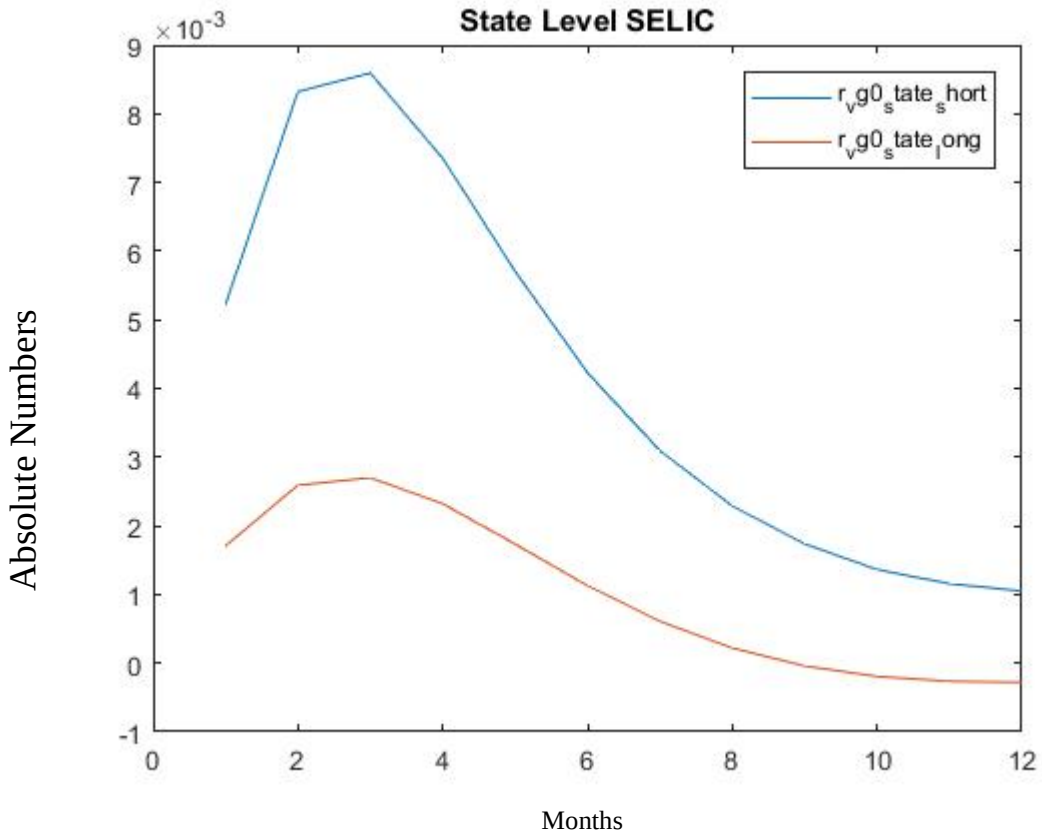
Source: Author's scripts of MATLAB (2017).

Graph 20: State Paths for Inflation (IPCA or Brazilian CPI)



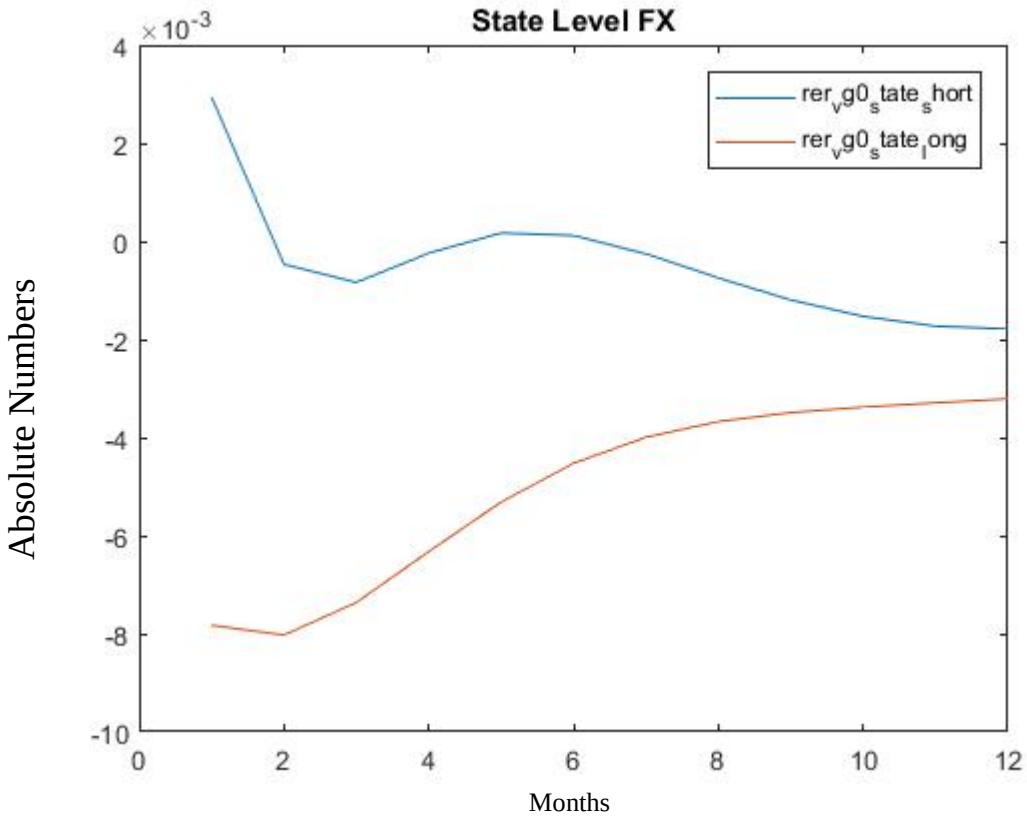
Source: Author's scripts of MATLAB (2017).

Graphs 21: State Paths for Interest (SELIC)



Source: Author's scripts of MATLAB (2017).

Graph 22: State Paths for FX (Brazilian Real to US$)



Source: Author's scripts of MATLAB (2017).

