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Rua Miguel Lupi, 20
1249-078 LISBOA
Portugal

Telephone: +351 - 213 925 912
E-mail: rem@iseg.ulisboa.pt

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Uncertainty and Effectiveness of Public Consumption

Eduardo de Sá Fortes Leitão Rodrigues (edfortes@phd.iseg.ulisboa.pt)

Instituto Superior de Economia e Gestão (ISEG)

Research in Economics and Mathematics (REM)

Research Unit on Complexity and Economics (UECE) - Rua Miguel Lupi 20, 1249-078 Lisbon, Portugal.

Universidade Federal Rural do Rio de Janeiro (UFRRJ)

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Abstract

This article investigates how increased uncertainty affects the effectiveness of public consumption on economic activity. The paper examines three main issues: first, the influence of uncertainty on output and macroeconomic aggregates. Second, the effects of public consumption on the economy. Third, the impact of a simultaneous shock of uncertainty and government consumption on economic activity.

We use Vector Autoregression (VAR) models for the United States, Brazil and a panel VAR with six European countries. The empirical results indicate a disruptive effect of uncertainty on GDP, private consumption, investment and hours worked. The fiscal effects point to slightly different results for the two countries. For Brazil and the United States, the increase in public spending has positive and significant effects on GDP. Regarding the effects of government consumption (high uncertainty), the fiscal effects are not statistically significant, while in times of low uncertainty the effects are positive and significant.

Subsequently, we designed a Dynamic Stochastic General Equilibrium (DSGE) model akin to Basu and Bundick (2017), and added three features: tax on labor income, the relationship between private consumption and government consumption and a simultaneous shock of uncertainty and government consumption. The model highlights four main conclusions. First, the negative influence of uncertainty on economic activity. Second, risk aversion magnifies the impact of the macroeconomic response. Third, public consumption has positive effects on economic activity. Finally, we examine the sensitivity of the economy's responses to different configurations of the relationship between public and private consumption, under normal conditions or uncertainty shocks. The findings suggest that, when the economy is hit by a simultaneous shock of uncertainty and public consumption, it obscures the effectiveness of the fiscal stimulus on the economy, corroborating the empirical results.

Keywords: Uncertainty Shocks, Public Consumption, Simultaneous Shocks

JEL-codes: D58, D80, E32, E62

1 Introduction

Uncertainty can play a key role in macroeconomic performance as a stimulus for economic fluctuations, by preventing agents from being able to clearly see the horizon of events and disrupting private decisions (Pindyck and Solimano, 1993). The mists of uncertainty affect the economy through different channels, whether due to the firms' investment decisions or the choices between consumption and savings. From the point of view of entrepreneurs, uncertainty can stimulate the postponement of investments and new hires until the uncertainty dissipates (Baker et al., 2016; Bernanke, 1993). On the household's side, insecurity about labor income in the future reduces consumption and encourages labor supply. These factors together contribute to the reduction of the level of economic activity.

In order to assess the role of uncertainty, an increasing strand of the literature has focused on the consequences of uncertainty shocks on macroeconomic dynamics (Basu and Bundick, 2017; Bloom, 2009; Fernandez-Villaverde, Guerron-Quintana, Rubio-Ramirez and Uribe, 2015). For this purpose, the literature offers different approaches to measure uncertainty and examine its impacts on economic activity. These uncertainty indicators can be classified into three main groups. The first category is based on the volatility of financial markets. The second captures the effects of uncertainty by terms contained in the news media or newspapers and, the third by the divergence of the forecasts for some economic aggregates and surveys that evaluate the operation and performance of companies.

Authors such as Bloom et al. (2012) have classified uncertainty as a potential element that influences the strength and duration of a recessive period. Therefore, the role of public institutions is once again the center of a new debate that assesses the effectiveness of fiscal policy in times of uncertainty shocks and whether it can mitigate macroeconomic costs of uncertainty. A central issue for policymakers is to assess the environment and consider what the likely effects of fiscal policy are. So, under what conditions can the fiscal stimulus be effective?

Studies on fiscal multipliers have diffuse results and some papers indicate a fiscal multiplier greater than one (Fatás and Mihov, 2001). However, there is no consensus on the value of multipliers of public consumption and public investment. Ilzetzki et al. (2013) apply the SVAR methodology in economies with different characteristics. They highlight that the multiplier depends on different factors, such as the degree of economic development, monetary policy and the degree of openness of the economy, which partially explains the different results. In the same vein, Batini et al. (2014) analyze the determinants for fiscal multipliers in developing economies and point out that it is not clear whether multipliers should be higher or lower than in developed economies. Their results suggest that there are not many studies for emerging and low-income countries, but

the findings indicate that fiscal multipliers are no greater than multipliers in developed economies. Ramey (2019) surveys the last years of research on fiscal policy. The results about the fiscal multiplier are mixed and suggests a range between 0.6 and 1 for public spending.

Another point of macroeconomic debate is whether the relationship between public and private consumption is complementary or not and how to insert this relationship into the utility function of consumers (Barro, 1981; Christiano, L. and Eichenbaum, M., 1992; Fernandez et al., 2004; Gomes, 2010; Hasumi, 2016). The evidence is not conclusive for developed economies and this divergence is amplified when the focus is on emerging economies.

This paper has three main objectives: examine the influence of uncertainty shocks on economic activity, the impact of public consumption shocks on the economy, and the combined effect of an uncertainty and a government consumption shocks. Uncertainty is defined as the market expectation of volatility by stock index option prices (VIX) for the United States and Brazil. For the Panel VAR of European countries, we use the VSTOXX volatility index as a proxy for uncertainty. Furthermore, we studied the repercussion of government consumption on economic activity after an uncertainty shock. We use Vector Autoregression (VAR) models and a Dynamic Stochastic General Equilibrium (DSGE) model, akin to Basu and Bundick (2017). We expand the DSGE model to include new features: i) government as a new agent, ii) tax on labor income, and iii) the relationship between private consumption and government consumption in the household utility function. In this sense, the new contributions allow to infer the combined effect of fiscal policy and shock of uncertainty in a theoretical model that can be compared with the findings of the empirical models.

In addition to contributions to the theoretical model, as far as we know, this work is the first to quantify the extent to which the effectiveness of fiscal policy is affected by economic uncertainty and the influence on fiscal effects for Brazil. Therefore, it also contributes to the scarce literature on fiscal impacts in emerging countries.

The empirical results indicate a disruptive effect of uncertainty on GDP, as well as consumption, investment and hours worked. The results with an expanded sample for the United States are aligned with the experiments of Basu and Bundick (2017). For Brazil, the behavior is quite similar, indicating the same movement among economic aggregates.

The fiscal impulses point to slightly different results for the two countries. For both economies, a government spending shock has positive and significant impacts on GDP. A similar effect can be seen for the experiment with a panel with six European countries.

However, there is a divergence in the impact on consumption and private investment (crowding-out for the United States). Regarding the consequences of government consumption, we found that in an environment of high uncertainty, the fiscal effects are not

statistically significant, while in times of low uncertainty, the effects are positive and significant.

Finally, through the theoretical model, we highlight three main conclusions. First, risk aversion magnifies the influence of uncertainty. Second, as in the empirical model, we confirm the negative impact of uncertainty on economic activity and its components. Third, with the addition of distorting taxes on labor income and public consumption as an element of the utility function, it was possible to verify the positive effects of fiscal policy (government consumption). Moreover, we examine the sensitivity of the economy's responses to different configurations for the relationship between public and private consumption, under normal conditions or uncertainty shocks. From the base model, the findings indicate that the fiscal effect is partially dissipated when an uncertainty shock occurs simultaneously.

This paper is organized as follows. Section 2 is the literature review. Section 3 presents the data and methodology. Section 4 summarizes the empirical evidence. Section 5 describes the DSGE model and results, and Section 6 concludes.

2 Literature Review

Fiscal policy is a well-documented topic in macroeconomics. However, in the post-global financial crisis period, there was a renewed attention due to the political and academic debate on the role of fiscal policy, specifically whether public spending could stimulate economies and lead countries to a trajectory of growth and reduction in unemployment. Moreover, they have investigated whether there would be a crowding-out effect of public spending on elements of aggregate demand, such as investment and private consumption (Matsumae and Hasumi, 2016). Regarding to the crowding-out effect on private investments, the results for advanced economies are similar and investments are not sensitive to interest rates. In this case, the level of economic activity is indicated as the main determinant of investment (Hemming et al., 2002). The authors reviewed the empirical and theoretical literature for the effectiveness of fiscal policy and the determinants of fiscal multipliers, such as periods of economic contraction/ expansion, classification of economies (developed or developing) and the presence of economic uncertainty. They point out that although fiscal policy affects interest rates, to verify the crowding-out effect, there must be a relationship between private investment and interest rates and suggest that the sensitivity of investment to the interest rate is small.

If there is a certain consensus about the consequences of government spending on private investment, the same cannot be said about the relationship between government and private consumption. The debate about the effectiveness of government consumption and its effects on private consumption is well known and the literature presents mixed results. Thus, the assessment of non-separability between government purchases and services and

private consumption, as well as an understanding of the effect (positive or negative) on the marginal utility of consumption are potentially relevant to understand the transmission channel of fiscal policy on output (NI, 1995).

Some authors argue that government spending and private consumption are substitutes (Bailey, 1971; Barro, 1981; Baxter and King, 1993; Kwan 2006). On the other hand, empirical studies (Boehm 2019; Fatas and Mihov 2001; Ganelli and Tervala, 2009; Tenhofen and Heppke-Falk, 2006; Linnemann and Schabert, 2006) have supported the positive effects of government spending on private consumption. One of the reasons for the different results derives from the way the relationship is established, which categories of public goods and services (defense, housing or education), the persistence of the shock (temporary or permanent), and the sample period of the study. The authors who advocate the relevance of public spending emphasize the basic functions of government, i.e. allocative, distributive and stabilization functions, highlighting the first. For these researchers, an efficient allocation is not achieved only by the private sector, and governments act in the supply of public goods and services.

Barro (1981), investigates the influence of government purchases in national defense. He divides purchases into temporary and permanent purchases and admits the substitution effect between public and private consumption. Christiano and Eichenbaum (1992) developed two Real Business Cycle (RBC) models where the impact of government spending on private consumption depends upon the coefficient of public spending. The authors admit that private and public consumption are associated as follows: $\mathrm{Ct} = \mathrm{C}_t^P + \alpha.\mathrm{G}_t$, where α is the term that governs the effect on the marginal utility of private consumption CP_t in relation to government spending G_t. It measures the contribution of public spending to marginal utility consumption. The setting indicates that government spending can affect the utility of consumers as long as it is different from zero. For $\alpha > 0$, the marginal utility of consumption decreases with increasing public spending. The opposite is true for negative values. The authors assess the possibility of substitution and independence between C_t^P and G_t, while other papers admit different scenarios. Karras (1994), study 30 countries, and highlights that private and government consumption are described as complementary or unrelated.

Evans and Karras (1996), examined 54 countries and the findings indicate that government services and private consumption tend to be complementary. McGrattan (1991) found a negative value for α, indicating that the marginal utility of the consumer increases with an increase in government consumption, but we emphasize that the standard error found in this paper does not allow us to reject the hypothesis of independence of utility in relation to public consumption. Campbell and Mankiw (1990), using different data sets, admit non-separability between private consumption and government purchases and indicate values between -0.1 and -0.05. In the same vein, Ni (1995) highlights that some results point to the complementarity between public and private consumption.

Fiorito and Kollintzas (2004), investigated the relationship between private and government consumption for 12 European countries. They divided government consumption into two types: "public goods" (justice, defense and others) and "merit goods", such as health, education and other services that the private sector could provide. The estimates indicate that "public goods" and services substitute and "merit goods" complement private consumption. Corroborating those findings, Ambler et al. (2017), investigated the crowd-in effect of public spending shocks on private consumption and find that an increase in public spending is associated with an increase in private consumption, in line with the empirical literature. Thus, the decision of which segments of goods and services will be provided by the government varies according to the orientation of each country and may change the impact on economic growth.

Our work is also related to the literature that investigates the effect of uncertainty on economic activity, especially after the financial crisis in 2007/2008 (Bloom, 2009). However, the literature on the relationship between uncertainty and fiscal policy is scarce. Murray (2018) describes the effects of fiscal policy uncertainty, but points out that some theories highlight the repercussion of uncertainty on investment decisions, as previously highlighted by Pindyck and Solimano (1993). Therefore, there is a transmission channel of economic uncertainty that affects private investments, household consumption and the level of economic activity. Some studies indicate that high levels of uncertainty make consumers and investors more cautious and disrupts the effectiveness of public policies (Bloom, 2014).

The literature assigns different transmission channels of uncertainty in the long and short term. The Real Option channel indicates that the volatility of important variables leads to the postponement of investment projects and the hiring of new workers until the uncertainty dissipates. The same behavior can be observed for agents in relation to long-term consumption (Barboza, 2018). However, in the short term, households are also unable to clearly distinguish future events and choose to reduce consumption and increase savings (precautionary saving channel).

Other studies investigate how the economy reacts to fiscal policy uncertainty and not macroeconomic uncertainty. Thus, when there is more uncertainty in the management of government spending, households react with caution and are more willing to increase the labor supply and save more. Johannsen (2012) studies how fiscal policy uncertainty affects economic activity, using a new-Keynesian model and a VAR model for the United States. The findings indicate that the effectiveness of fiscal policy is influenced by the level of uncertainty of fiscal policy. The author suggests that fiscal policy uncertainty can have negative impacts on consumption, investment and GDP and emphasizes that fiscal policy uncertainty can have adverse effects when monetary policy fails to reduce interest rates due to the Zero Lower Bound (ZLB)[1]. Using New Keynesian model and VAR,

[1]The response or action of monetary policy after a fiscal stimulus is a central point in the investigation

Villaverde et al. (2015) also noted that uncertainty about future fiscal policy negatively affects economic activity in the United States, reducing output by 1.5 % in the presence of ZLB.

Whereas the uncertainty is not a directly observed variable and, due to the wide range of uncertainty concepts, researchers have used proxies to capture the impact on economic activity and the welfare of agents. The volatility of the stock market or GDP are classic measures, but depending on the focus of the study, the indicator may capture a measure derived from the volatility of the financial market or the frequency that newspapers report on politics, economics and uncertainty. An alternative way is to check the divergence of forecasts for banks and industrial sectors. Therefore, the greater the standard deviation of the predictions, the greater the effect of uncertainty.

Baker et al. (2016) develop an indicator (EPU) to capture the effects on economic policy over time. This index considers the number of times that words associated with economic or political uncertainty appear in widely publicized newspapers. From this procedure, they calculate the uncertainty index of an economy. In the same line, Ahir et al. (2018) developed the World Uncertainty Index (WUI) to facilitate comparability between countries. The index is based on a single source and the reports follow a standardized process. However, it is necessary to consider whether the agents would be aware and the effect of the news in the newspapers.

Berg (2019) investigates how business uncertainty affects the effectiveness of fiscal policy in Germany. Using an alternative measure of uncertainty for business, derived from the firm-level data, the author suggests that a monetary policy is less effective during episodes of high uncertainty and fiscal policy is the better option to foster economic activity. The author agrees that fiscal policy is less effective when the economy is hit by the uncertainty shock, and the consequent increase in the caution of consumers and firms, generating smaller fiscal multipliers. However, the author argues that the multipliers are greater in the years that follow, due to the influence on business confidence.

Other studies provide different types of uncertainty proxies. Basu and Bundick (2017) use volatility in the financial markets to measure uncertainty. The VIX index is a measure of the implied volatility of the Standard and Poor's stock index. Since 1993, the volatility index (VIX) has been widely used as a measure of investor sentiment or the "investor fear gauge". High index values point to greater anxiety or pessimistic expectations. On the other hand, low values indicate an optimistic attitude by the agents. In this way, different studies have mapped the movement of the VIX to assess market expectations (Pati et. al, 2017).

Figure 1 depicts the behavior for two of the mentioned uncertainty measures, and, as we

of fiscal multipliers. Depending on the accommodation of the monetary policy, greater or lesser will be the effect on fiscal multipliers. The ZLB case refers to a limit scenario of monetary policy, with the interest rate reaching the zero lower bound.

can observe, the two indices present a countercyclical behavior. The indexes presented a positive correlation (0.39) over the sample period (1990-2019), despite different methodologies. Unlike the EPU index, the uncertainty (VIX) is an ex-ante measure, while EPU uses an ex-post measure of volatility. An important question to consider is whether the VIX index can be considered as a broader measure of uncertainty.

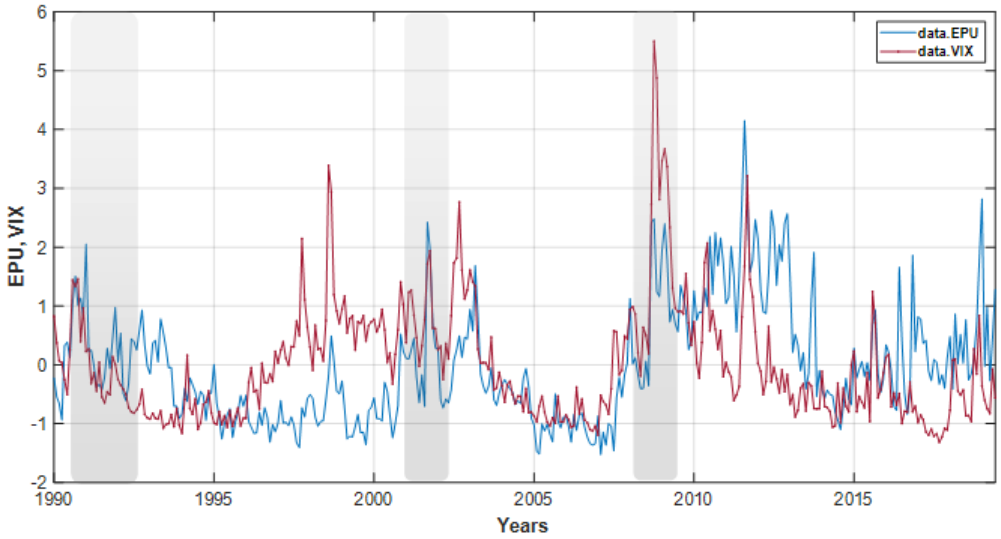

Figure 1: VIX e EPU (The United States)*. Source: Chicago Board Options Exchange (CBOE) -http://www.cboe.com/products/VIX-index-volatility/volatility-indexes. Economic Policy Uncertainty (EPU) - https://www.policyuncertainty.com/index.html * Standardized data.