4.4.3 City Level Models

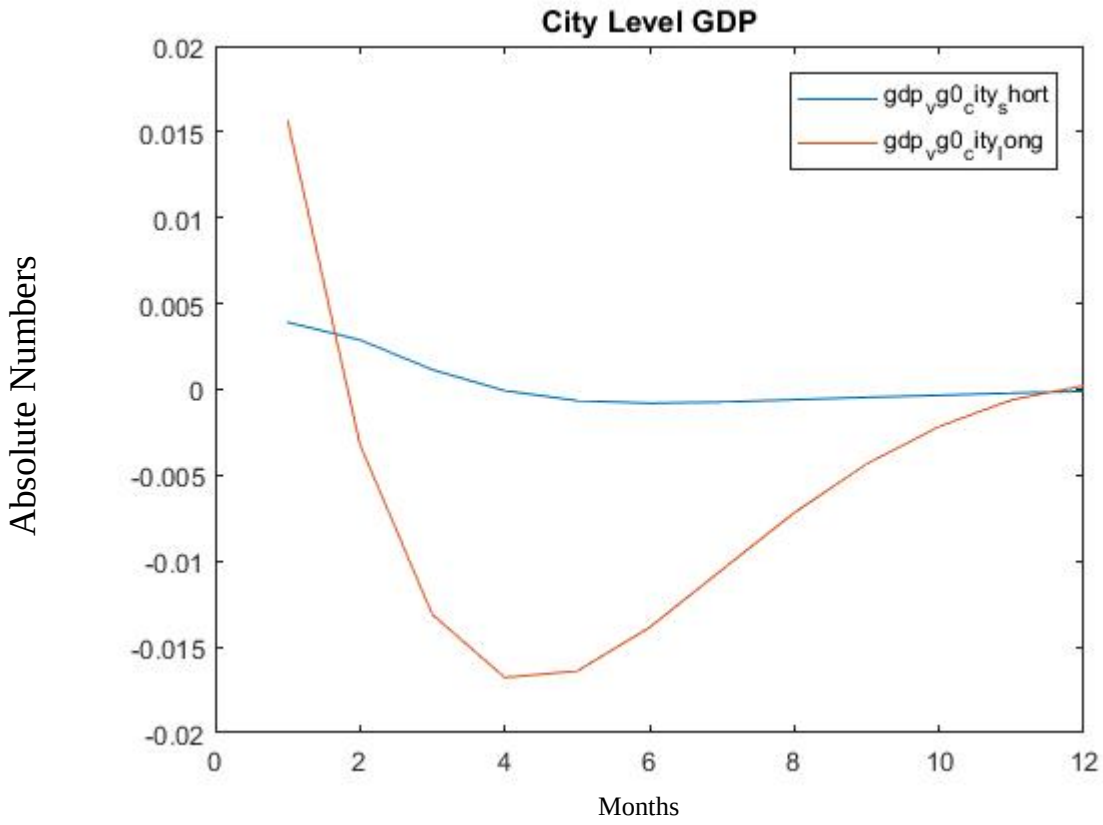
Discussing the impacts on the city level, GDP, inflation, interest and FX were about the same as the previous models. For GDP, the long run represented a bigger recession in the subsequent 4 months. In the short run, a simple IS-LM-FX model explains the neutrality of a fiscal policy shock.

For inflation, the short run model showed an inflationary process. In the long run, there is neutrality of this variable. Even the city level fiscal policy has effects on inflation, which makes evident the caution cities managers must have as to public finance.

For interest, SELIC behaved in an intense way in the short run. IRF showed an increase in the SELIC rate. In the long run there was a milder increase. Even city level fiscal policy can significantly change the federal interest rate of a country.

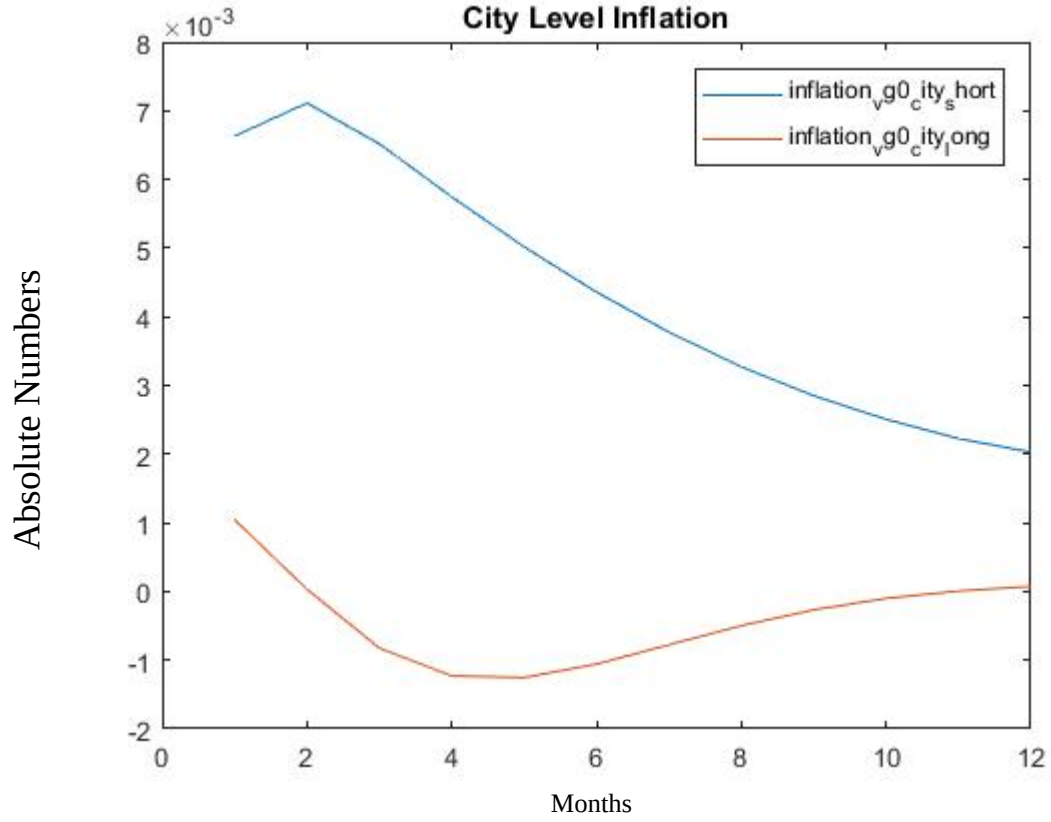
For FX, there is an appreciation in the long run, as well as in the short run at the end of the period. However, this model showed a small appreciation in the begging of the stochastic simulation (first 2 months).