3 Data and Methodology

The empirical study is organized in three stages. First, we investigate the effect of the change in public consumption in the United States, Brazil and a panel with six European countries, by using a VAR model. Second, we evaluate the impacts of uncertainty on macroeconomic variables such as GDP, labor, private consumption and investment[2].Finally, we investigate the fiscal effect in an environment of high and low uncertainty. In addition to the empirical models, we use a DSGE model that incorporates public consumption in the household utility function and economic uncertainty shocks.

The US time series are in billions of Chained 2012 Dollars (seasonally adjusted). They are available on the Federal Reserve Bank of St Louis. We select government consumption[3], household consumption, private investment and GDP. The sample covers the period from 1986Q2 to 2019Q2, for a total of 133 observations.

[2]We convert GDP, public consumption, private consumption, investment, and hours worked to per capita terms and detrend the log of data series using the HP filter with a parameter of 1600 (level data).

[3]In addition to government consumption, we also use general government consumption as a fraction of the average long-term GDP (GC/GDPss)

For the European panel[4], we use GDP, final consumption expenditure of general government (GC), households consumption (PC), and gross fixed capital formation (I), available in Eurostat database. They are seasonally adjusted in millions of Chained 2010 Euros (2000Q1 - 2019Q2).

The Brazilian time series are in billions of National Currency Units (chained 1995). The models were estimated using the Brazilian Accounts System, available by the Brazilian Institute of Geography and Statistics (IBGE), and Institute for Applied Economic Research (Ipea). The sample covers the period 1996Q1 to 2019Q4 (96 observations). One of the challenges in assessing the consequences of uncertainty shocks in developing countries is the availability of data, especially at a quarterly frequency. Since there is no long time series for private investment data, we use government consumption and private consumption.

Following Basu and Bundick (2017), we expanded the models and examined the effect on GDP, labor, private consumption, private investment and the co-movement between these aggregates after the uncertainty shock (VIX index). In this model, we define private consumption as the sum of non-durable goods and services and private investment as the sum of durable goods and private fixed investment. To assess the effect of a fiscal stimulus, we include the government consumption (GC) variable. Except for the interest rate, the time series are based on the natural log level. Such as the US data, the Brazilian time series are based on the natural logarithm level, except for interest rate, price index, and M2 money stock. For Brazil, the sample is smaller and covers the period from 2011Q2 to 2019Q3 (34 observations), due to the small sample of the VIX index.

For the panel of European countries, we use the EURO STOXX 50 Volatility Index (VSTOXX) which describes the implied volatility of the EURO STOXX 50 Index, available in Datastream. In the same vein as the VIX index, VSTOXX provides a ”fear index” based on an analysis of the economy in the future.

Table 1 and figure 2 display the descriptive statistics and graphs of the time series for the first model in the United States. We use data in percent log differences because we reject the hypothesis of stationarity for series.

[4]Belgium, Finland, France, Germany, Italy, and Spain.

Table 1: Descriptive Statistics and Tests (First Difference - The United States)

First Difference	Gov Consumption	Private Consumption	Private Investment	GDP
Mean	0.003202	0.006976	0.008237	0.006388
Median	0.002588	0.007062	0.007790	0.006946
Maximum	0.021373	0.018550	0.088435	0.018146
Minimum	-0.015630	-0.009350	-0.122799	-0.021876
Std. Dev.	0.006813	0.004990	0.029682	0.005723
Skewness	0.080823	-0.439079	-0.882153	-1.228908
Kurtosis	3.034278	3.977056	6.337750	7.242166
Jarque-Bera	0.150173	9.491907	78.39340	132.2026
Probability	0.927663	0.008687	0.000000	0.000000
Augmented Dickey-Fuller t-Stat	-4.063979	-2.835949	-8.377586	-4.976691
Observations	132.0000	132.0000	132.0000	132.0000

Source: Authors' calculations.

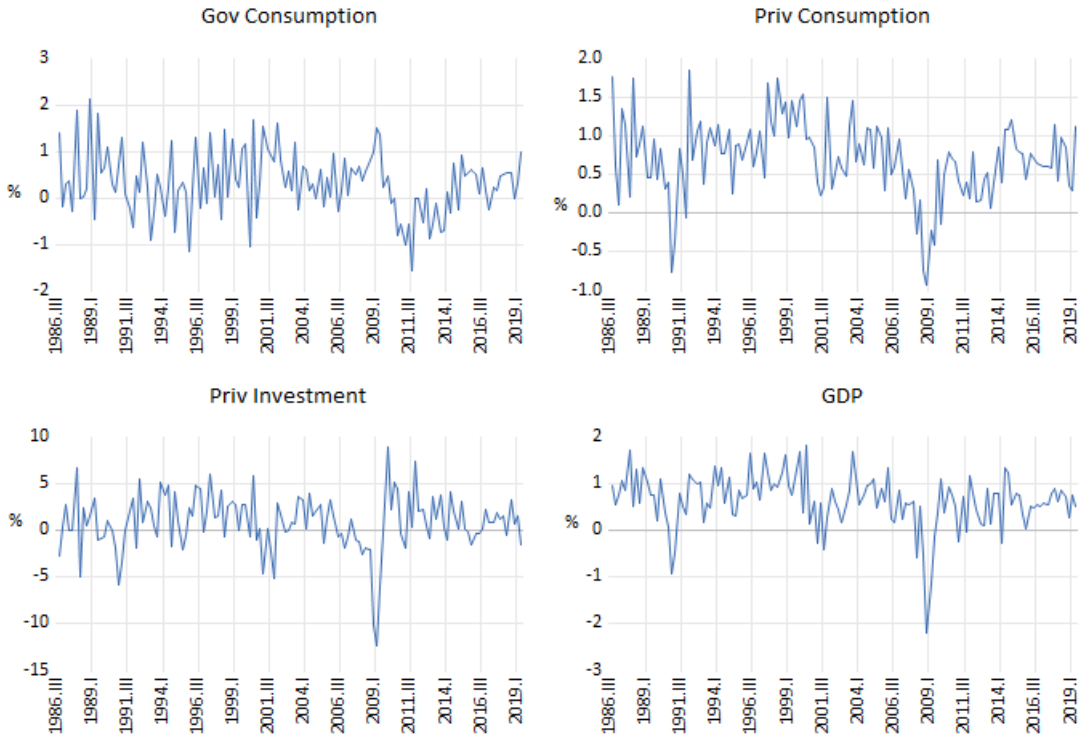

Figure 2: Series (First Difference - The United States). Source Author's calculations.

Table 2 and figure 3 are associated with the expanded model, inspired by Basu and Bundick (2017). We detrend the log of data series (level) using the HP filter. The next four figures show the statistics for Brazil and follow the same transformations as the previous figures.

Table 2: Descriptive Statistics and Tests (The United States)

	VIX	GC/GDPss	GDP	Priv Consumption	Priv Investment	Labor	Price	M2	r
Mean	1.28E-12	-8.62E-13	4.82E-12	4.38E-12	4.35E-12	3.10E-12	2.08E-12	4.08E-12	1.06E-11
Median	-2.741381	-0.036899	-0.038418	-0.047753	0.345271	0.114622	0.013277	-0.008749	-0.592955
Maximum	89.46811	3.198952	2.325016	1.544121	7.796449	1.271742	0.941434	4.152516	210.7391
Minimum	-50.04911	-2.191569	-2.825093	-1.384753	-17.75343	-3.402721	-0.787799	-3.795031	-251.0383
Std. Dev.	24.43431	1.065801	1.068498	0.686084	4.524787	0.786865	0.409683	1.329064	92.79382
Skewness	0.885823	0.666286	0.004569	0.265097	-1.065110	-1.408817	0.065897	0.160161	-0.159069
Kurtosis	4.321638	3.736881	2.816727	2.384861	5.140317	6.538293	2.409734	3.336064	3.078382
Jarque-Bera	26.87002	12.75308	0.185199	3.627266	50.15336	112.5222	2.011807	1.185495	0.590453
Probability	0.000001	0.001701	0.911559	0.163061	0.000000	0.000000	0.365714	0.552806	0.744363
Augmented Dickey-Fuller t Stat	-6.379126	-3.267067	-4.534659	-5.403378	-3.874945	-5.152300	-3.453056	-4.846468	-4.631179
Observations	132	132	132	132	132	132	132	132	132

Source: Authors' calculations.

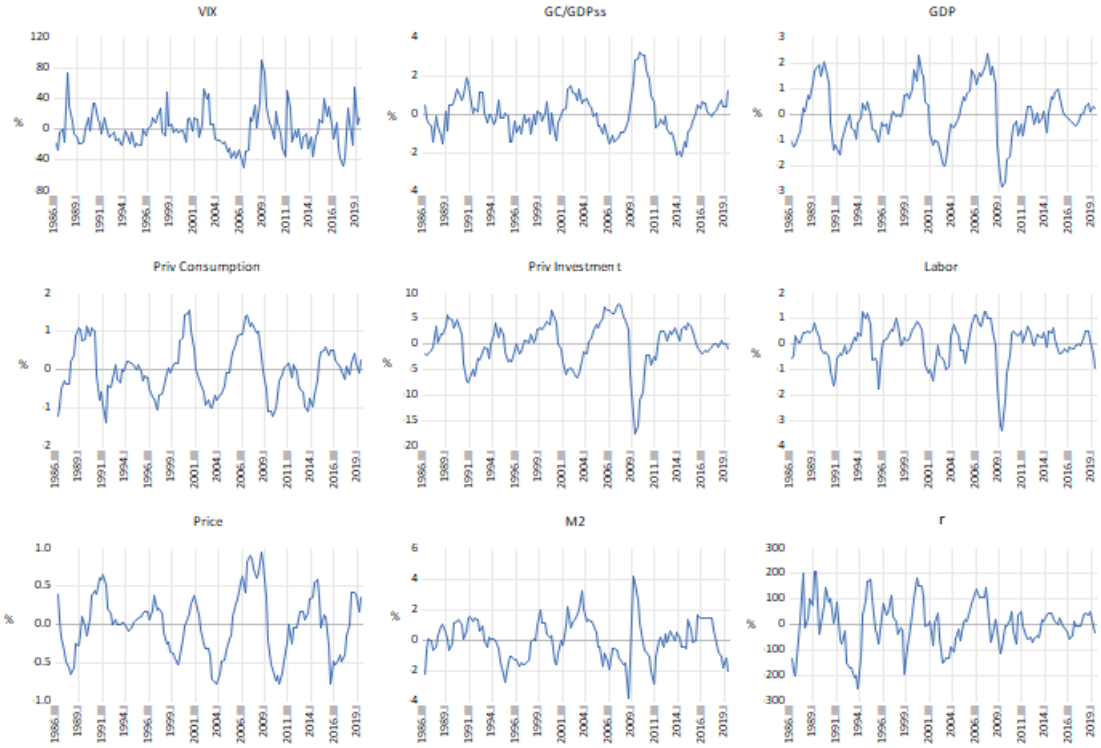

Figure 3: Series (The United States). Source Author's calculations.

Table 3: Descriptive Statistics and Tests (First Difference - Brazil).

First Difference	Gov Consumption	Private Consumption	GDP
Mean	0.004183	0.006490	0.005677
Median	0.004262	0.007315	0.008035
Maximum	0.124277	0.051597	0.037734
Minimum	-0.162765	-0.032847	-0.038500
Std. Dev.	0.024937	0.012526	0.011863
Skewness	-1.957574	-0.134840	-0.701942
Kurtosis	27.64975	4.647825	4.478826
Jarque-Bera	2465.799	11.03605	16.45803
Probability	0.000000	0.004014	0.000267
Augmented Dickey-Fuller t-Stat	-16.80449	-3.940351	-7.434001
Observations	95.00000	95.00000	95.00000

Source: Authors' calculations.

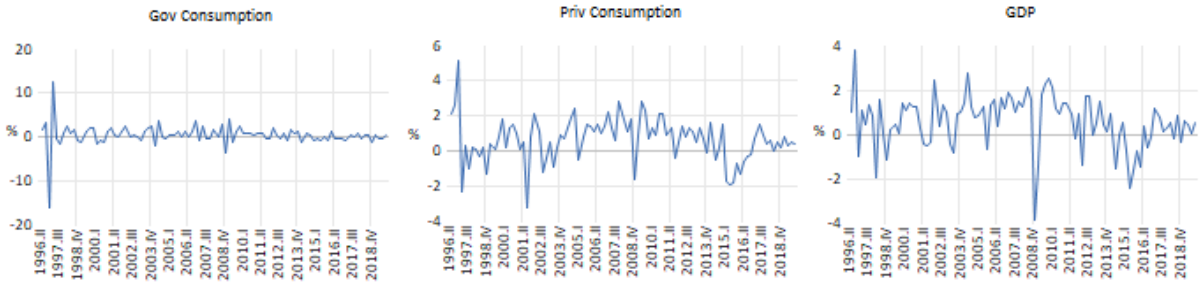

Figure 4: Series (First Difference - Brazil).

Table 4: Descriptive Statistics and Tests (Brazil).

	VIX	GC/GDPss	GDP	Priv Consumption	Labor	Price	M2	r
Mean	1.26E-11	4.02E-11	4.77E-11	4.61E-11	2.43E-11	46.02295	0.791695	2.87E-14
Median	-6.024816	-0.086684	0.076440	-0.001866	-0.261438	43.32058	0.978477	0.000136
Maximum	44.75360	2.099975	3.337440	4.512585	5.276012	125.9991	4.313628	0.179326
Minimum	-43.55691	-1.840919	-3.337876	-3.697828	-4.696397	7.307925	-2.304717	-0.238023
Std. Dev.	19.84077	0.854971	1.899886	2.217809	3.080061	25.72083	1.569638	0.115646
Skewness	0.429125	0.331422	0.144646	0.049733	0.033306	0.934643	-0.239508	-0.214703
Kurtosis	2.993549	3.140677	1.911649	2.093946	1.709530	4.113842	2.762707	2.150778
Jarque-Bera	1.043568	0.650464	1.796612	1.177005	2.365479	6.707741	0.404832	1.282887
Probability	0.593461	0.722360	0.407259	0.555158	0.306438	0.034949	0.816755	0.526532
Augmented Dickey-Fuller t Stat	-3.573612	-2.934643	-1.779117	-2.037331	-4.529899	-3.636018	-2.032168	-2.640486
Observations	34	34	34	34	34	34	34	34

Source: Authors' calculations.

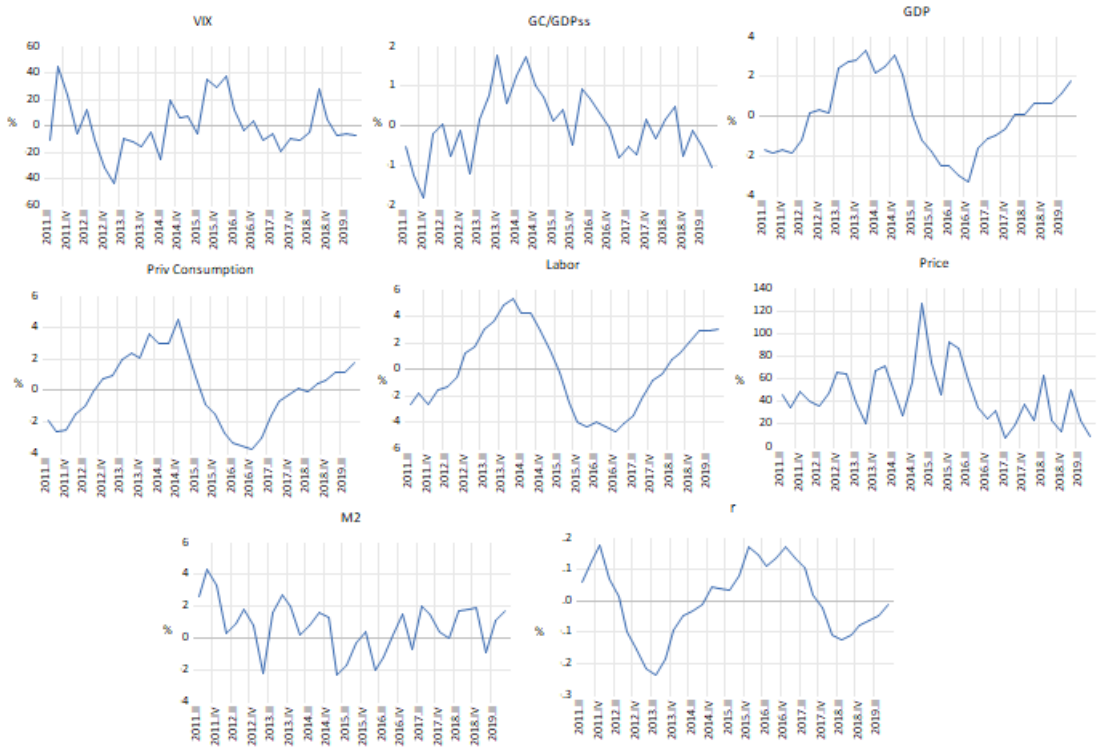

Figure 5: Series (Brazil).