Graph 23: City Level Paths for Output of Brazil



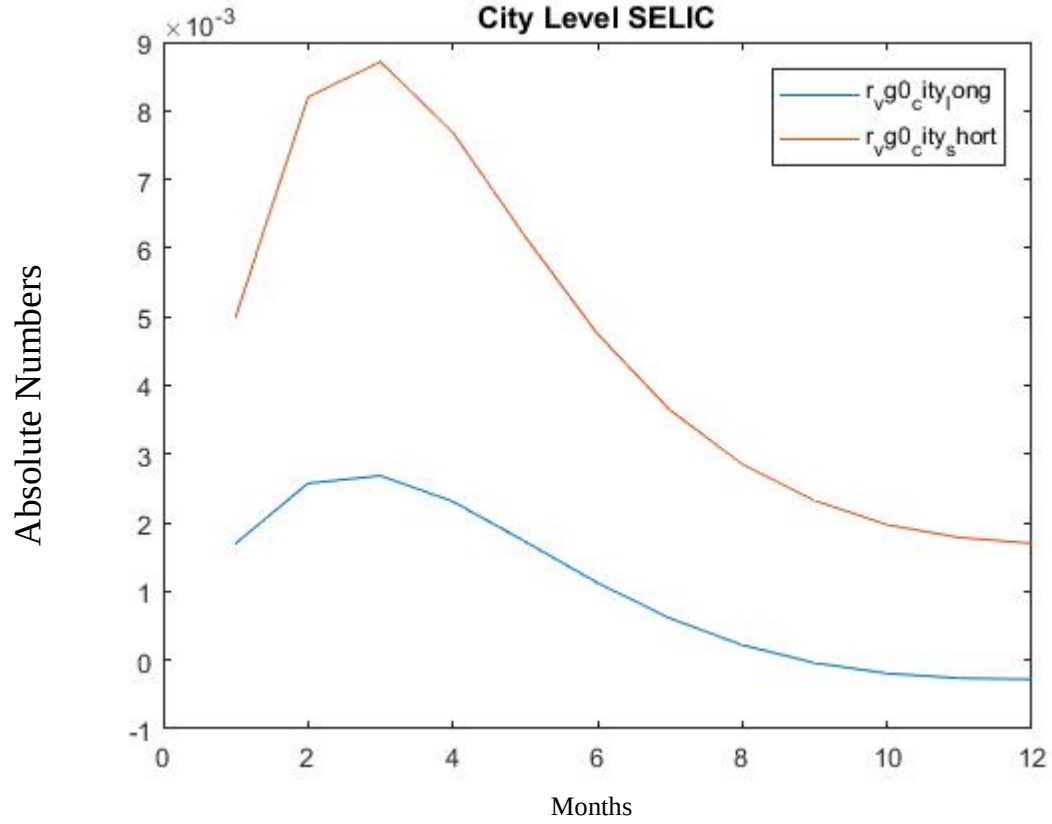
Source: Author's scripts of MATLAB (2017).

Graph 24: City Level Paths for Inflation (IPCA or Brazilian CPI)



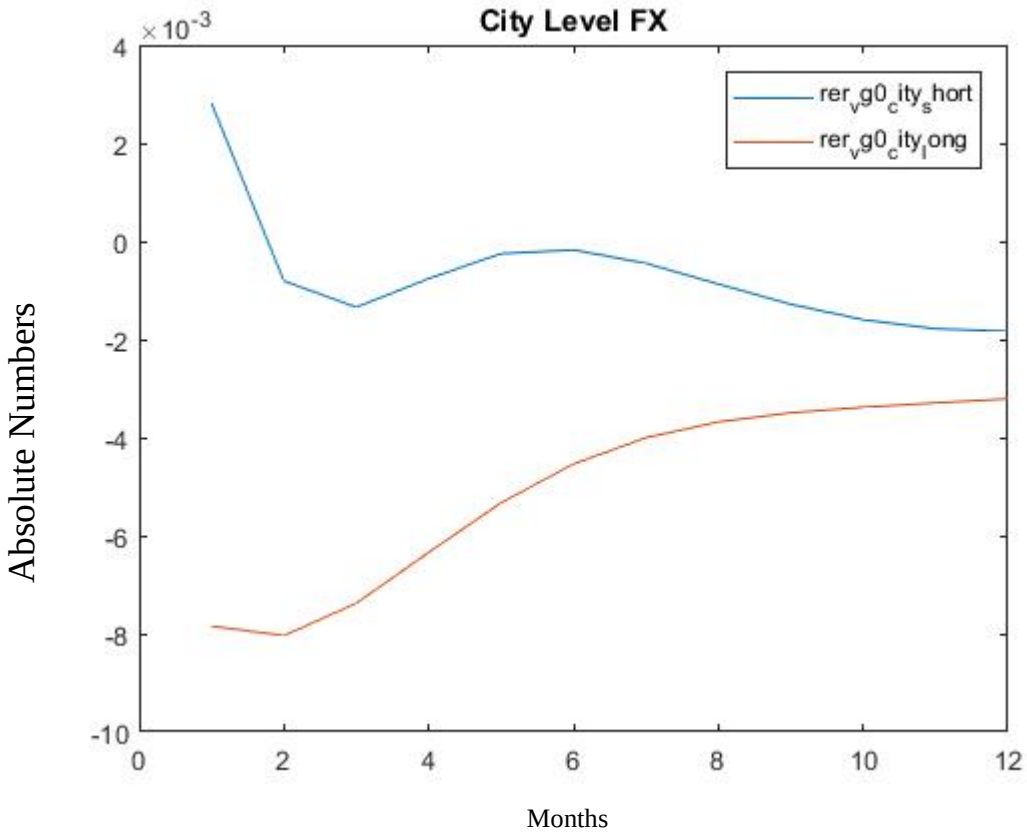
Source: Author's scripts of MATLAB (2017).

Graph 25: City Level Paths for Interest (SELIC)



Source: Author's scripts of MATLAB (2017).

Graph 26: City Level Paths for FX (Brazilian Real to US$)



Source: Author's scripts of MATLAB (2017).

4.5 FORECASTS

4.5.1 Forecasts for 2017-2022

In this section, we provide some forecasts for the variables proposed in the VARs models only. We assume that time series methods have more power to forecast than DSGE models and the latter models are only superior for economic analysis. Another point is that we used reduced-form VARs, since they have more power for forecasting out-of-sample than structural VARs, which are better for policy analysis. The cointegrated VARs became VEC models and then we forecasted IPCA, SELIC and IBC-Br for the next years[16]. Also, only federal

[16] The purpose of this Thesis is to analyze the impacts of fiscal policy on key macroeconomic variables. Forecasts are addressed in a secondary way. If they are close to the financial Market analysts, we assume they are positive. If not, maybe some information is missing in the forecasting models.