Finally, table 5 and figure 6 describe the behavior of the variables used for the panel model.

Table 5: Descriptive Statistics and Tests (PVAR - Europe).

First Difference	Gov Consumption	Priv Consumption	Investment	GDP	VSTOXX
Mean	0.347361	0.296272	0.282100	0.316209	23.62333
Median	0.336048	0.340181	0.375151	0.394006	21.62000
Maximum	6.554167	2.960390	9.584319	2.816226	56.98667
Minimum	-10.25187	-5.020177	-10.56672	-6.744033	12.26333
Std. Dev.	0.981954	0.703608	2.093048	0.782570	8.929049
Skewness	-1.873076	-1.189342	-0.404083	-2.601780	1.610168
Kurtosis	37.74952	11.22398	7.465819	21.82771	5.945832
Jarque-Bera	23515.08	1410.871	396.4859	7345.022	366.6834
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	160.4809	136.8777	130.3302	146.0886	10913.98
Sum Sq. Dev.	444.5113	228.2245	2019.572	282.3238	36754.57
Augmented Dickey-Fuller t stat	-4.565047	-8.114856	-10.41523	-13.60688	-9.121423
Observations	462.0000	462.0000	462.0000	462.0000	462.0000

Source: Authors' calculations.

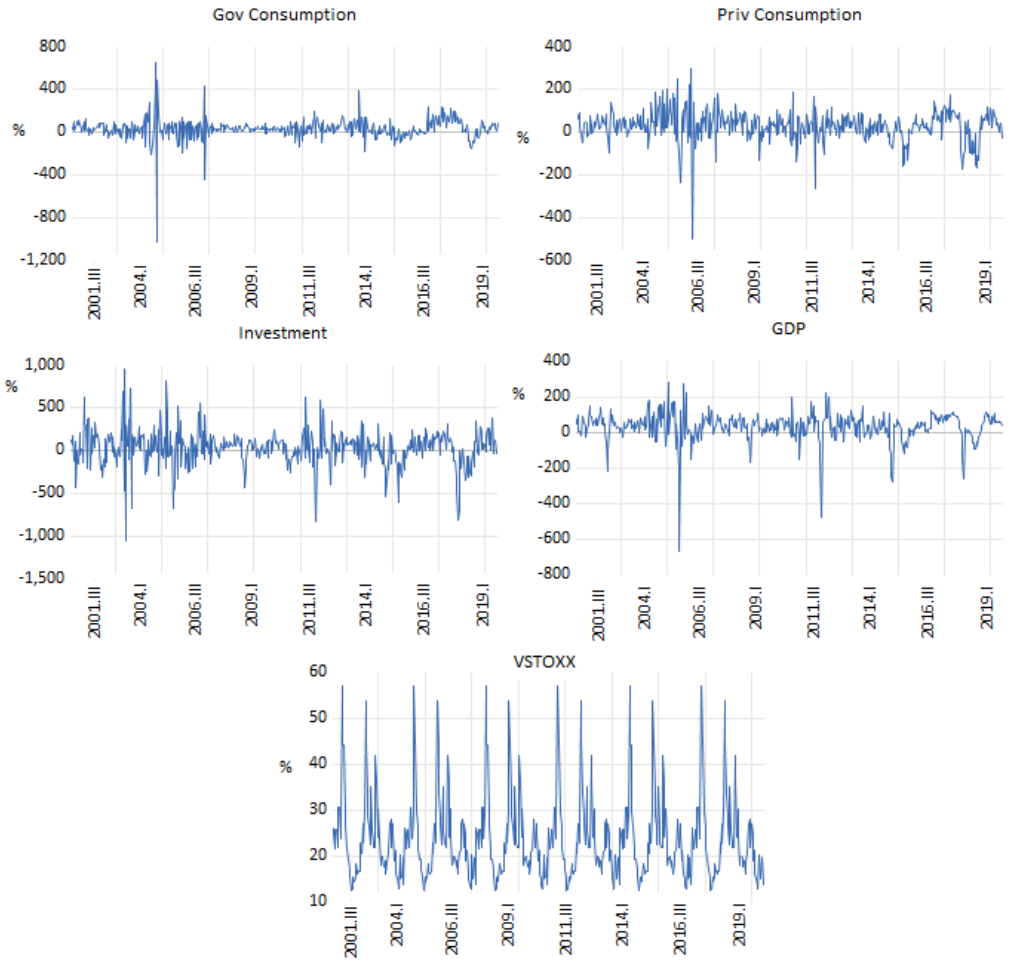

Figure 6: Series - First Difference (PVAR Europe). Note:VSTOXX in level.

4 Empirical Evidence

In this section, we present the empirical results of three experiments based on the VAR approach[5]: i) a government consumption shock, ii) uncertainty shock and iii) the effects of a government consumption shocks in times of high and low uncertainty. In all experiments, we examined the effects for Brazil and the United States. Furthermore, in the first and third experiments, we also use a panel VAR with six European countries to bring new evidence about the sign and magnitude of the fiscal stimulus[6].

The first experiment points to a positive impact of government consumption on economic activity. On the other hand, an uncertainty shock has a negative influence on GDP. We replicated the results in Basu and Bundick (2017) with a larger sample, and we found very similar results. An increase in future uncertainty causes declines in GDP, household

[5]The identification follows the Cholesky decomposition.

[6]In all experiments, the IRF bands (shaded zone) represent 95% confidence level interval.

consumption, private investment and hours worked. The third experiment suggests that high uncertainty obscures the effectiveness of fiscal stimulus on the economy. Finally, the findings of the log-level simulations (government consumption and uncertainty) will be compared with those of the theoretical model.

4.1 Experiment 1: Government Consumption Stimulus

4.1.1 Government Consumption Stimulus (Growth Rates)

The United States (1986Q2 - 2019Q2)

In this first experiment, we initially examined the effects of public consumption in variation and, later, at log-level, with other economic variables. Thus, we can compare the results with those obtained by our DSGE model and the findings of Basu and Bundick (2017). In the first US model, the economic variables are the growth rates of general government consumption (GC), private consumption (PC), private investment (PI) and output (GDP).

$$Y_t = C + \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_t \tag{1}$$

Where: C is a (4x1) vector of intercept terms; Yt represents the $Y_t = [\Delta lnGC_t, \Delta lnPC_t, \Delta lnPI_t, \Delta lnGDP_t]$;

A is the matrix of autoregressive coefficients of order (4x4) and the vector of disturbances is $\varepsilon_t = [\varepsilon_t^{GC}, \varepsilon_t^{PC}, \varepsilon_t^{PI}, \varepsilon_t^{GDP}]$.

The model is stable[7], since all inverse roots of the characteristic polynomial are within the unit circle. The assumptions associated with the residuals were verified. An inspection of the IRFs, displayed in Figure 7, indicates that a shock in public spending has a positive and significant effect on GDP (impact) followed by a downward movement, reaching the minimum value in the second quarter and then returning to the equilibrium value. We observed a similar movement for household consumption, but the initial impact was not statistically significant.

Finally, private investment has a negative response (statistically significant effect), with a minimum value six months after the initial shock. Then return to the equilibrium state.

[7] Lag Order equal to one.

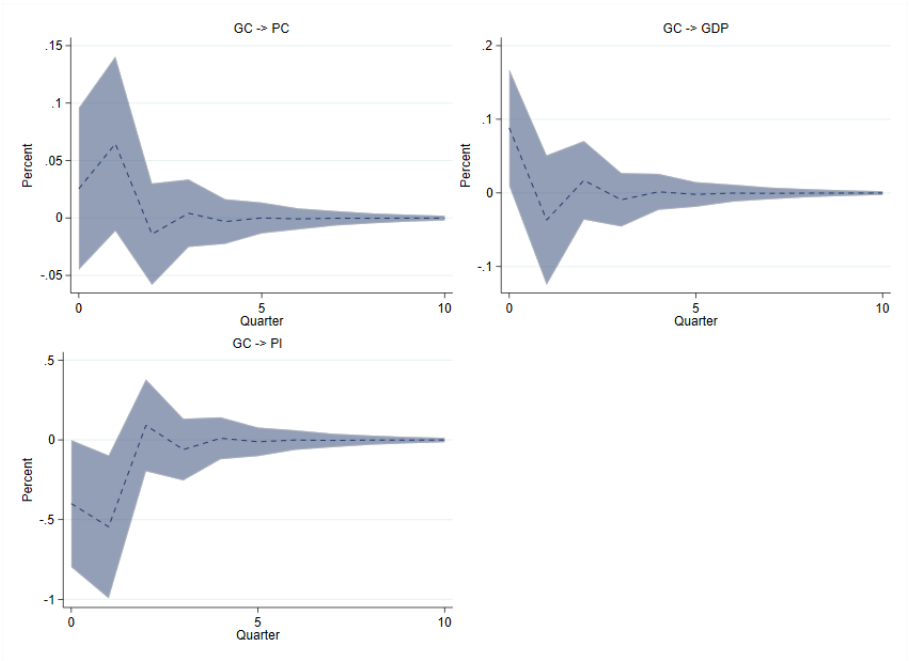

Figure 7: Impulse Response Function (Experiment 1 Gov Consumption USA - Consumption and Investment). Source: Authors' calculations. Note: The bands (shaded zone) represent 95% confidence level interval.

Our findings are in line with different studies for the United States (Blanchard and Perotti, 2002). They also found similar effects on output and private investment. The variance decomposition reports that, unlike household consumption, private investment has a greater proportion of the effects attributed to government consumption, with a more intense influence from the second quarter (Appendix).

4.1.2 Government Consumption Stimulus (Level)

The United States (1986Q2 - 2019Q2)

The following model[8] expands the number of variables. In order to compare the results with those of the theoretical model, we adjusted government consumption. The economic variables are general government consumption as a fraction of the average long-term GDP (GC/GDPss), output (GDP), private consumption (PC), private investment (PI), hours worked (labor), price (P), M2, and interest rates (r)[9].

As in the previous model, the responses indicate similar patterns, stimulating (significant) economic activity. Therefore, we obtain that an increase in the level of government consumption stimulates household consumption and has a negative, but limited, impact on

[8]Lag Order equal to four.

[9]Private consumption is defined as the sum of non-durables and services consumption. Private investment is calculated as the sum of consumer durables and private fixed investment.

private investment. The dynamic effects of the shock on public spending appear in the figure below.

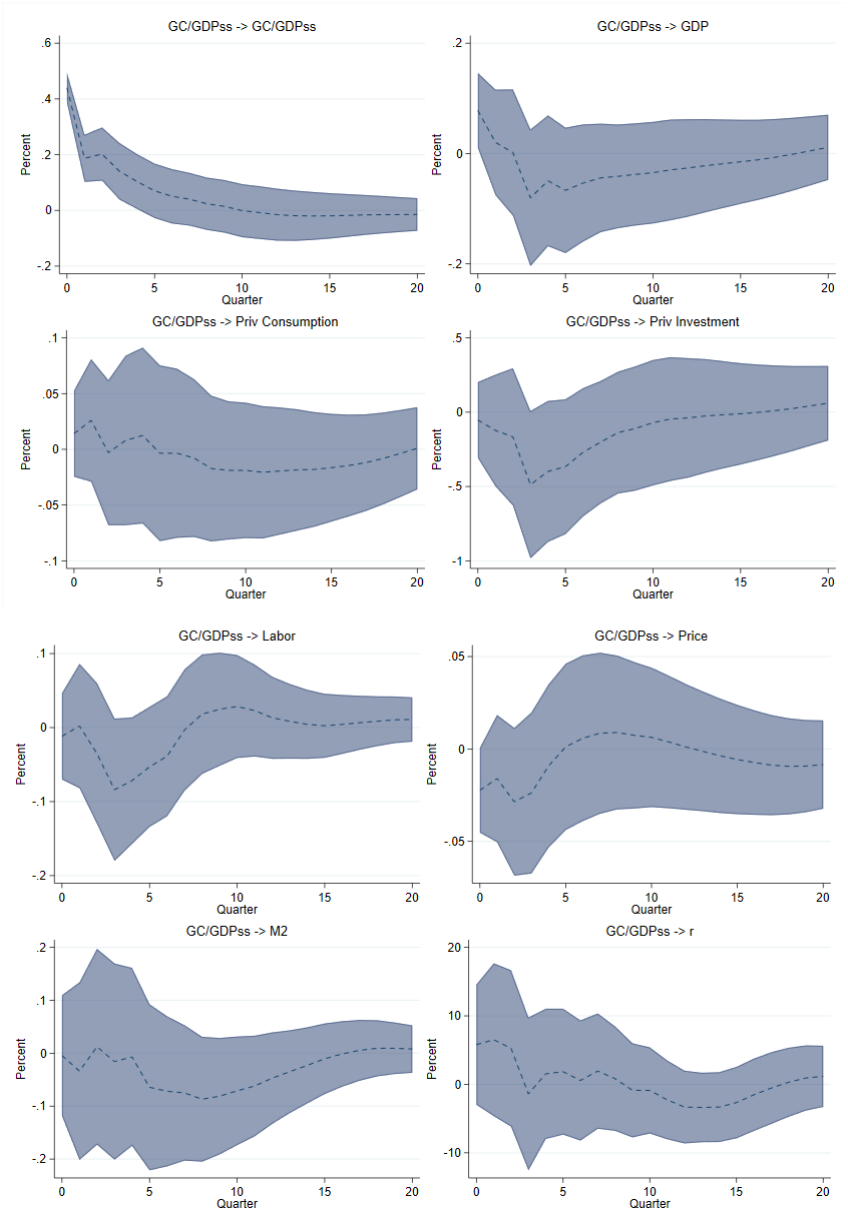

Figure 8: Impulse Response Function (Experiment 1 Gov Consumption USA - Level). Source: Authors' calculations.

4.1.3 Government Consumption Stimulus (Growth Rates)

Brazil (1996Q1 to 2019Q4) - Growth rates

Due to the lack of quarterly data for private investment, we use only household consumption and GDP. Thus, the experience for Brazil has the same model used for the United

States, except for private investment. As in the previous VAR model, the system is stable, and lag order selection followed the AIC criterion[10].

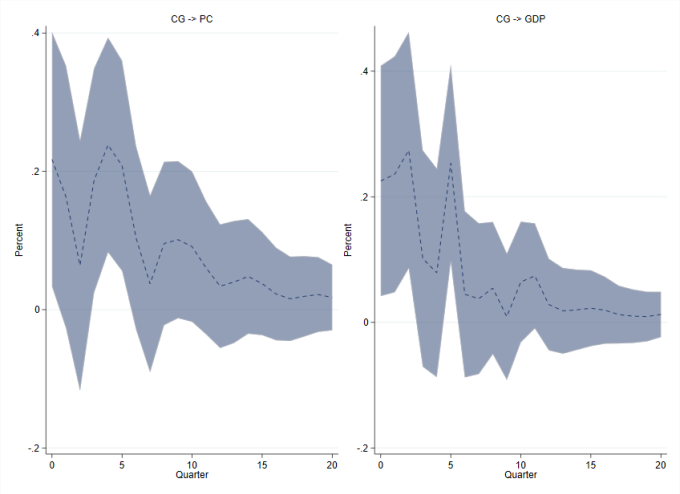

Figure 9: Impulse Response Function (Experiment 1 Gov Consumption Brazil - Consumption and Investment). Source: Authors' calculations.

Figure 9 depicts the influence of the government consumption shock on GDP and household consumption. We observed that in both cases, the impact is positive (statistically significant) and the positive effect on the output is significant for at least two quarters, with a peak response in the second quarter. In contrast to the United States model, the effect on household consumption is significant. Thereafter, consumption and GDP smoothly return to equilibrium.

The analysis of the variance decomposition suggests a greater effect of public consumption in the Brazilian case, close to 20% for GDP, while for the United States a more discrete and stable value. Besides, this influence increases over the first quarter and subsequent stabilization (see appendix).

4.1.4 Government Consumption Stimulus (Level)

Brazil (1996Q1 to 2019Q4)

In the same way that we proceed for the United States, we simulate the reaction of a fiscal stimulus for the Brazilian economy. The following figure describes the dynamic economic responses caused by the fiscal impulse.

The first evidence of the fiscal shock is the increase in household consumption and the number of hours worked. In short, the Brazilian model[11] shows results in the same direction as those observed for the United States economy and the findings point to Keynesian effects, despite low statistical significance, probably due to the smaller sample.

[10] Lag Order equal to five.
[11] Lag Order equal to two.

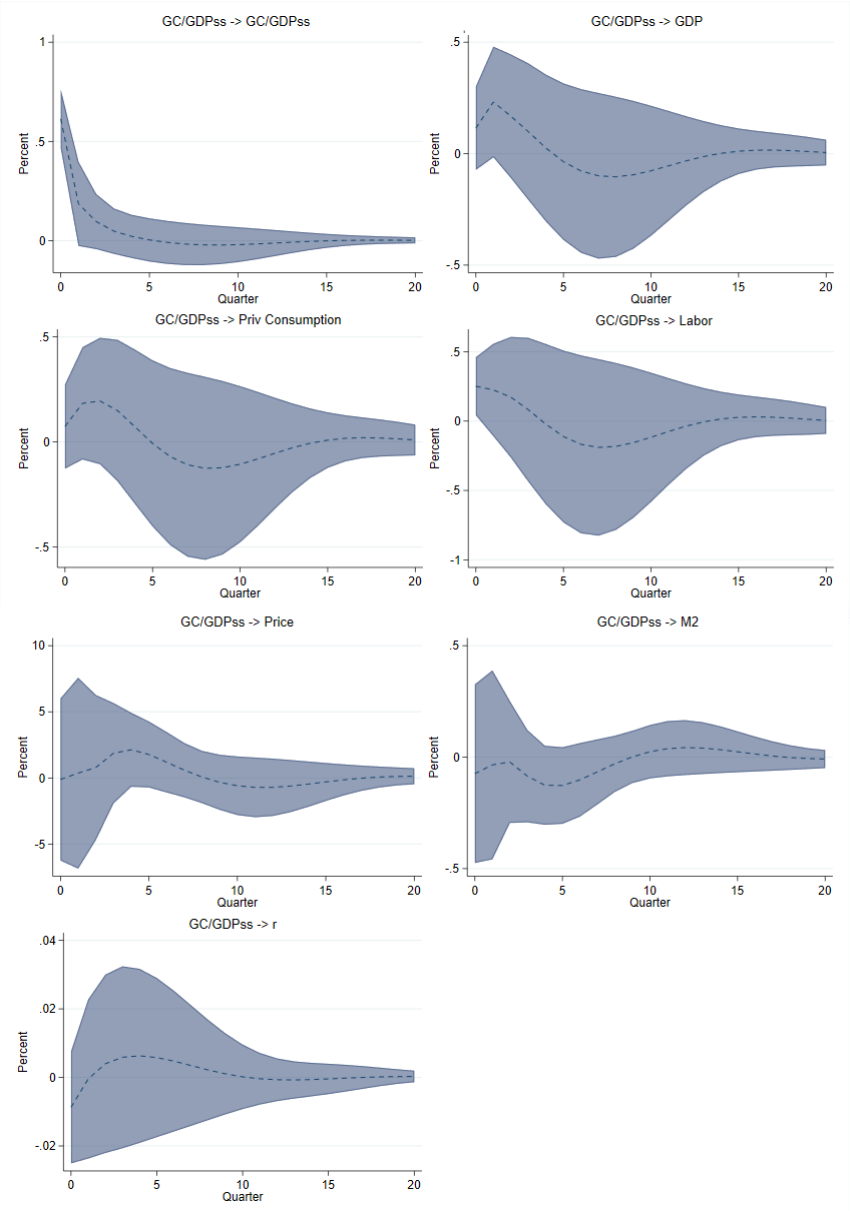

Figure 10: Impulse Response Function (Experiment 1 Gov Consumption Brazil - Level). Source: Authors' calculations.

4.1.5 Government Consumption Stimulus (Growth Rates)

Panel VAR Europe (200Q1 to 2019Q4) - Growth rates

In this section, we present a PVAR model for European countries to compare the effects caused by fiscal policy and confirm the patterns observed in the previous models.

We construct our Panel VAR (order p) with six European countries over a period of 78 quarters (2000Q1-2019Q2). Y_{it} is a vector of endogenous variables for each country

(index i), in quarter t.

$$\begin{gathered}\mathbf{Y}_{it} = \mathbf{Y}_{it-1}\mathbf{B}_1 + \cdots + \mathbf{Y}_{it-p+1}\mathbf{B}_{p-1} + \mathbf{Y}_{it-p}\mathbf{B}_p + \mathbf{X}_{it}\mathbf{C} + \mathbf{u}_i + \mathbf{e}_{it} \\ i \in \{1,2,\ldots,6\}, \quad t \in \{1,2,\ldots,78\}\end{gathered} \tag{2}$$

where Y_{it} is a vector of dependent variables and X_{it} is a vector of endogenous variables. The linear coefficients of each economy (i) can be correlated with the error, leading to biased estimates. To circumvent this obstacle, we performed a transformation in the model to eliminate the fixed effects of each country and, through the generalized method of moments (GMM) approach, added instruments to our model with lagged data.

After analyzing the preliminary tests, we verified that the time series are stationary, the data have no gaps and our panel is balanced. Thus, we follow Abrigo and Love (2016) and use first difference transformation (FD) to remove the individual fixed effects[12].

To identify shocks, we impose a restriction (Cholesky) on the variance-covariance structure of the residues and establish the contemporary effects among the variables. The economic variables are the growth rates of government consumption (GC), private consumption (PC), investment (I) and output (GDP). They are ordered as follows: GC, PC, I and GDP.

After performing the tests and analysis to check the stability of the model[13], we simulated the impulse response functions (IRF), whose graphs are displayed in the figure below. The findings suggest a Keynesian effect, by showing that positive shocks in government consumption foster GDP growth and private consumption.

Figure 11 highlights the positive effect on household consumption and GDP growth (statistically significant)[14] after the initial shock. Despite having a less persistent effect, government consumption has a positive and significant impact on investment, indicating a potential crowding-in effect.

[12] We use lagged variables as instruments, that is, lags two and three.
[13] The information criteria indicate the lag equal to one.
[14] Significance level of 5%.

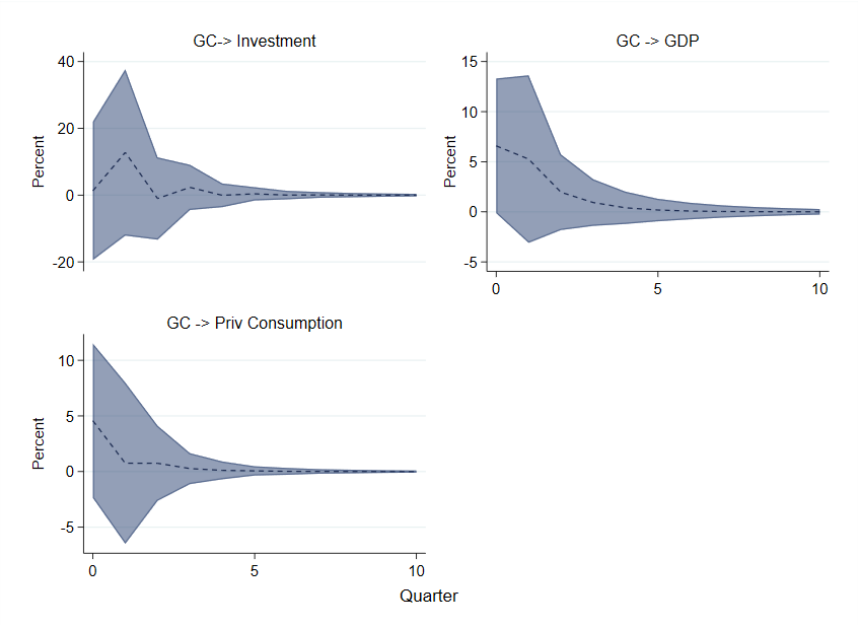

Figure 11: IRF (PVAR Europe). Source: Authors' calculations.

4.2 Experiment 2: Uncertainty Shocks

The United States (1986Q3 to 2019Q2)

Following the paper of Basu and Bundick (2017), we replicated the baseline VAR model with a larger sample[15]. Next, we describe the model configuration and the results. The identification follows the Cholesky decomposition, where the uncertainty proxy (VIX) has an immediate impact on economic activity.

The following variables are used (in order): VIX, GDP, private consumption (C), private investment (INV), hours worked (N), Price (P), M2, interest rate (r). The variables enter the VAR in log levels, except the interest rate. Private consumption is defined as the sum of non-durables and services consumption. In addition, private investment is calculated as the sum of consumer durables and private fixed investment.

Figure 12 plots the IRFs to an identified uncertainty shock with the 95% confidence intervals. The uncertainty shock causes declines in GDP, private consumption, and investment (significant). After the impact, GDP, household consumption, private investment and labor decreased together. The peak response of these variables occurs after four quarters (significant), with emphasis on private investment. After two years, the effect was dissipated.

Analyzing the decomposition of variance, we note that the shock of uncertainty explains around 13 to 15% of the forecast errors of GDP and private consumption in almost all

[15]Lag Order equal to four.

quarters. On the other hand, private investment and labor show higher values, with peaks of 20%.

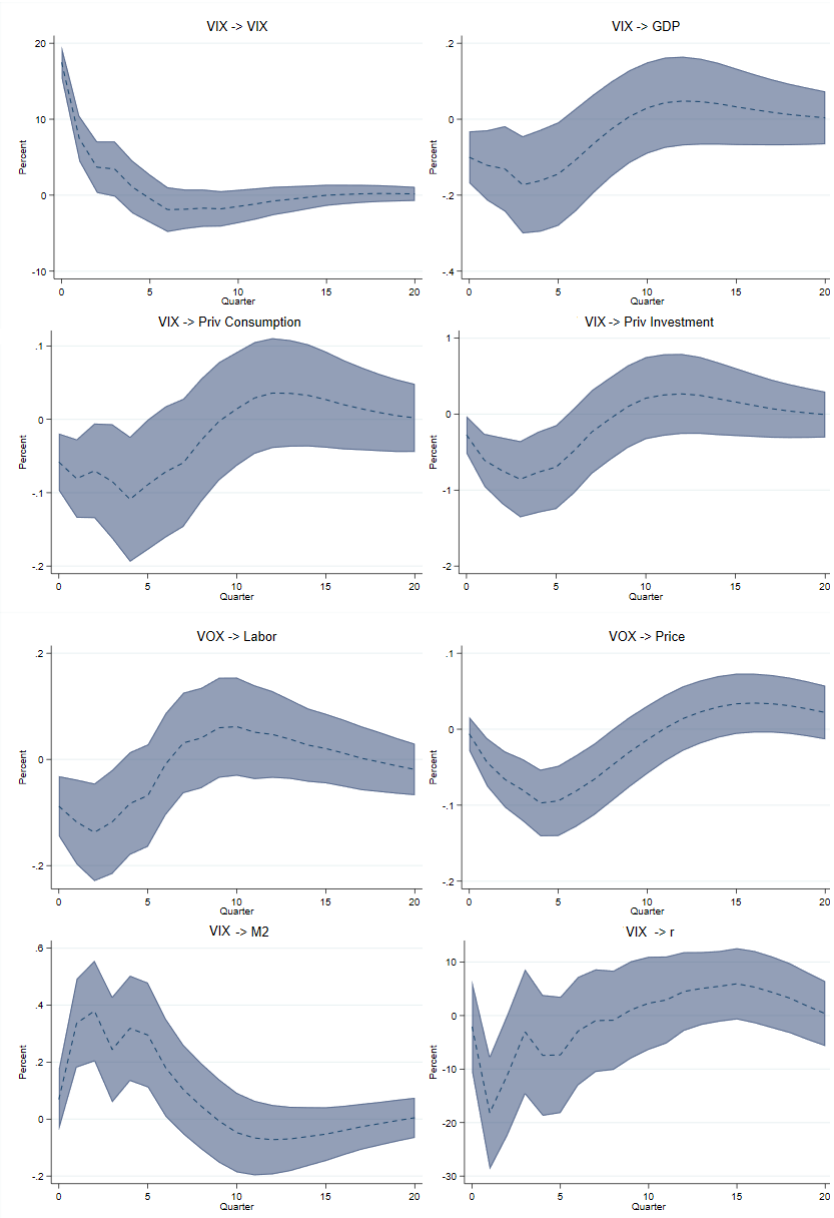

Figure 12: Impulse Response Function (Experiment 2 Uncertainty Shock USA). Source: Authors' calculations.

Brazil (2011Q2 to 2019Q3)

For Brazil, the same variables and ordering were used, but Price, M2 and r do not enter the VAR model in log levels. The pattern of results is very similar to the US model, with emphasis on the co-movement of the four key macroeconomic aggregates[16].

As the IRFs indicate, although the intensity is similar, the persistence is slightly higher

[16]Lag Order equal to one.

than the US model. In this case, peak shock responses occur after six quarters (statistically significant) and detrimental effects persist after eight quarters with significant results.

An inspection of the Variance Decomposition suggests that uncertainty has a greater influence on Brazilian variables than on the United States model. The analysis indicates that the uncertainty shocks have a high percentage of explanation for the variance of the errors of the analyzed variables. The uncertainty indicator has a small initial impact followed by a strong acceleration in the proportion of the four main economic aggregates, especially on GDP and private investment.

The findings for the United States and Brazil are consistent with the experiment developed for the US economy by Basu and Bundick (2017), but with a smaller sample.

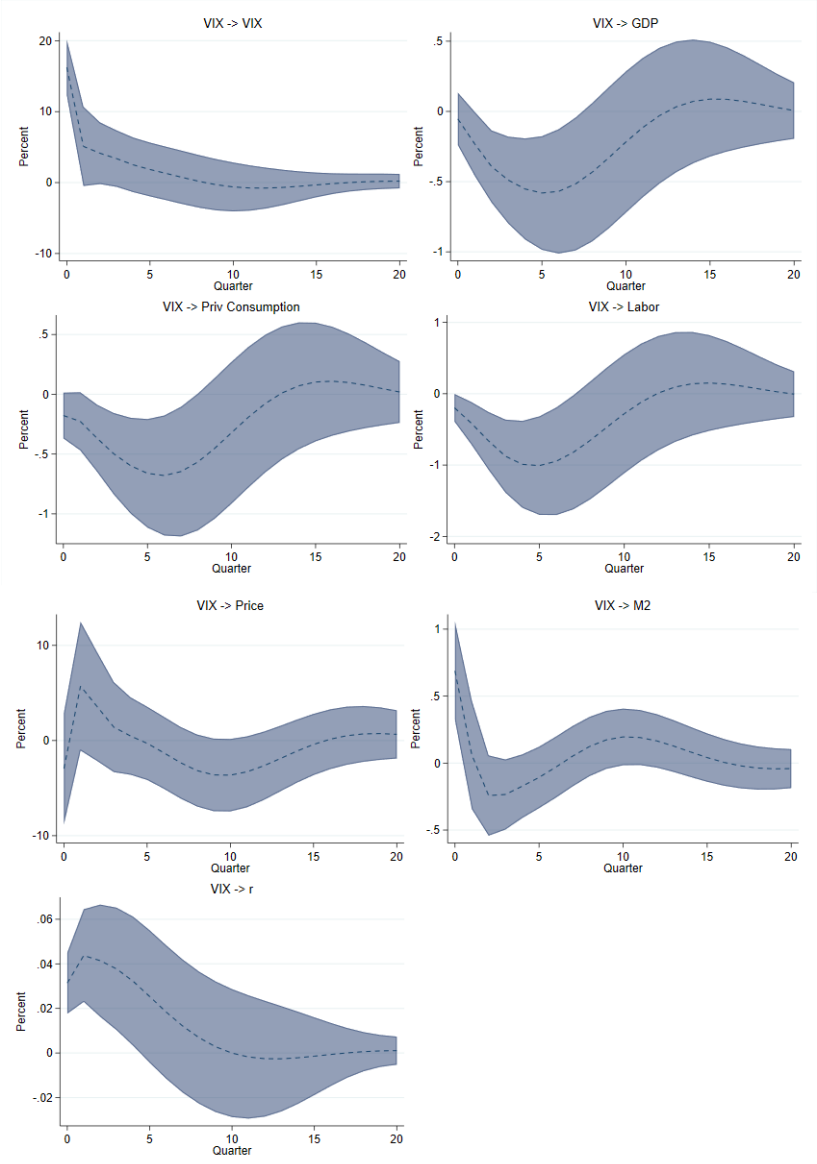

Figure 13: Impulse Response Function (Experiment 2 Uncertainty Shock - Brazil). Source: Authors' calculations.

4.3 Experiment 3: Fiscal stimulus in times of high and low uncertainty.

In this subsection, We perform models in first difference for Brazil and for the panel of European countries. For the United States, we use a first model in first difference and a second model in level.

We present the results of the VAR model for low and high uncertainty scenarios. To establish the scenarios, we divided the sample of the VIX index into two. For the scenario of high uncertainty values greater than or equal to the median. Values below the median are defined as low uncertainty.

The expressions define the settings for the two uncertainty scenarios.Y_t^{High} represents the values when VIX $\geq$ the median, and Y_t^{Low} when VIX $\leq$ the median.

$$Y_t^{High} = C^{High} + \sum_{i=1}^{p} A_i Y_{t-i}^{High} + \varepsilon_t \tag{3}$$

$$Y_t^{Low} = C^{Low} + \sum_{i=1}^{p} A_i Y_{t-i}^{Low} + \varepsilon_t \tag{4}$$

The United States (1986Q2 - 2019Q2) - Growth Rates

For this experiment, we use two models, high[17] and low uncertainty[18]. The variables are the growth rates of general government consumption (GC), private consumption (PC), private investment (PI) and output (GDP).

[17] Lag Order equal to two.
[18] Lag Order equal to one.