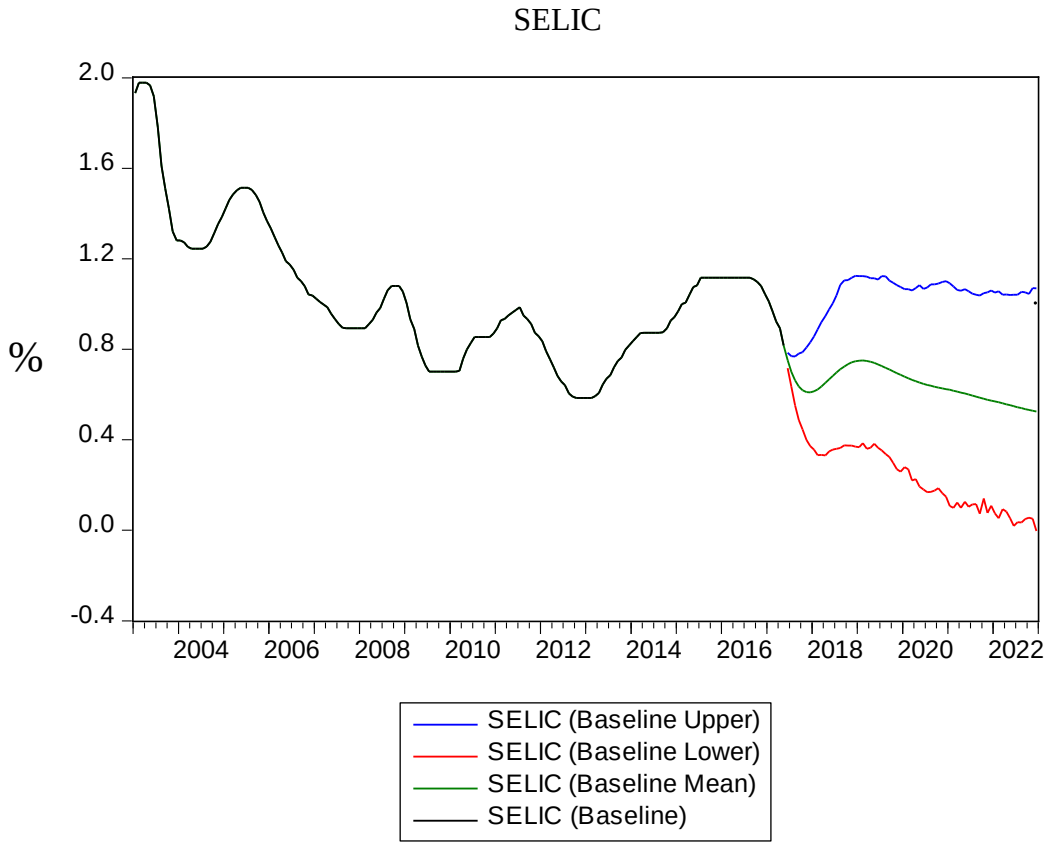
parameters were used to make the forecasts, since they are more significant to determine these three macroeconomic variables.

SELIC forecasts for the baseline mean are very close to the market expectations included at the FOCUS Report of the Central Bank of Brazil, which includes the very best forecasters of the nation to analyze several variables, such as interest, inflation and output growth. SELIC will remain falling until 2022 to the lowest levels in history if the variable keeps its trajectory. Certainly, it depends on the next year's presidential election. If it turns to be negative, with a not so positive President for the market, SELIC may rise again since 2018.

Here we see that even in an optimistic view of the GDP growth path, only in the beginning of 2019 would Brazil be at the point it was in 2014, before the recession. In a normal view, Brazil will grow slightly and will reach the 2014 level of GDP in 2020. Here it is possible to argue that this scenario may happen if a central candidate of the 2018 elections for President wins. If not, maybe the lower bound scenario may rule.

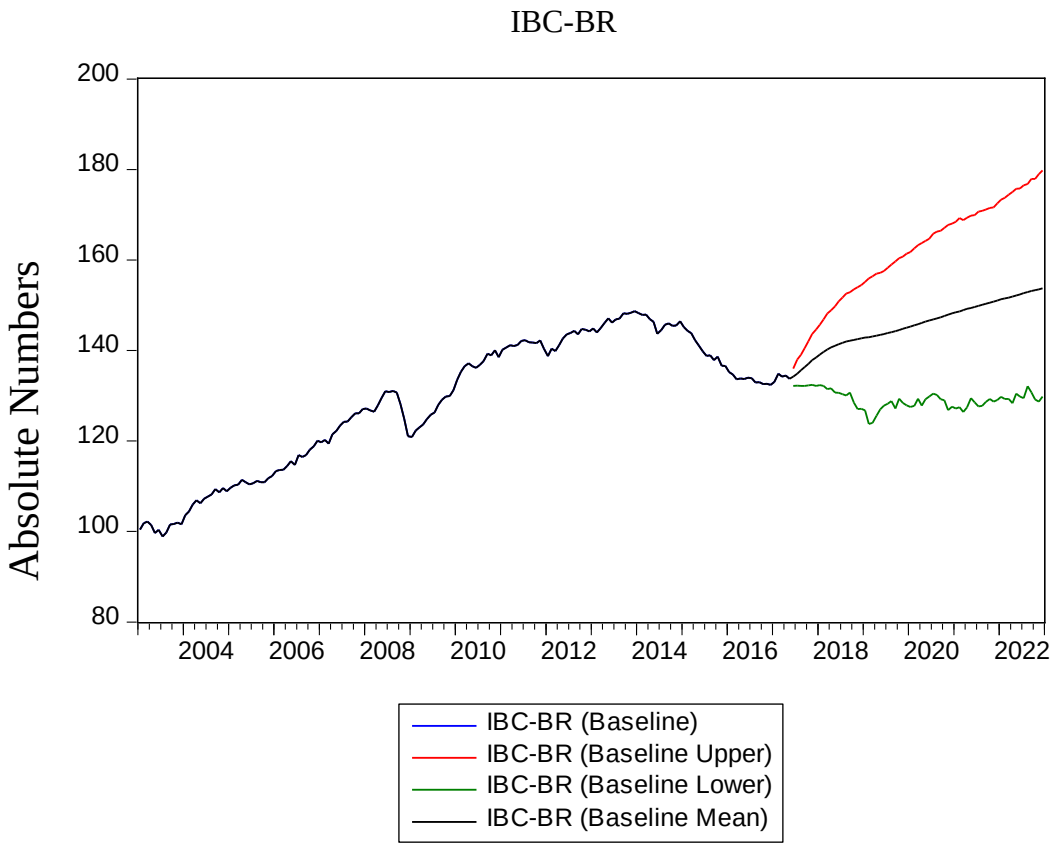
Inflation is, except of Nominal Exchange Rate, a candidate for the most difficult variable to forecast. VAR and ARMA models may perform well in the short run, for a few months or quarters, but not in the long run. The mean of the projection may have the more reasonable results.