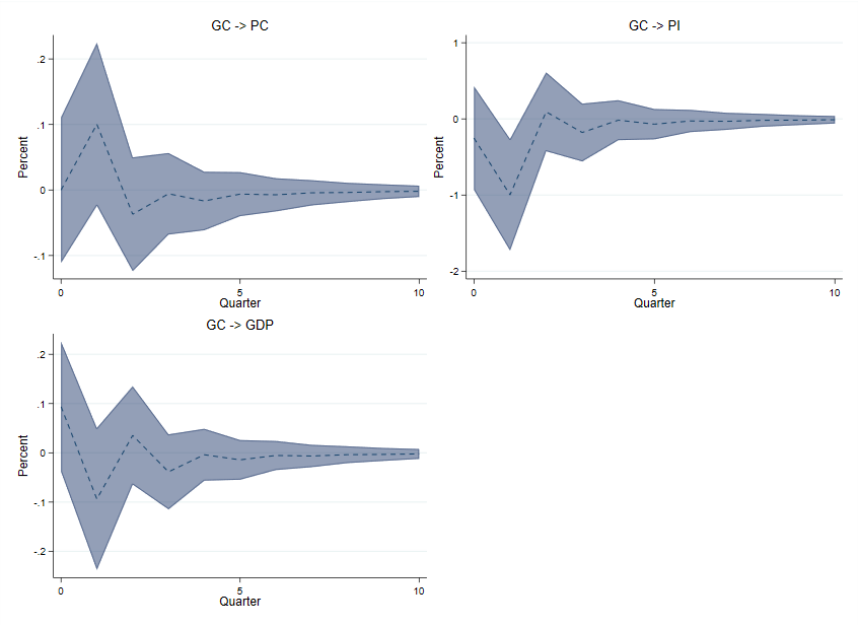

Figure 14: Impulse Response Function (Experiment 3 – Fiscal Shock and High Uncertainty - USA). Source: Authors' calculations.

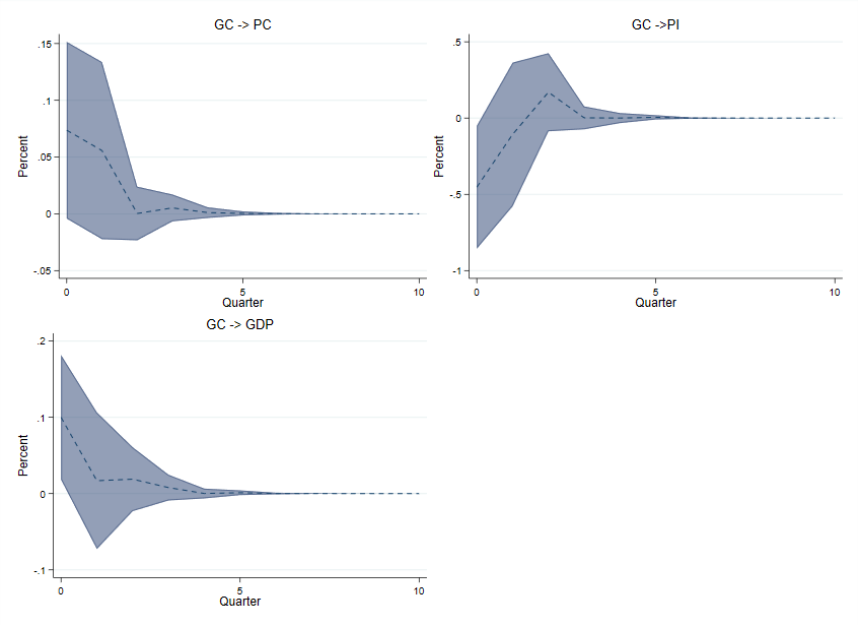

Figure 15: Impulse Response Function (Experiment 3 – Fiscal Shock and Low Uncertainty - USA - Fist Difference). Source: Authors' calculations.

Figures 14 and 15 show the effects of government consumption innovations for the two uncertainty scenarios. The findings indicate that high uncertainty reduces the influence of fiscal stimulus. On the other hand, when economic conditions are more predictable, the effect of fiscal policy is clearer. In this case, the impulses caused by government consumption raise GDP, and consumption (impact), while private investment is negatively affected (statistically significant).

The United States (1986Q3 to 2019Q2) - Level

To confirm the previous findings, we perform two new experiments (level) for the United States. The variables used are government consumption (a fraction of the average long-term output), GDP, private consumption, private investment, hours worked (labor), Prices, M2, interest rate (r).

Despite a smaller sample, the model is stable and the residual tests performed. VAR Lag Order Selection Criteria indicated 3 lags for the low uncertainty model and 1 lag for the high uncertainty model.

The simulations for the two scenarios are shown in figure 16. The first set of graphs indicates that the fiscal stimulus in a less uncertain environment (low VIX) stimulates private investment, which even with a small initial impact, is aligned with the real options approach and a potential transmission channel uncertainty. Household consumption and the level of economic activity have significant effects for at least two quarters.

On the other hand, the same fiscal stimulus in an environment of high uncertainty (second set of graphs) produces opposite responses. Uncertainty raises the precaution of agents who postpone their decisions, leading to an adverse effect on consumption, private investment, GDP, with an intense and significant response on hours worked (labor).

The findings indicate that uncertainty reduces the effect of the fiscal stimulus, especially when we compare the two scenarios with those generated by the shock in public consumption (figure 8) and uncertainty (figure 12) with the full sample.

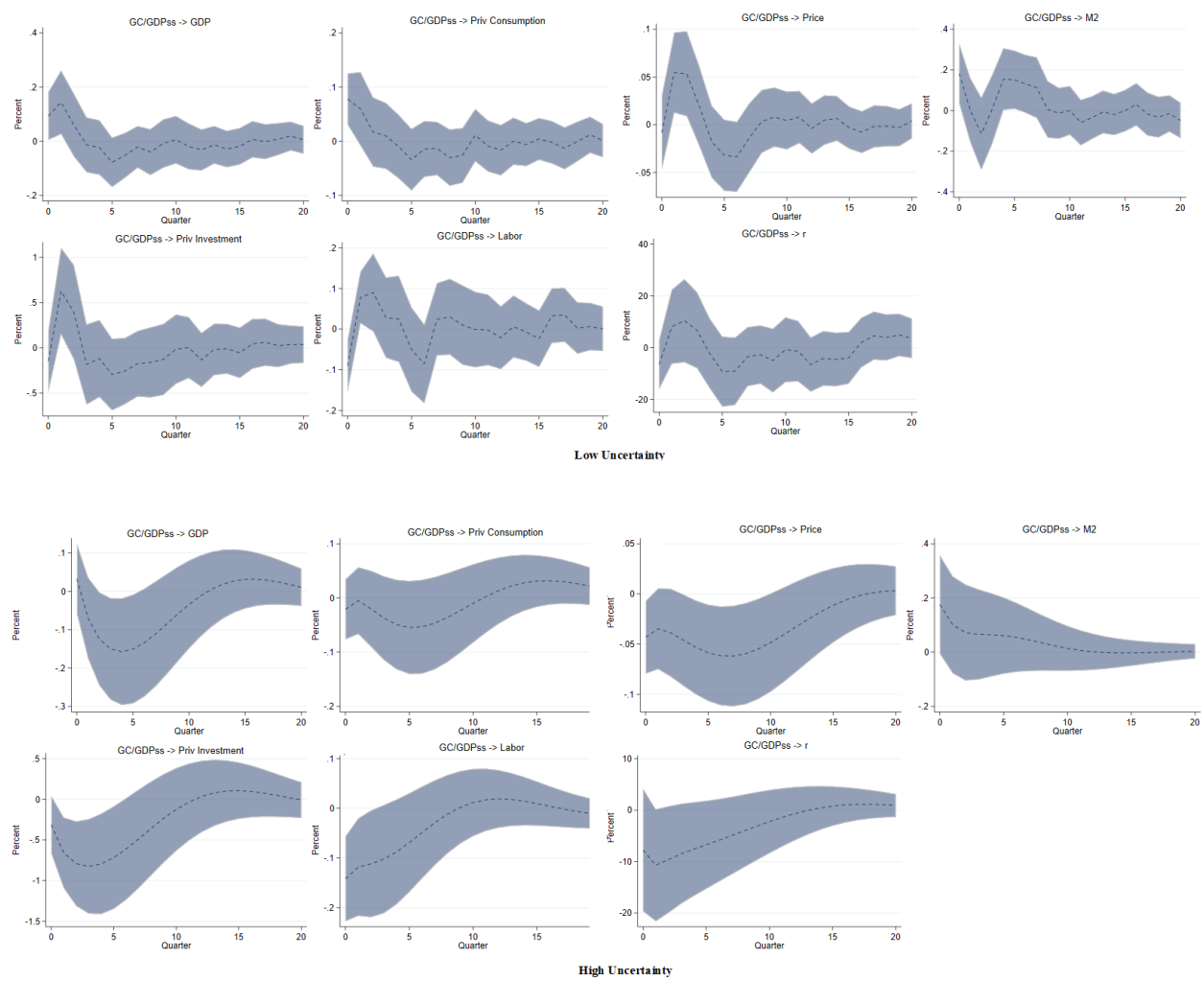

Figure 16: Impulse Response Function (Experiment 3 – Fiscal Shock: Low and High Uncertainty - USA - Level). Source: Authors' calculations.

Brazil (2011Q2 - 2019Q3) - Growth Rates

For Brazil, the sample is smaller because there is no long time series of the VIX index. However, the models[19] have the same variables described for the United States, except for private investment. The results for the Brazilian models do not allow us to reject the hypothesis that the impacts of public spending are reduced in an environment of high uncertainty. Indeed, the IRFs for Brazil are not conclusive, probably due to the small sample size.

[19]For high uncertainty the lag order is equal to one and for low uncertainty is equal to two.

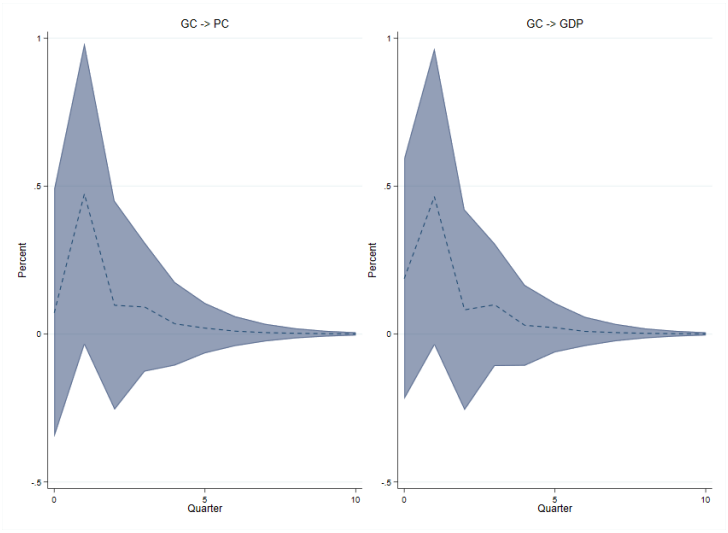

Figure 17: Impulse Response Function (Experiment 3 – Fiscal Shock and High Uncertainty - Brazil). Source: Authors' calculations.

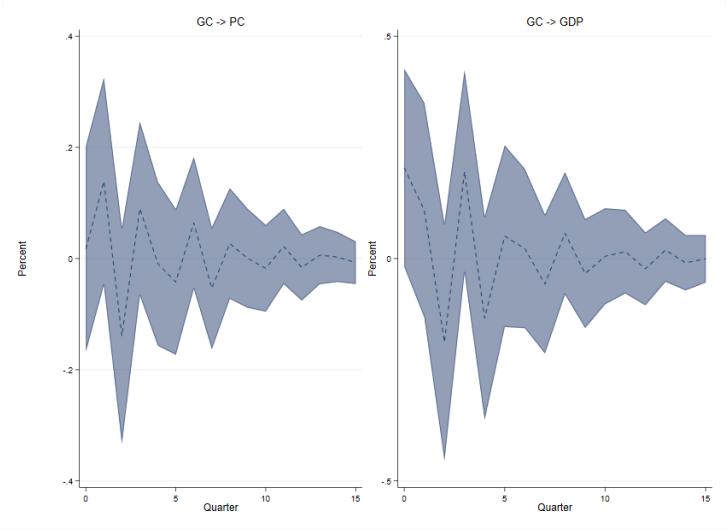

Figure 18: Impulse Response Function (Experiment 3 – Fiscal Shock and Low Uncertainty - Brazil). Source: Authors' calculations.

PVAR - Europe (2000Q1 - 2019Q2) - Growth Rates

To confirm the findings observed for scenarios of high and low uncertainty in the United States and Brazil, we performed a panel model for six European countries[20]. As we do not have the VIX indicator for the European case, we use the VSTOXX index,[21] as a measure of investor sensitivity and market volatility.

[20] As in the previous PVAR model, we use lagged variables as instruments, that is, lags two and three.
[21] VSTOXX index is based on the expected volatility implied by EURO STOXX 50 options.

Figures 19 and 20 indicate the effects of a shock on government consumption in scenarios of high and low uncertainty, respectively. The first figure displays a slight impact of government consumption on economic activity. In contrast, we observed a positive and statistically significant influence in times of low uncertainty.

These results are in line with the hypothesis that in times of high uncertainty, agents change consumption and investment decisions and, therefore, the government spending produces less intense effects. On the other hand, periods of high confidence and less volatility enhance the effects of the fiscal stimulus.

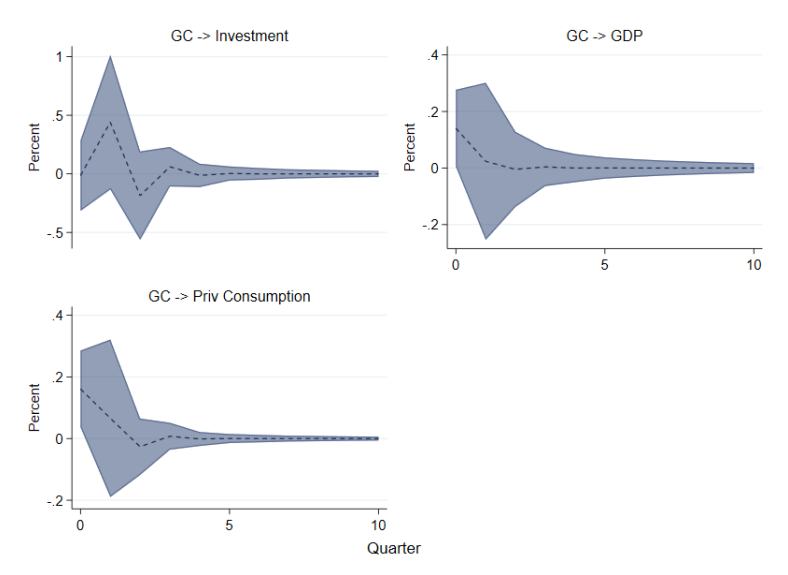

Figure 19: Impulse Response Function (Experiment 3 – Fiscal Shock and High Uncertainty - PVAR Europe). Source: Authors' calculations.

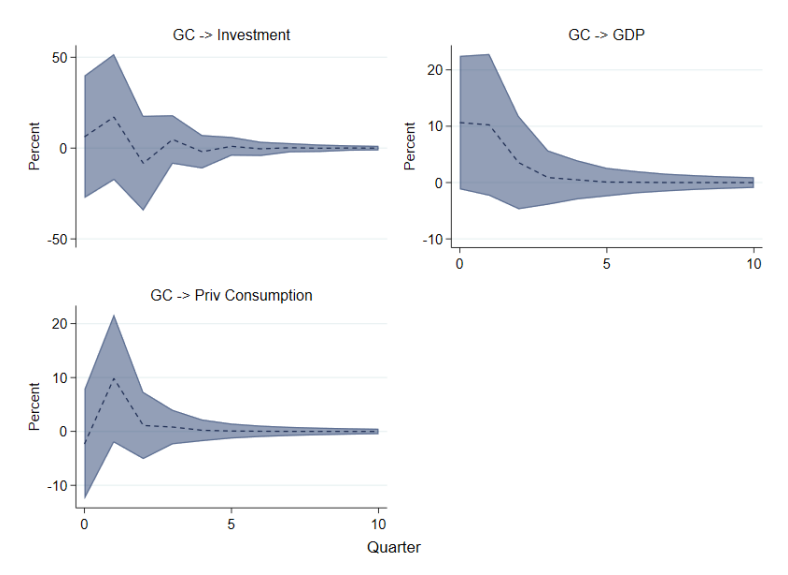

Figure 20: Impulse Response Function (Experiment 3 – Fiscal Shock and Low Uncertainty - PVAR Europe). Source: Authors' calculations.

5 DSGE Model

Next, we extend the model by Basu and Bundick (2017) by incorporating fiscal instruments. We included the tax on labor income and changed the utility function to accommodate the interaction between public and private consumption. Therefore, we can verify the changes caused by a distortionary tax, and the sensitivity of the economy to different configurations of the relationship between private and public consumption. Furthermore, we verify the adherence of the theoretical model to the empirical results, where the fiscal stimulus has positive impacts on economic activity, while shocks of uncertainty have adverse effects.

This section outlines the DSGE model to achieve two goals. First, we examine the ability of macroeconomic models to generate the co-movement of macroeconomic aggregates in response to uncertainty shocks, in line with empirical results and literature. Second, we investigate how our theoretical model reacts to an increase in public consumption (with different configurations) and uncertainty, as analyzed in the previous section. The model features optimizing consumers, firms and monetary authority that follows a Taylor rule to stabilize output and consumer prices. We admit the existence of sticky prices and use the specification of Rotemberg (1982). In our model, we consider that the discount rate of households is affected by shocks of uncertainty (time-varying second moment), signalling the influence of uncertainty on future demand.

We use higher order approximations[22], in this case of third order, because we are interested in the dynamic effects of second moment shocks (shocks to the variance of a shock). The intuition of this effect is associated with the impacts of risk aversion and precaution, central elements of our model. If the second derivative of the utility function is negative, we perceive that the agents are not attracted by risk, but to understand the reaction to risk, we depend on the third derivative of utility. Therefore, if the result is positive, households have an intense response, increasing savings. The impact of uncertainty and the reactions of agents, under different configurations, will be analyzed in the following sections.

5.1 Households

Consumers maximize lifetime utility, regarding the flow of consumption and leisure, subject to intertemporal household budget.

$$V_t = \max \left[a_t \left(\left(C_t^p + \Omega . GC_t \right)^{\eta} \left(1 - N_t \right)^{1-\eta} \right)^{\frac{1-\sigma}{\sigma_V}} + \beta \left(E_t V_{t+1}^{1-\sigma} \right)^{\frac{1}{\theta_V}} \right]^{\frac{\theta_V}{1-\sigma}} \tag{5}$$

[22] To solve the models, Dynare will use higher order perturbations (third order approximations).

$$CP_t + GC_t + \frac{P_t^E}{P_t} S_{t+1} + \frac{1}{R_t^R} B_{t+1} \leq \frac{W_t}{P_t} N_t (1-t) + \left(\frac{D_t^E}{P_t} + \frac{P_t^E}{P_t} \right) S_t + B_t \tag{6}$$

We developed a formulation of Epstein-Zin (EZ) preferences and recursive utility. The choice for EZ is related to the fact that we adjust the model to the financial market data (Basu and Bundick, 2017). Backus et al. (2004), are optimistic in the use of exotic preferences, such as EZ, since have become a frequent source of insights for the perception of behavioral economics, especially on topics such as asset pricing and precautionary saving. Furthermore, two aspects of preferences are highlighted: risk aversion of households (σ) and intertemporal substitution (ψ). Therefore, θ_v governs consumers' solution concerning uncertainty.

The utility function was adjusted to accommodate the relationship between private consumption (C^P) and public consumption (GC). Where Ω measures the contribution of public spending to the marginal utility of consumption.

5.2 Government

We admit that the government achieves budgetary balance in each period. Moreover, the tax on labor income (t) and public consumption (GC_t) are determined exogenously by the parameters t and ζ, respectively. The final public consumption is defined as a fraction of steady-state output.

$$GC_t = \zeta . GDPss \tag{7}$$

We admit Transfers (T) as a residual value, which assumes a value to satisfy the government's budget constraint.

Optimization

The solution recursively defined between the present consumption and a certainty equivalent of random utility is distinguished from other configurations that assume the optimization occurs within one period. Therefore, a time series path is a series of utility maximization over a period. On the other hand, a recursive approach involves two or more periods, and a time series path is the result of a series of decisions from more than one period. In our model, households obtain the resources through the income from labor and the return of the portfolio, composed of shares and bonds (risk-free). These resources are allocated to consumption and investments.

The maximization of the consumer's decision implies the following first order conditions

(FOC).

$$\frac{\partial V_t}{\partial C_t} = \frac{\theta_v}{(1-\sigma)} V_t^{\frac{(1-\sigma)}{\theta_v}\frac{\theta_v}{(1-\sigma)}-1} \frac{(1-\sigma)}{\theta_v} a_t \eta \frac{\left((C_t^P - \Omega CG_t)^\eta (1-N_t)^{1-\eta}\right)^{(1-\sigma)/\theta_v}}{(C_t^P - \Omega.CG_t)} = \lambda_t \tag{8}$$

$$\lambda_t = a_t V_t^{1-(1-\sigma)/\theta_v} \eta \frac{\left((C_t^P - \Omega.CG_t)^\eta (1-N_t)^{1-\eta}\right)^{(1-\sigma)/\theta_v}}{(C_t^P - \Omega CG_t)}$$

Therefore, we define the marginal utility of wealth, denoted by λ_t.

$$\frac{\partial V_t}{\partial N_t} = a_t V_t^{1-(1-\sigma)/\theta_v}(1-\eta) \frac{\left(C_t^\eta (1-N_t)^{1-\eta}\right)^{(1-\sigma)/\theta_y}}{(1-N_t)} = \lambda_t \frac{W_t}{P_t}(1-t) \tag{9}$$

Using the equations 7 and 8, we obtain:

$$\frac{W_t}{P_t} = \frac{C_t(1-\eta)}{(1-N_t)\eta(1-t)} \tag{10}$$

As previously highlighted, the Epstein-Zin function uses a stochastic discount factor M_{t+s} between two moments.

$$M_{t+s} = \left(\frac{\partial V_t/\partial C_{t+s}}{\partial V_t/\partial C_t}\right) = \left(\beta^s \frac{a_{t+s}}{a_t}\right)\left(\frac{C_t}{C_{t+s}}\right)\left(\frac{C_{t+s}^\eta (1-N_{t+s})^{1-\eta}}{C_t^\eta (1-N_t)^{1-\eta}}\right)^{\frac{1-\sigma}{\partial V}}\left(\frac{V_{t+s}}{E_t\left[V_{t+s}^{1-\sigma}\right]}\right)^{1-\frac{1}{\partial V}} \tag{11}$$

Still using the FOC results, through the Lagrangian approach, we obtain Euler's equations for equity risk-free firm shares (equity return) and bonds for a period, respectively.

$$\frac{P_t^E}{P_t} = E_t\left\{M_{t+1}\left(\frac{D_{t+1}^E}{P_{t+1}} + \frac{P_{t+1}^E}{P_{t+1}}\right)\right\} \tag{12}$$

$$1 = R_t^R E_t\left\{M_{t+1}\right\} \tag{13}$$

To gain intuition, the effect on the welfare of consumers will depend on the parameter Ω and the role of GC in the aggregate fluctuations, in the labor market and economic

activity.

When Ω is equal to the unit, the total consumption and welfare level will not be changed. In this case, the utility of goods and services produced by the government is the same as that generated by private goods. The only input channel for GC is in the constraint with the sum $C^P + GC$. Thus, exogenous shocks for GC induce the exchange of a unit of GC for one of C^P, leaving GDP and number of hours worked unchanged, as in the classic RBC models.

When this parameter is less than the unit (positive), public consumption harms the level of welfare. Therefore, the impact of an increase in public spending generates a negative income effect, which induces agents to increase their labor supply and decrease their private consumption (Aiyagari, Christiano and Eichenbaum, 1992; Baxter and King, 1993). For $\Omega = 0$ government consumption is simply a drain on resources. Private agents respond as a reduction in their wealth, although they have not suffered a reduction in utility. Thus, increases in CG are associated with increases in the number of hours worked.

Finally, for $\Omega < 0$, the increase in public spending and services has a complementary relationship with private consumption and, therefore, an increase in GC increases private consumption, stimulating hours worked and output. This type of response is in line with the Brazilian case, previously analyzed. Thus, the presence of the government in the economy, as well as the category of public goods and services (education, defense or health) can assist in the calibration of the model.

5.3 Productive Sector

In our model, we consider the imperfect competition, with interactions in the structure of the productive sector of the economy. There are two types of firms in the model. The first operates in an environment of monopolistic competition, where producers face a quadratic cost of changing their price. The second category of firms aggregates the products to form a final good, in an environment of perfect competition.

5.3.1 Firms (Intermediate Goods)

In addition to the cost of adjusting prices, firms in the intermediate sector have (convex) costs when deciding to change the amount of installed capital. They decide what rate of capital to use for each period (U_t), which affects the depreciation of assets. To finance operations, firms issue S_t shares and risk-free bonds of a B_t period. Therefore, in addition to the connection through the labor market, households maintain a connection through the acquisition of financial assets. This link is critical in the transmission of future uncertainty, after an uncertainty shock.

Each firm produces differentiated goods, but they are faced with the same configuration of the Cobb-Douglas production function (constant returns to scale), given a fixed cost. The objective function to be optimized by firms is discounted cash flows (D_t), and they decide the amount of labor (N_t), investment (I_t), the utilization rate (U_t) and the price (P_t), given the production of the final good and its price. The cash flow produced is discounted at the households' stochastic discount rate.

$$\max E_t \sum_{s=0}^{\infty} M_{t+s} \left[\frac{D_{t+s}(i)}{P_{t+s}} \right] \tag{14}$$

Where D_t is the discounted cash flows:

$$\frac{D_t(i)}{P_t} = \left[\frac{P_t(i)}{P_t} \right]^{1-\theta_\mu} Y_t - \frac{W_t}{P_t} N_t(i) - I_t(i) - \frac{\phi_P}{2} \left[\frac{P_t(i)}{\Pi P_{t-1}(i)} - 1 \right]^2 Y_t \tag{15}$$

The expression $\phi_P/2 \left[\frac{P_t(i)}{\Pi P_{t-1}(i)} - 1 \right]^2 Y_t$ is Rotemberg cost definition and the optimization is subject to the following restrictions:

Production function:

$$\left[\frac{P_t(i)}{P_t} \right]^{-\theta_\mu} Y_t \leq \left[K_t(i) U_t(i) \right]^{\alpha} \left[N_t(i) \right]^{1-\alpha} - \Phi \tag{16}$$

Capital accumulation:

The capital stock follows the law of motion

$$K_{t+1}(i) = \left(1 - \delta\left(U_t(i)\right) - \frac{\phi_K}{2} \left(\frac{I_t(i)}{K_t(i)} - \delta \right)^2 \right) K_t(i) + I_t(i) \tag{17}$$

Where, $\left[\frac{P_t(i)}{P_t} \right]^{-\theta_\mu} Y_t$ is the demand for intermediate goods (link with the final goods sector). It is decreasing in relation to relative prices and growing in reaction to the production of the final good. Φ represents the fixed cost, ϕ_k is the adjustment cost to changing investment and ϕ_P is the adjustment cost to changing prices.

As mentioned, the depreciation rate is affected by the chosen amount of capital.

$$\delta\left(U_t(i)\right) = \delta + \delta_1 \left(U_t(i) - U \right) + \left(\frac{\delta_2}{2} \right) \left(U_t(i) - U \right)^2 \tag{18}$$

In this sense, each firm decides according to the following FOCs:

Labor FOC

$$\frac{W_t}{P_t} N_t(i) = (1-\alpha) mc_t \left[K_t(i) U_t(i)\right]^{\alpha} \left[N_t(i)\right]^{1-\alpha} \tag{19}$$

Capital FOC

$$\frac{R_t^K}{P_t} U_t(i) K_t(i) = \alpha mc_t \left[K_t(i) U_t(i)\right]^{\alpha} \left[N_t(i)\right]^{1-\alpha} \tag{20}$$

Utilization FOC

$$q_t \delta'\left(U_t(i)\right) U_t(i) K_t(i) = \alpha mc_t \left[K_t(i) U_t(i)\right]^{\alpha} \left[N_t(i)\right]^{1-\alpha} \tag{21}$$

mc_t is the marginal cost and q_t is the value of the additional unit of installed capital (Tobin's Q).

Pricing FOC

$$\begin{aligned} \phi_P \left[\frac{P_t(i)}{\Pi P_{t-1}(i)} - 1\right] \left[\frac{P_t}{\Pi P_{t-1}(i)}\right] = \left(1-\theta_\mu\right) \left[\frac{P_t(i)}{P_t}\right]^{-\theta_\mu} + \theta_\mu \Xi_t \left[\frac{P_t(i)}{P_t}\right]^{-\theta_\mu - 1} \\ + \phi_P E_t \left\{ M_{t+1} \frac{Y_{t+1}}{Y_t} \left[\frac{P_{t+1}(i)}{\Pi P_t(i)} - 1\right] \left[\frac{P_{t+1}(i)}{\Pi P_t(i)} \frac{P_t}{P_t(i)}\right] \right\} \end{aligned} \tag{22}$$

$$\begin{aligned} q_t = E_t \left\{ M_{t+1} \left(U_{t+1}(i) \frac{R_{t+1}^K}{P_{t+1}} + q_{t+1} \left(1 - \delta\left(U_{t+1}(i)\right) - \frac{\phi_K}{2} \left(\frac{I_{t+1}(i)}{K_{t+1}(i)} - \delta \right)^2 \right.\right.\right. \\ \left.\left.\left. + \phi_K \left(\frac{I_{t+1}(i)}{K_{t+1}(i)} - \delta \right) \left(\frac{I_{t+1}(i)}{K_{t+1}(i)} \right) \right) \right) \right\} \end{aligned} \tag{23}$$

FOC investment

$$\frac{1}{q_t} = 1 - \phi_K \left(\frac{I_t(i)}{K_t(i)} - \delta \right) \tag{24}$$

The number of B_t for each firm is equal to leverage (ν) multiplied by K_t. Accordingly, cash flows are distributed among bond and shareholders. Therefore, dividends can be defined as:

$$\frac{D_t^E(i)}{P_t} = \frac{D_t(i)}{P_t} - \nu \left(K_t(i) - \frac{1}{R_t^R} K_{t+1}(i) \right) \tag{25}$$

In the equilibrium, the system identifies the behavior of a single representative intermediate good producer (Rotemberg's assumption). Therefore, there is a convergence of values for hours worked, capital, level of utilization, as well as a single markup (μ) = 1 / mc_t.

An interesting solution that we can obtain for the expression of the marginal cost is obtained from the FOC (Labor and Capital) and replacing in the production function.

$$\mathrm{N}_{i,t} = mc_t(1-\alpha)\frac{Y_{i,t}}{W_t}$$

$$\mathrm{K}_{i,t} = mc_t\alpha\frac{Y_{i,t}}{R_t}$$

$$\mathrm{W}_t N_{i,t} = R_t K_{i,t}\frac{(1-\alpha)}{\alpha}$$

$$\mathrm{Y}_{i,t} = \left(cm_t\alpha\frac{Y_{i,t}}{R_t}\right)^{\alpha}\left(mc_t(1-\alpha)\frac{Y_{i,t}}{W_t}\right)^{1-\alpha}$$

$$\mathrm{Y}_{i,t} = mc_t\alpha^{\alpha}(1-\alpha)^{1-\alpha}R_t^{-\alpha}W_t^{\alpha-1}Y_{i,t}$$

$$\mathrm{mc}_t = \left(\tfrac{1}{\alpha}\right)^{\alpha}\left(\tfrac{1}{1-\alpha}\right)^{1-\alpha}R_t^{\alpha}W_t^{1-\alpha}$$

Therefore, the marginal cost, and the markup, do not depend on each firm, but they are the same for all producers of intermediate goods.

5.3.2 Firms (Final Goods)

The firm that produces the final goods and services (constant returns to scale), from units of the intermediate goods, seek to maximize profits, where the price of the intermediate good is known. The final goods sector is competitive, generating pure gains equal to zero (zero-profit condition).

$$P_t Y_t - \int_0^1 P_t(i)Y_t(i)di \tag{26}$$

As a result of FOC, the demand for intermediate goods is decreasing in relation to relative prices and growing in reaction to the production of the final good.

$$Y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\theta_\mu} Y_t \tag{27}$$

And the price is defined as:

$$P_t = \left[\int_0^1 P_t(i)^{1-\theta_\mu}di\right]^{\frac{1}{1-\theta_\mu}} \tag{28}$$

5.4 Monetary Authority

The Central Bank follows the Taylor rule is described below.

$$Ln(R_t) = \rho_r Ln(R_{t-1}) + (1-\rho_r)\left(Ln(R) + \rho_\pi\left(Ln(\Pi_t) - Ln(\Pi)\right) + \rho_y Ln(Y_t/Y_{t-1})\right) \tag{29}$$

Finally, the equation for a nominal bond (zero-net supply) in equilibrium:

$$1 = R_t E_t \left\{ M_{t+1} \left(\frac{1}{\Pi_{t+1}} \right) \right\} \tag{30}$$

5.5 Shocks

Uncertainty

In our model, we use uncertainty shocks with an ex-ante concept. Following Basu and Bundick (2017), we discipline our model and uncertainty shock process consistent with the behavior of the observable measure of aggregate uncertainty (VIX). To connect the model to observable volatility, we calculate the index in the model as the expected volatility of the return on equity of producers of intermediate goods.

Using the result (equation 11), we define the return on equity, calculate the variance and annualized the result for quarterly data. Next, we transformed the annual volatility units into percentage points.

$$R^E_{t+1} = \frac{D^E_{t+1} + P^E_{t+1}}{P^E_t} \tag{31}$$

$$Var_t \left\{ R^E_{t+1} \right\} = E_t \left\{ \left(R^E_{t+1} \right)^2 \right\} - \left(E_t R^E_{t+1} \right)^2 \tag{32}$$

$$V_t = \sqrt{4.VAR_t \left\{ R^E_{t+1} \right\}}.100 \tag{33}$$

The objective is to identify the effects of (independent) variations in volatility in the shock process on households' preferences. We parameterize as follows:

$$a_t = (1 - \rho_a)\, a + \rho_a a_{t-1} + \sigma^a_{t-1} \varepsilon^a_t \tag{34}$$

$$\sigma^a_t = (1 - \rho_{\sigma^a})\, \sigma^a + \rho_{\sigma^a} \sigma^a_{t-1} + \sigma^{\sigma^a} \varepsilon^{\sigma^a}_t \tag{35}$$

The shocks are defined independently and follow a standard normal distribution, and ε^a_t represents the shock of the first moment and describes the innovations of the stochastic process (level). $\varepsilon^{\sigma^a}_t$ reflects the second moment or what we are interested in evaluating as an "uncertainty" shock. It depicts innovations for the volatility of exogenous processes, affecting the trajectory of consumer decisions. Associated with the shocks of uncertainty, we can add shocks from a stochastic process to government consumption as described in McGrattan et al. (1997) and Tchakarov and Straub (2007).