Graph 27: Forecasts of SELIC from 2017 to 2022 using reduced form VARs at Federal Level



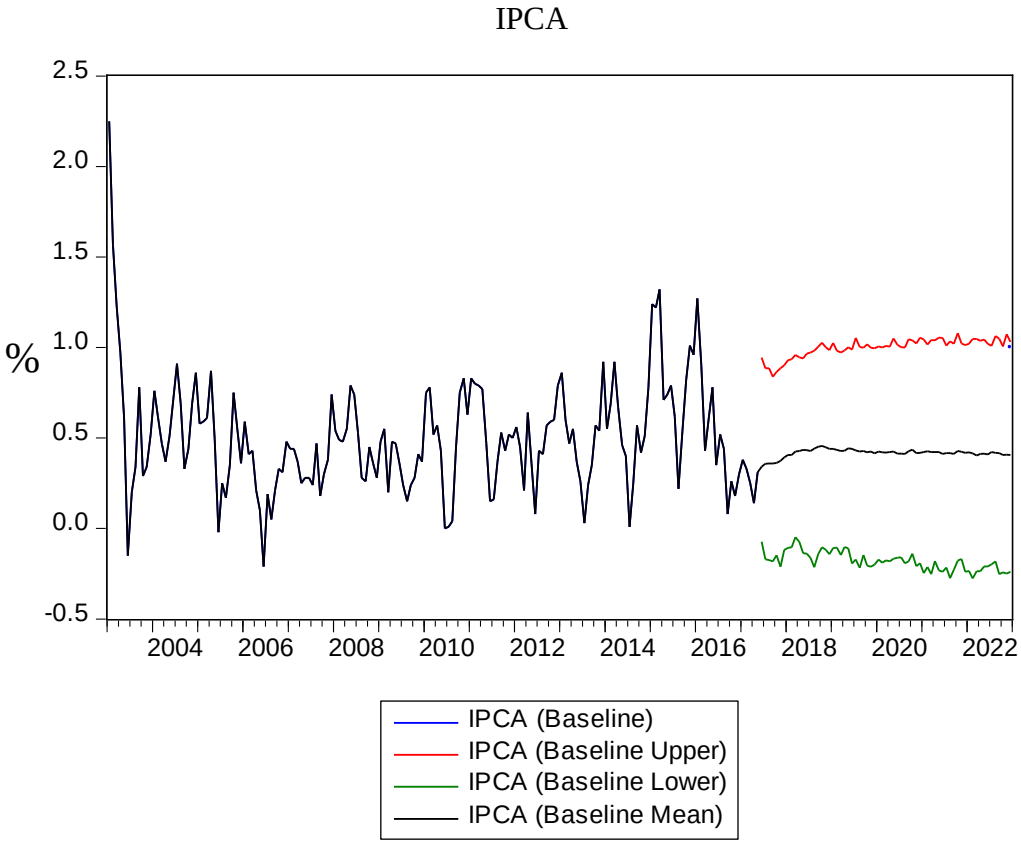
Source: Results from research.

Graph 28: Forecasts of Output (IBC-Br) from 2017 to 2022 using reduced form VARs at Federal Level



Source: Results from research.

Graph 29: Forecasts of Inflation (IPCA or Brazilian CPI) from 2017 to 2022 using reduced form VARs at Federal Level



Source: Results from research.

5 CONCLUSION

The debate about the reasons which led Brazil to face its recent recession had some important insights, matching economy theory written decades ago. Perhaps a boom in a nation's debt may worsen economic indicators and set a path for a recession to happen, as economists, analysts, finance professionals and the work of Alesina (2010) claim.

In chapter two, the links between fiscal policy and economic recessions were clear. Brazil is an example of what may happen if debt sustainability is ignored, leading to an increase in the debt/GDP level of the nation. The New Neo-Classical Synthesis approach seems to be the more adequate method to conduct fiscal policy, which is what sets government expenditure according to the capability of the country to generate income.

In chapter three, time series methods and DSGE models presented ways to measure fiscal policy shocks on an economy, including the Brazilian economy. DSGE models with properties for an emerging market may lead to interesting insights and conclusions as well.

In chapter four, it was found that, indeed, an increase in government expenditure will increase inflation and interest rates, the real exchange rate will appreciate, and GDP will fall, as Alesina (2010) showed. Even for different levels of macroeconomic fiscal policy, as state or city level, the effects are similar or worse. Fiscal policy is as important as monetary policy, which was the most debated issue after hyperinflations worldwide happened and a New Philips Curve came up.

Finally, this work posits that fiscal policy can start a recession, even when a boom is happening at the beginning of the analyzed period. The results matched with Cavalcanti and Vereda's (2015) DSGE model, stating that the parameters were well estimated using the VAR Models. Although the results were positive and like Cavalcanti and Vereda's (2015) model, there are limitations.

Even with the best techniques to calibrate and write the math behind it, the DSGE model may present poor micro foundations for some parts, when it is very difficult to structure an economy perfectly. This would lead to an inferior macroeconomic analysis, which must be taken cautiously. Also, extending a DSGE Model to three types of entities needs further research to parametrize the DSGE to the subnational levels.

APENDIX[17]

VECM: Output of Federal Level Nominal Result Impact on Output (IBC-Br)

Vector Error Correction Estimates
Date: 10/27/17 Time: 22:29
Sample (adjusted): 2004M02 2017M05
Included observations: 160 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
IBC_BR12MONTHS(-1)	1.000000	
NOMINALRESULT12MON	-4.02E-06 (1.3E-05) [-0.30299]	
@TREND(03M01)	-0.129188 (0.06187) [-2.08818]	
C	-117.2057	
Error Correction:	**D(IBC_BR12**	**D(NOMINALR**
CointEq1	-0.008789 (0.00146) [-6.01046]	289.0206 (217.049) [1.33159]
D(IBC_BR12MONTHS(-1))	0.930439 (0.02384) [39.0223]	-7828.500 (3539.20) [-2.21194]
D(NOMINALRESULT12M	-2.04E-07 (5.5E-07) [-0.37189]	0.014452 (0.08132) [0.17772]
C	0.289767 (0.05100) [5.68158]	-5715.888 (7570.23) [-0.75505]
SELIC	-0.300172 (0.05270) [-5.69545]	8182.431 (7822.97) [1.04595]
IPCA	0.037241 (0.03243) [1.14818]	3229.162 (4814.40) [0.67073]
DUMMYIBC	-0.040601 (0.05598) [-0.72525]	-5231.362 (8309.63) [-0.62955]
DUMMYRESULTADON	0.034830 (0.05337) [0.65264]	6844.026 (7921.50) [0.86398]
R-squared	0.952798	0.119410
Adj. R-squared	0.950624	0.078857
Sum sq. resids	1.523263	3.36E+10
S.E. equation	0.100107	14859.21
F-statistic	438.3143	2.944519
Log likelihood	145.3154	-1759.947
Akaike AIC	-1.716442	22.09933
Schwarz SC	-1.562684	22.25309
Mean dependent	0.201766	2913.400
S.D. dependent	0.450514	15482.19
Determinant resid covariance (dof adj.)		2180729.
Determinant resid covariance		1968108.
Log likelihood		-1613.467
Akaike information criterion		20.40584
Schwarz criterion		20.77101

[17] Results from Eviews 9.5 using the data detailed in chapter 4.

VECM: Output of Federal Level Nominal Result Impact on Inflation (IPCA or Brazilian CPI)

Vector Error Correction Estimates
Date: 11/06/17 Time: 23:56
Sample (adjusted): 2003M12 2017M05
Included observations: 162 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
IPCA(-1)	1.000000	
NOMINALRESULT12MON	-1.87E-06 (9.2E-07) [-2.04259]	
@TREND(03M01)	0.015076 (0.00584) [2.58176]	
C	-1.603483	
Error Correction:	**D(IPCA)**	**D(NOMINALR**
CointEq1	-0.479461 (0.07216) [-6.64422]	1056.189 (5580.29) [0.18927]
D(IPCA(-1))	0.149924 (0.07937) [1.88899]	3145.540 (6137.44) [0.51252]
D(NOMINALRESULT12M	-8.19E-07 (1.0E-06) [-0.78825]	0.058664 (0.08038) [0.72983]
C	-2.282402 (0.54377) [-4.19734]	-26127.67 (42050.0) [-0.62135]
SELIC	-0.024033 (0.11349) [-0.21176]	8528.454 (8776.11) [0.97178]
IBC_BR12MONTHS	0.017564 (0.00368) [4.77352]	146.0389 (284.526) [0.51327]
DUMMYIBC	0.194451 (0.10787) [1.80270]	-2183.179 (8341.34) [-0.26173]
DUMMYRESULTADON	-0.067752 (0.10386) [-0.65237]	7246.890 (8031.12) [0.90235]
R-squared	0.232190	0.085520
Adj. R-squared	0.197289	0.043953
Sum sq. resids	5.838501	3.49E+10
S.E. equation	0.194711	15056.98
F-statistic	6.652914	2.057400
Log likelihood	39.30486	-1784.141
Akaike AIC	-0.386480	22.12519
Schwarz SC	-0.234006	22.27767
Mean dependent	-0.000185	2893.645
S.D. dependent	0.217326	15399.20
Determinant resid covariance (dof adj.)		8550877.
Determinant resid covariance		7727198.
Log likelihood		-1744.417
Akaike information criterion		21.77058
Schwarz criterion		22.13270

Source: Eviews outputs from research.

VECM: Output of Federal Level Nominal Result Impact on Interest (SELIC or Brazilian Fed Funds)

Vector Error Correction Estimates
Date: 10/28/17 Time: 02:02
Sample (adjusted): 2003M12 2017M05
Included observations: 162 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
SELIC(-1)	1.000000	
NOMINALRESULT12MON	-1.68E-06 (7.9E-07) [-2.12179]	
@TREND(03M01)	0.012571 (0.00520) [2.41704]	
C	-1.903132	
Error Correction:	**D(SELIC)**	**D(NOMINALR**
CointEq1	-0.037078 (0.00892) [-4.15634]	18559.56 (9462.82) [1.96132]
D(SELIC(-1))	0.614430 (0.08086) [7.59911]	48233.31 (85767.0) [0.56238]
D(SELIC(-2))	0.195833 (0.07845) [2.49613]	-131059.2 (83220.5) [-1.57484]
D(NOMINALRESULT12M	-4.12E-08 (7.5E-08) [-0.55029]	0.072992 (0.07935) [0.91986]
D(NOMINALRESULT12M	2.72E-08 (7.5E-08) [0.36307]	-0.115982 (0.07937) [-1.46127]
C	-0.065743 (0.02010) [-3.27069]	21221.67 (21321.5) [0.99532]
IPCA	0.008008 (0.00454) [1.76251]	6185.350 (4819.28) [1.28346]
IBC BR12MONTHS	0.000450 (0.00015) [2.94720]	-172.0951 (161.937) [-1.06273]
DUMMYIBC	-6.52E-05 (0.00798) [-0.00817]	-8955.520 (8462.79) [-0.82189]
DUMMYRESULTADON	0.010936 (0.00774) [1.41260]	8991.424 (8211.97) [1.09492]
R-squared	0.712624	0.131833
Adj. R-squared	0.695609	0.080428
Sum sq. resids	0.029458	3.31E+10
S.E. equation	0.013921	14766.96
F-statistic	41.88047	2.564604
Log likelihood	467.7350	-1779.931
Akaike AIC	-5.651050	22.09791
Schwarz SC	-5.460457	22.28851
Mean dependent	-0.003111	2893.645
S.D. dependent	0.025233	15399.20
Determinant resid covariance (dof adj.)		42259.36
Determinant resid covariance		37203.18
Log likelihood		-1312.192
Akaike information criterion		16.48385
Schwarz criterion		16.92222

Source: Eviews outputs from research.