5.6 Calibrated Parameters

Whenever possible, we use the Basu and Bundick (2017) calibration and for the remaining parameters we use the related literature (table 6). In particular, we use government consumption information from Barro (1981) and Evans and Karras (1996) and McGrattan et al. (1997). However, the values for the GC/GDP ratio, as well as the model used in the simulations (AR1), were estimated from data from the United States economy. For the tax income labor, we use Torres (2009).

The elasticity of output with respect to labor (1-α) is equal to 2/3. The Uncertainty resolution preference, governed by the parameter θ_v, which is set to $(1/\beta)$ -1 + δ, as in Basu and Bundick (2017). The effect of public spending on the marginal utility of consumption parameter (Ω) is equal to 0.025 (baseline), but we conducted different simulations to assess the effect on the key variables of the economy. Hence, it is possible to verify different effects on household consumption in the presence or absence of uncertainty shocks.

5.7 Results

In this section, we discuss the results of the DSGE model simulations and their implications.

We designed three experiments. First, we examine the influence of uncertainty shocks on macroeconomic aggregates and compare the results with those obtained in the empirical models for the United States. Subsequently, a sensitivity analysis of the theoretical model was performed, with changes in the assumptions about flexible prices and risk aversion.

Second, we compared the results of a shock on public consumption (baseline DSGE model) with empirical findings (the United States) and then We examine the sensitivity of responses to different parameter settings that measure the impact of government spending on the marginal utility of consumption (Ω).

The third experiment combines the effects of an uncertainty shock and government consumption. Hence, we can test the hypothesis that the fiscal stimulus is mitigated in the presence of higher uncertainty. As in previous experiments, we compare the result with the empirical results.

5.7.1 First Experiment - Uncertainty Shocks

Figure 21 describes the responses of macroeconomic aggregates to an uncertainty shock. The solid line is the result of the DSGE model, while the dashed line is derived from the empirical model for the United States. Based on the literature and our empirical results, we argue that the co-movement of economic variables can be verified in the responses of the theoretical model.

Table 6: Baseline Calibration

Description	Parameter	Calibration	Source
Household Discount Factor	β	0.994	Basu and Bundick (2017)
Steady State Depreciation Rate	δ	0.025	Basu and Bundick (2017)
Household Risk Aversion	σ	80	van Binsbergen et al. (2012); Basu and Bundick (2017)
Intertemporal Elasticity of Substitution (IES)	ψ	0.8	Basu and Kimball (2002),
Consumption Weight in Period Utility Function	η	0.32	Basu and Bundick (2017)
Uncertainty resolution preference	Θ_v	$(1-\sigma)/(1-1/\psi)$	Basu and Bundick (2017)
Capital's Share in Production	α	0.333	Basu and Bundick (2017)
First-Order Utilization Parameter	δ_1	$(1/\beta) -1 + \delta$	Basu and Bundick (2017)
Second-Order Utilization Parameter	δ_2	0.01	Fernandez-Villaverde et al. (2013)
Adjustment Cost to Changing Investment	ϕk	10	van Binsbergen et al. (2012); Basu and Bundick (2017)
Adjustment Cost to Changing Prices	ϕp	100	Basu and Bundick (2017); Ireland (2003)
Inflation Rate (Steady State)	π	1.005	Basu and Bundick (2017)
Effect of public spending on the marginal utility of consumption	Ω	0.025	Barro (1981); Karras and Evans (1996)
Government Consumption (% GDP)	ζ	0.15	McGrattan et al. (1997); Torres (2009)
Tax (Income Labour)	t	0.225	Torres (2009)
Central Bank Interest Rate Smoothing Coeficient	ρ_r	0.5	Basu and Bundick (2017)
Monetary Authority Reaction (Inflation)	ρ_π	1.5	Basu and Bundick (2017)
Monetary Authority Reaction (GDP Growth)	ρ_y	0.5	Basu and Bundick (2017)
Elasticity of Substitution Intermediate Goods	Θ_μ	6	Basu and Bundick (2017)
Firm Leverage	ν	0.9	Basu and Bundick (2017)
1st Moment Preference Shock Persistence	ρ_a	0.9	Basu and Bundick (2017)
Volatility of Preference Shock (Steady-State)	σ^a	0.03	Basu and Bundick (2017)
2nd Moment Preference Shock Persistence	$\rho_{\sigma a}$	0.7	Basu and Bundick (2017)
Volatility of Second Moment Preference Shocks	$\sigma^{\sigma a}$	0.005	Basu and Bundick (2017)
Frisch labour supply elasticity (Steady-State)		2	Basu and Bundick (2017)

Source: Authors' calculations.

The shock causes a decrease in economic activity (GDP), hours worked, private investment, and consumption. It is possible to identify the co-movement, described in the literature, with the peak reaction occurring after the fourth quarter. We emphasize that the lowest investment value is more than twice the reduction in GDP and household consumption, indicating a potential uncertainty transmission mechanism, as described by the Real Options approach. As in the empirical model, two years after the shock, the effects are practically null.

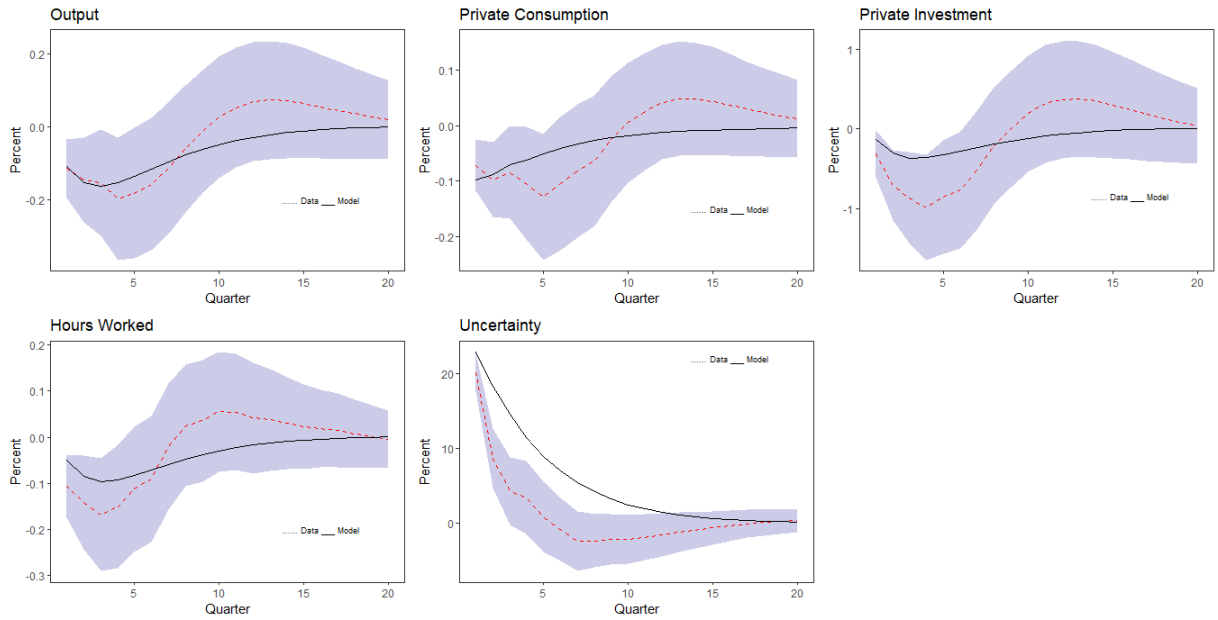

Figure 21: Impulse Response Functions - DSGE and VAR (Uncertainty Shock). Source: Authors' calculations.

The intuition is that after the initial shock of uncertainty, households consume less and increase savings, due to precaution and risk aversion. Furthermore, they increase the labor supply and seek to accumulate more assets. The presence of an intermediate sector (differentiated products), nominal price rigidity and increase in labor supply decrease the marginal costs of firms (intermediate goods) that can increase the markup. In turn, the higher markup reduces the demand for labor and reduces real wages and investment in capital stock. As a result, we see the combined effect of macroeconomic aggregates.

To assess the effect of price flexibility, we eliminate the assumption of price rigidity and set the parameter ϕ_p equal to zero. Figure 22 displays dynamic effects under the condition of flexible prices. The connections described above are no longer verified, altering the balance in the labor market, as well as other decisions. Now, the results are quite different and the co-movement cannot be verified, as highlighted by Basu and Bundick (2017).

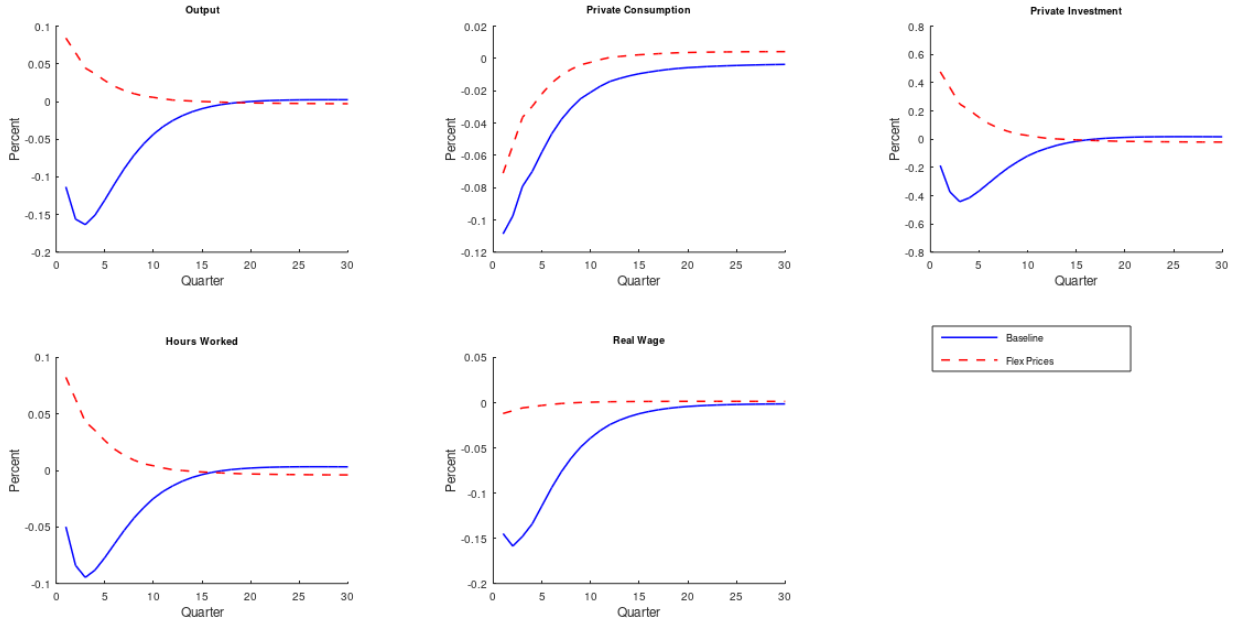

Figure 22: Impulse Response Functions - DSGE (Uncertainty Shock: baseline and Flexible Prices). Source: Authors' calculations.

Finally, we examine the economy's sensitivity after reducing risk aversion (σ) from 80 (van Binsbergen et al.,2012; Basu and Bundick, 2017) to 30 (Basu and Bundick, 2017). The adjustment in the risk aversion parameter directly affects consumers' choices and influenced the decisions between leisure and labor.

Figure 23 highlights that the responses of the output and other economic aggregates are noticeably less intense to the shock of uncertainty.

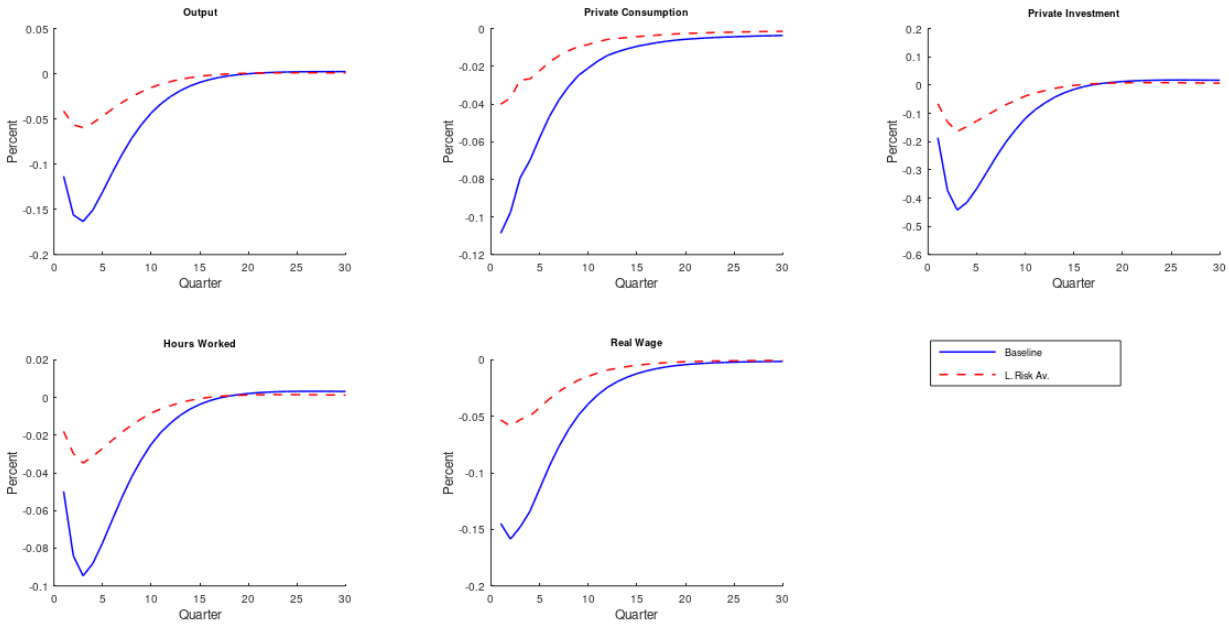

Figure 23: Impulse Response Functions - DSGE (Uncertainty Shock: Risk Aversion). Source: Authors' calculations.

5.7.2 Second Experiment - Fiscal Stimulus

In our model, public consumption is exogenous, defined as a fraction (ζ) of GDP (15%). In this subsection, we investigate the response of an increase in ζ (Fiscal Shock) on output, labor, investment, private consumption, and real wage. We compared the responses of the theoretical model and the impulses generated by the empirical models. Finally, we examine the responses of the empirical model with three different configurations for the relationship between public and private consumption.

Empirical simulations point to a positive (significant) impact of government consumption on the level of economic activity. The projection of the calibrated model (baseline) has a similar direction and is within the 95% confidence interval. For private investment, the fiscal shock has an adverse effect, as indicated in the theoretical model and empirical results. With regard to household consumption, the theoretical model indicates a negative impact, while the data show a positive stimulus. This divergence can be attributed to the value of the parameter ω, which governs the relationship between public and private consumption. Using another calibration we can achieve results closer to those of the empirical model and will be analyzed below.

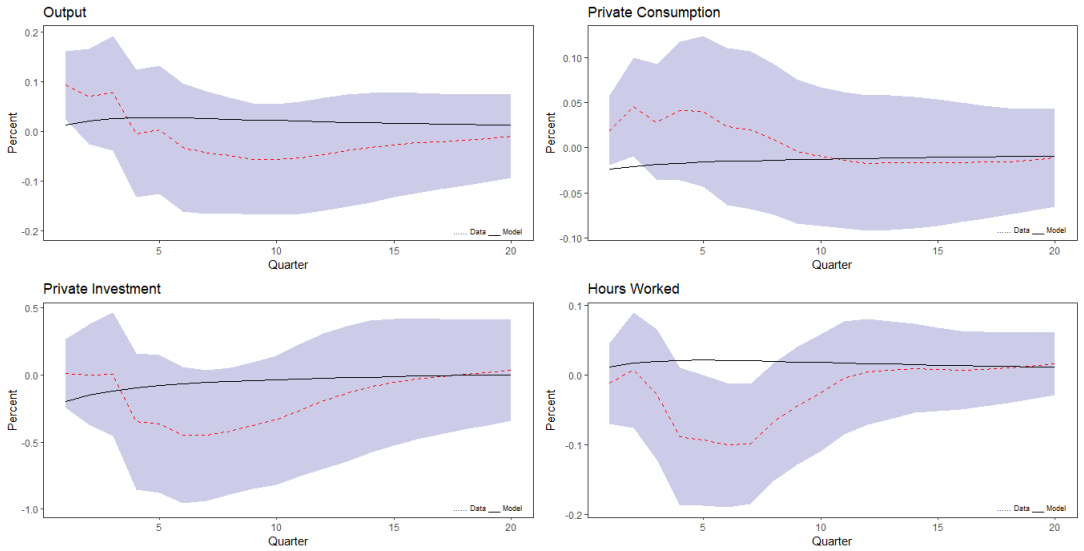

Figure 24: Impulse Response Functions - DSGE and VAR (Fiscal Shock). Source: Authors' calculations.

The following figure highlights three different configurations for the relationship between government consumption and private consumption, that is, Ω=0.025 (substitutes - baseline), Ω=-0.025 (complementary), and Ω=0.5 (substitutes). In the three simulations, GDP and hours worked are stimulated, and an inverse result for private consumption, real wages and investment, indicating a potential crowding-out effect. However, we emphasize that the relationship between the role of government consumption and households significantly alters the economic dynamics and the persistence of the shock[23].

[23] We did not highlight the perfect substitution configuration (Ω = 1) with a finding similar to a classic RBC model. In this case, an increase in government consumption leads to a symmetrical reduction in the consumption of private goods and services. Therefore, there is no influence on hours worked, private investment and production.