VECM: Output of State Level Nominal Result Impact on Output (IBC-Br)

Vector Error Correction Estimates
Date: 09/25/17 Time: 10:36
Sample (adjusted): 2004M03 2017M05
Included observations: 159 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
IBC_BR12MONTHS(-1)	1.000000
STATENOMINALRESULT(-	0.000218 (7.8E-05) [2.78640]
@TREND(03M01)	-0.213511 (0.06597) [-3.23637]
C	-116.6727

Error Correction:	D(IBC_BR12M	D(STATENOM
CointEq1	-0.011358 (0.00203) [-5.60886]	-24.25952 (61.2591) [-0.39602]
D(IBC_BR12MONTHS(-1))	0.953037 (0.08122) [11.7334]	2407.368 (2457.09) [0.97976]
D(IBC_BR12MONTHS(-2))	-0.024708 (0.08144) [-0.30339]	-693.4287 (2463.58) [-0.28147]
D(STATENOMINALRESUL	-1.87E-06 (2.7E-06) [-0.68539]	0.344121 (0.08269) [4.16137]
D(STATENOMINALRESUL	2.59E-06 (2.7E-06) [0.95283]	-0.003334 (0.08209) [-0.04061]
C	0.165322 (0.04892) [3.52344]	752.7804 (1479.38) [0.53036]
SELIC	-0.211670 (0.04537) [-4.66521]	-2399.417 (1372.54) [-1.74816]
IPCA	0.057182 (0.03215) [1.77885]	2479.862 (972.433) [2.55016]
DUMMYEST	0.061216 (0.03148) [1.94447]	-645.2977 (952.349) [-0.67759]
DUMMYIBC	-0.007734 (0.02816) [-0.27467]	1841.087 (851.833) [2.16132]
R-squared	0.956544	0.286105
Adj. R-squared	0.953919	0.242964
Sum sq. resids	1.402377	1.28E+09
S.E. equation	0.097015	2934.774
F-statistic	364.4139	6.634919
Log likelihood	150.4823	-1489.964
Akaike AIC	-1.767073	18.86748
Schwarz SC	-1.574060	19.06049
Mean dependent	0.201672	227.3710
S.D. dependent	0.451936	3373.046

Determinant resid covariance (dof adj.)	80532.40
Determinant resid covariance	70721.08
Log likelihood	-1338.959
Akaike information criterion	17.13156
Schwarz criterion	17.57549

Source: Eviews outputs from research.

VECM: Output of State Level Nominal Result Impact on Inflation (IPCA or Brazilian CPI)

Vector Error Correction Estimates
Date: 10/13/17 Time: 16:45
Sample (adjusted): 2003M12 2017M05
Included observations: 162 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
IPCA(-1)	1.000000	
STATENOMINALRESULT(-	-8.89E-06	
	(3.2E-06)	
	[-2.78541]	
@TREND(03M01)	0.008008	
	(0.00305)	
	[2.62388]	
C	-0.946797	
Error Correction:	**D(IPCA)**	**D(STATENOM**
CointEq1	-0.470662	2384.946
	(0.07504)	(1148.25)
	[-6.27236]	[2.07702]
D(IPCA(-1))	0.155765	1075.980
	(0.08128)	(1243.85)
	[1.91630]	[0.86503]
D(STATENOMINALRESUL	-6.28E-07	0.381608
	(4.8E-06)	(0.07293)
	[-0.13175]	[5.23253]
C	-0.750550	-321.3035
	(0.47869)	(7325.15)
	[-1.56792]	[-0.04386]
SELIC	-0.135306	-753.7742
	(0.11698)	(1790.12)
	[-1.15683]	[-0.42108]
IBC BR12MONTHS	0.006868	14.48629
	(0.00321)	(49.0472)
	[2.08025]	[0.29535]
DUMMYIBC	0.108106	540.3361
	(0.05424)	(829.957)
	[1.99321]	[0.65104]
DUMMYEST	-0.020625	-1869.869
	(0.06472)	(990.315)
	[-0.31870]	[-1.88816]
R-squared	0.219063	0.277191
Adj. R-squared	0.183565	0.244336
Sum sq. resids	5.938322	1.39E+09
S.E. equation	0.196368	3004.906
F-statistic	6.171273	8.436800
Log likelihood	37.93171	-1523.062
Akaike AIC	-0.369527	18.90200
Schwarz SC	-0.217053	19.05448
Mean dependent	-0.000185	131.7570
S.D. dependent	0.217326	3456.738
Determinant resid covariance (dof adj.)		342357.7
Determinant resid covariance		309379.5
Log likelihood		-1483.764
Akaike information criterion		18.55265
Schwarz criterion		18.91477

Source: Eviews outputs from research.

VECM: Output of State Level Nominal Result Impact on Interest (SELIC or Brazilian Fed Funds)

Vector Error Correction Estimates
Date: 10/13/17 Time: 16:45
Sample (adjusted): 2003M12 2017M05
Included observations: 162 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
SELIC(-1)	1.000000	
STATENOMINALRESULT(-	-1.50E-05	
	(2.8E-06)	
	[-5.32942]	
@TREND(03M01)	0.012951	
	(0.00280)	
	[4.62172]	
C	-1.714298	
Error Correction:	D(SELIC)	D(STATENOM
CointEq1	-0.032449	3599.897
	(0.00731)	(1573.67)
	[-4.43845]	[2.28759]
D(SELIC(-1))	0.710839	21796.78
	(0.04801)	(10333.8)
	[14.8067]	[2.10928]
D(STATENOMINALRESUL	1.39E-07	0.389683
	(3.5E-07)	(0.07516)
	[0.39798]	[5.18447]
C	-0.056223	-2344.690
	(0.02096)	(4512.23)
	[-2.68207]	[-0.51963]
IPCA	0.003247	2356.190
	(0.00453)	(975.139)
	[0.71665]	[2.41626]
IBC BR12MONTHS	0.000406	18.50405
	(0.00017)	(36.4957)
	[2.39495]	[0.50702]
DUMMYIBC	0.007403	-672.0426
	(0.00387)	(833.665)
	[1.91150]	[-0.80613]
DUMMYEST	-0.001656	-1825.258
	(0.00444)	(955.883)
	[-0.37289]	[-1.90950]
R-squared	0.713955	0.293809
Adj. R-squared	0.700953	0.261709
Sum sq. resids	0.029322	1.36E+09
S.E. equation	0.013799	2970.162
F-statistic	54.91095	9.153044
Log likelihood	468.1110	-1521.178
Akaike AIC	-5.680382	18.87874
Schwarz SC	-5.527908	19.03122
Mean dependent	-0.003111	131.7570
S.D. dependent	0.025233	3456.738
Determinant resid covariance (dof adj.)		1667.902
Determinant resid covariance		1507.239
Log likelihood		-1052.497
Akaike information criterion		13.22836
Schwarz criterion		13.59048

Source: Eviews outputs from research.

VECM: Output of City Level Nominal Result Impact on Output (IBC-Br)

Vector Error Correction Estimates
Date: 10/13/17 Time: 16:33
Sample (adjusted): 2004M02 2017M05
Included observations: 160 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
IBC_BR12MONTHS(-1)	1.000000	
CITIES(-1)	0.000279	
	(0.00021)	
	[1.34395]	
@TREND(03M01)	-0.352155	
	(0.03527)	
	[-9.98376]	
C	-98.76599	
Error Correction:	**D(IBC_BR12**	**D(CITIES)**
CointEq1	-0.014333	59.81012
	(0.00249)	(16.8440)
	[-5.75291]	[3.55082]
D(IBC_BR12MONTHS(-1))	0.924565	439.3892
	(0.02580)	(174.403)
	[35.8415]	[2.51940]
D(CITIES(-1))	-4.79E-07	0.163920
	(1.2E-05)	(0.08170)
	[-0.03968]	[2.00644]
C	0.140491	-513.2411
	(0.03964)	(267.967)
	[3.54460]	[-1.91531]
SELIC	-0.104510	27.12970
	(0.03551)	(240.101)
	[-2.94284]	[0.11299]
IPCA	0.070182	365.9412
	(0.03391)	(229.249)
	[2.06975]	[1.59626]
DUMMYIBC	-0.101302	117.1961
	(0.02907)	(196.517)
	[-3.48513]	[0.59637]
DUMMYMUN	-0.173576	1101.839
	(0.05105)	(345.168)
	[-3.39987]	[3.19218]
R-squared	0.953468	0.247226
Adj. R-squared	0.951325	0.212559
Sum sq. resids	1.501632	68638476
S.E. equation	0.099394	671.9888
F-statistic	444.9410	7.131405
Log likelihood	146.4596	-1264.565
Akaike AIC	-1.730744	15.90707
Schwarz SC	-1.576986	16.06083
Mean dependent	0.201766	5.985500
S.D. dependent	0.450514	757.2738
Determinant resid covariance (dof adj.)		4359.171
Determinant resid covariance		3934.152
Log likelihood		-1116.256
Akaike information criterion		14.19070
Schwarz criterion		14.55588

Source: Eviews outputs from research.

VECM: Output of City Level Nominal Result Impact on Inflation (IPCA or Brazilian CPI)

Vector Error Correction Estimates
Date: 10/13/17 Time: 16:40
Sample (adjusted): 2003M12 2017M05
Included observations: 162 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
IPCA(-1)	1.000000
CITIES(-1)	-2.47E-05 (1.3E-05) [-1.87803]
C	-0.838610 (0.82766) [-1.01323]

Error Correction:	D(IPCA)	D(CITIES)
CointEq1	-0.419650 (0.07097) [-5.91328]	743.0175 (251.498) [2.95437]
D(IPCA(-1))	0.138152 (0.08174) [1.69013]	281.6820 (289.674) [0.97241]
D(CITIES(-1))	3.55E-05 (2.1E-05) [1.67278]	0.298418 (0.07519) [3.96884]
SELIC	-0.024602 (0.05181) [-0.47483]	-82.57001 (183.620) [-0.44968]
IBC_BR12MONTHS	-0.001492 (0.00049) [-3.04670]	3.594703 (1.73516) [2.07168]
DUMMYIBC	0.099532 (0.05586) [1.78196]	-139.1423 (197.943) [-0.70294]
DUMMYMUN	-0.105789 (0.06374) [-1.65961]	100.1199 (225.897) [0.44321]
R-squared	0.199093	0.215049
Adj. R-squared	0.168090	0.184663
Sum sq. resids	6.090174	76485675
S.E. equation	0.198221	702.4642
F-statistic	6.421755	7.077413
Log likelihood	35.88645	-1288.134
Akaike AIC	-0.356623	15.98931
Schwarz SC	-0.223208	16.12273
Mean dependent	-0.000185	-10.72586
S.D. dependent	0.217326	777.9573
Determinant resid covariance (dof adj.)		19210.38
Determinant resid covariance		17586.09
Log likelihood		-1251.500
Akaike information criterion		15.66049
Schwarz criterion		15.98450

Source: Eviews outputs from research.

VECM: Output of City Level Nominal Result Impact on Interest (SELIC or Brazilian Fed Funds)

Vector Error Correction Estimates
Date: 10/13/17 Time: 16:42
Sample (adjusted): 2003M12 2017M05
Included observations: 162 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
SELIC(-1)	1.000000
CITIES(-1)	-0.000113 (2.8E-05) [-3.99846]
C	-4.469339 (0.81669) [-5.47248]

Error Correction:	D(SELIC)	D(CITIES)
CointEq1	-0.006673 (0.00393) [-1.69949]	671.9454 (186.682) [3.59941]
D(SELIC(-1))	0.776513 (0.04766) [16.2930]	4287.647 (2266.00) [1.89217]
D(CITIES(-1))	1.21E-06 (1.5E-06) [0.77934]	0.284933 (0.07357) [3.87314]
IPCA	0.007395 (0.00463) [1.59867]	509.5620 (219.933) [2.31690]
IBC_BR12MONTHS	-0.000240 (0.00013) [-1.91873]	19.76038 (5.95318) [3.31930]
DUMMYIBC	0.004907 (0.00422) [1.16349]	-358.7900 (200.526) [-1.78924]
DUMMYMUN	-0.011236 (0.00511) [-2.19854]	467.7968 (242.985) [1.92521]
R-squared	0.684937	0.250728
Adj. R-squared	0.672741	0.221723
Sum sq. resids	0.032296	73009122
S.E. equation	0.014435	686.3138
F-statistic	56.16090	8.644559
Log likelihood	460.2845	-1284.366
Akaike AIC	-5.596105	15.94280
Schwarz SC	-5.462691	16.07621
Mean dependent	-0.003111	-10.72586
S.D. dependent	0.025233	777.9573

Determinant resid covariance (dof adj.)	97.81457
Determinant resid covariance	89.54408
Log likelihood	-823.8093
Akaike information criterion	10.38036
Schwarz criterion	10.70437

Source: Eviews outputs from research.

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