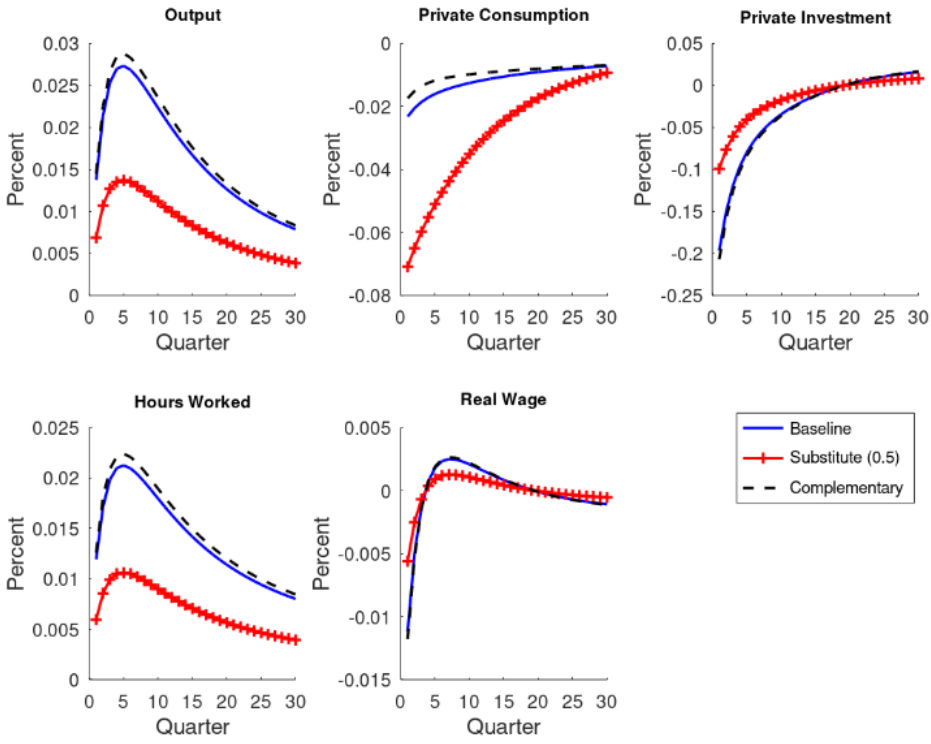

Figure 25: Impulse Response Functions - DSGE: Fiscal Stimulus - Stochastic Simulation - Ω. Source: Authors' calculations.

Our findings are in line with the pattern of behavior found in the empirical results of the economies investigated in section 4, except for private consumption. In this case, it is important to note that economic differences and the role of the government may explain this inaccuracy in the results. These results are supported by some authors such as Fiorito and Kollintzas (2004). They investigated the effects of public consumption for 12 European countries. The findings suggest that "public goods", such as justice and defense, have a substitution relationship, while health and education indicate a complementary association with private consumption.

Unfortunately, World Bank data are not continuous for all years, but with regard to government expenditure on education (% GDP), Brazil spent 5.95%, while European Union and the United States spent 5.28% and 4.96%, respectively (2014)[24]. On the other hand, Brazil spent 1.33% on military expenditure, while the United States spent 3.48%, corresponding to approximately 10% of general government expenditures, while Brazil 3.5%[25].

Specifically in the Brazilian case, the government has a relevant participation in sectors where the private sector also operates, such as infrastructure, health and education. Pub-

[24]https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?end=2016locations=BR-US-XCstart=2001view=chart

[25]https://data.worldbank.org/indicator/MS.MIL.XPND.GD.ZS?end=2016locations=BR-USstart=2014

lic spending on education and health exceeds defense spending, with an average annual proportion (2000-2019) equal to 1.36 for education and 2.12 for health[26].

5.7.3 Third Experiment - Fiscal Stimulus under High Uncertainty

The last experiment simulates a simultaneous shock to government consumption and uncertainty.

To achieve this goal, we first redefined the equation that characterizes government consumption behavior. Despite remaining exogenous, the parameter ζ assumes a random behavior, where $\overline{\zeta}$ and ρ_{ζ} are equal to Steady State and 0.923, respectively[27].

$$\zeta_t = \left(1-\rho_{\zeta}\right)\overline{\zeta} + \rho_{\zeta}\,\zeta_{t-1} + \sigma_{t-1}^{\zeta}\varepsilon_t^{\zeta} \tag{36}$$

$$a_t = (1-\rho_a)\,a + \rho_a a_{t-1} + \sigma_{t-1}^{a}\varepsilon_t^{a} \tag{37}$$

$$\sigma_t^a = (1-\rho_{\sigma^a})\,\sigma^a + \rho_{\sigma^a}\sigma_{t-1}^a + \sigma^{\sigma^a}\varepsilon_t^{\sigma^a} \tag{38}$$

Figure 26 displays the three effects. The blue solid line highlights the impact derived from a government consumption shock. The red dotted line indicates the effects of the uncertainty shock, as described in the baseline model. The black dashed line represents a simultaneous shock (government consumption and uncertainty) equal to one standard deviation.

[26] Time series of central government public expenditure. https://www.tesourotransparente.gov.br/publicacoes/desmentos-da-uniao-series-historicas/2019/11?ano$_s elecionado = 2020$

[27] The econometric model was estimated for the United States (see appendix).

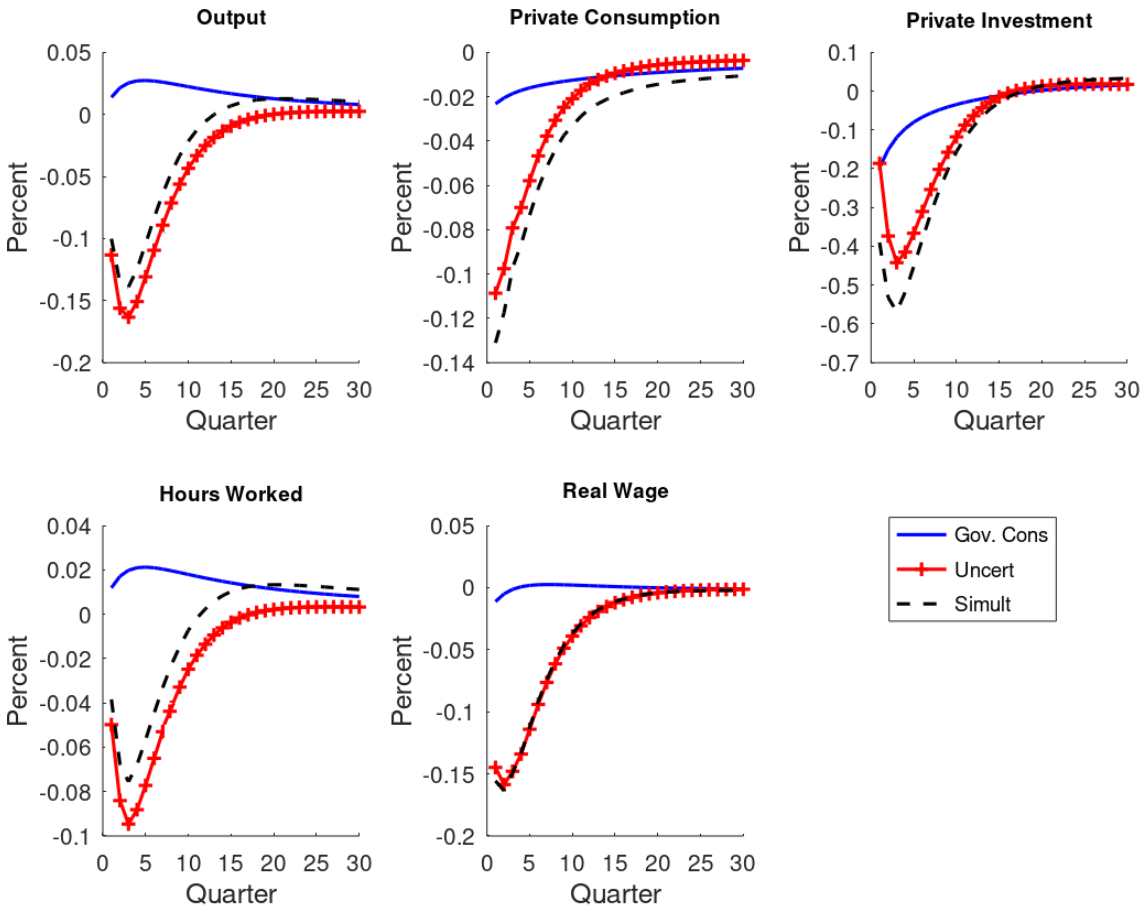

Figure 26: Impulse Response Functions - DSGE: Stochastic Simulation: Government Consumption, Uncertainty and Simultaneous Shock). Source: Authors' calculations.

Finally, we examine the results of the model with simultaneous shock with those obtained in the experiment of increasing public consumption in a scenario of high uncertainty.

The following set of graphs highlights the dynamics of economic variables after a shock to government consumption and uncertainty. We observed that both in the theoretical model (solid line) and in the empirical data (dashed line), the economic activity has an attenuated or adverse reaction after the shock. Except for private consumption, the simulations of the theoretical model adhere to those of the empirical model.

Therefore, our findings suggest that the effect resulting from a simultaneous shocks mitigates the effectiveness of stimulating public spending on economic activity, as indicated by the empirical results.

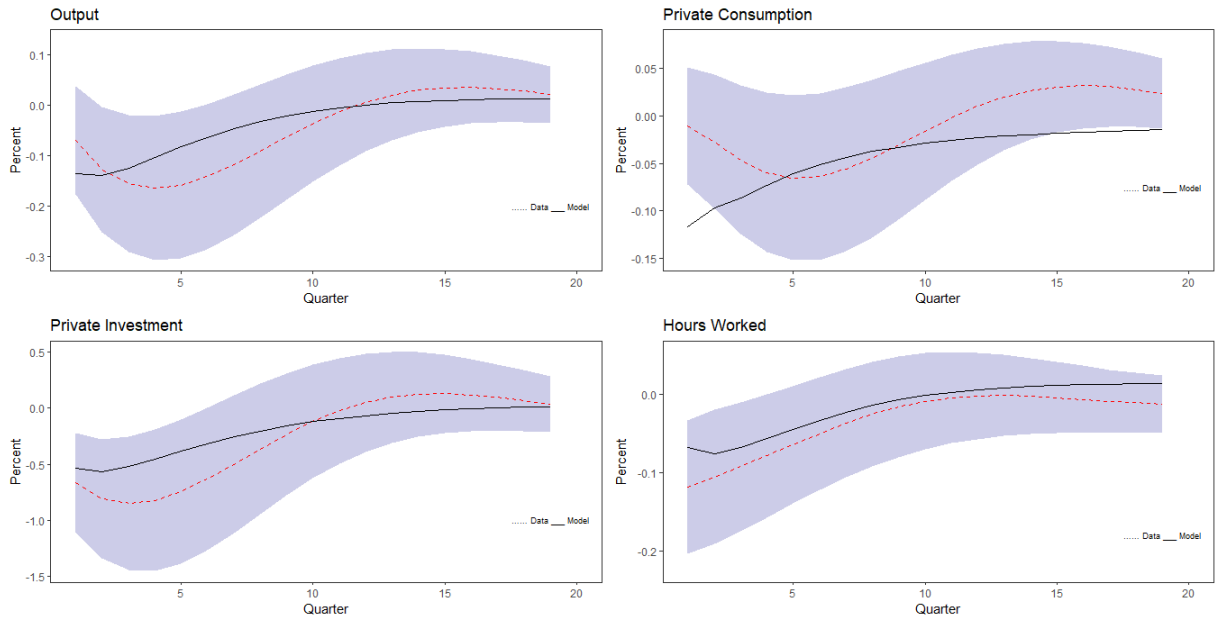

Figure 27: Impulse Response Functions - DSGE and data: Stochastic Simulation: Government Consumption, Uncertainty and Simultaneous Shock). Source: Authors' calculations.

6 Conclusion

This paper investigated how government consumption and uncertainty shocks affect the main macroeconomic aggregates, individually and simultaneously. To develop this analysis, six experiments were used, three empirical and three theoretical. The empirical results indicated that the uncertainty shocks (VIX) reduce output, hours worked, consumption and private investment (co-movement), aligned with different papers, such as Basu and Bundick (2017). Regarding the increase in government spending, the models pointed to an increase in economic activity, household consumption (statistically significant only for Brazil) and a reduction in private investment (crowding-out). The increase in public consumption, associated with moments of high uncertainty, mitigates the positive effects on the economy.

The theoretical baseline model indicated (first experiment), that uncertainty disrupts the decisions of private agents. With regard to fiscal stimulus (government consumption), we observed an increase in economic activity, maintaining the pattern described in the literature.

We performed sensitivity analyzes for three parameters: risk aversion (σ), the effect of public consumption on utility (Ω) and price rigidity (ϕp). Thus, the analysis confirmed that the relative price rigidity is an important part that affects the marginal cost, markup and allows the reduction of the aggregates, after uncertainty shocks. Moreover, σ confirmed to have a key role, because depending on the perception of the agents, the de-

mand shocks on the economy may be less intense, not inducing the co-movement among macroeconomic aggregates. In a future study, this configuration could be investigated with heterogeneous agents.

We simulate different government profiles by changing the values of the Ω parameter. Therefore, it was possible to "replicate" different economies where public goods and services have a complementary relationship to goods provided by the private sector.

In the third experiment, we redesigned our baseline model and included two modifications. First, we transform the parameter ζ into a lagged random variable. Second, we added an exogenous shock to affect simultaneously government consumption and uncertainty. The findings indicated that the fiscal effect is dissipated, when it occurs simultaneously with a shock of uncertainty, corroborating the empirical results.

Different avenues of investigation are still possible, beyond the scope of this paper. First, we can expand the model and consider two types of agents, Ricardian and non-Ricardian. Thus, we examine the impact of uncertainty on only one category of agents or both. Furthermore, we can analyze the impact of the income distribution between the two categories of agents, after a fiscal shock or macroeconomic uncertainty. Second, analyze a new measure to estimate the effect of macroeconomic uncertainty. Perhaps a proxy that is not associated with the financial market.

7 References

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A Appendix

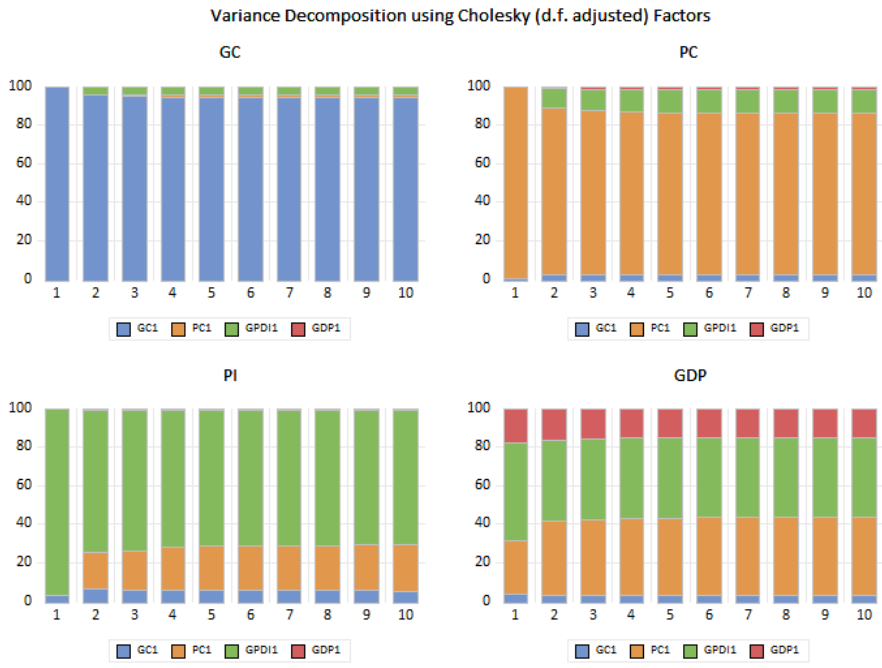

Figure A28: Variance Decomposition (Experiment 1 Gov Spending USA). Source: Authors' calculations.

Figure A29: Variance Decomposition (Experiment 1 Gov Spending USA). Source: Authors' calculations.

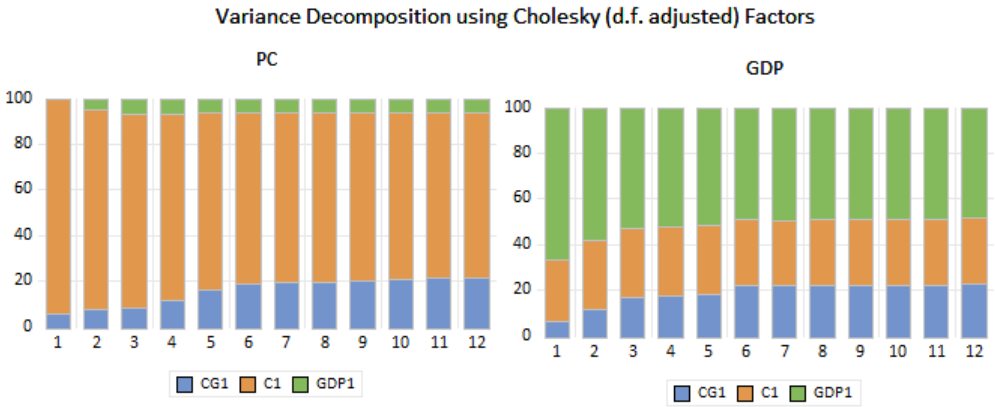

Figure A30: Variance Decomposition (Experiment 1 Gov Spending Brazil). Source: Authors' calculations.

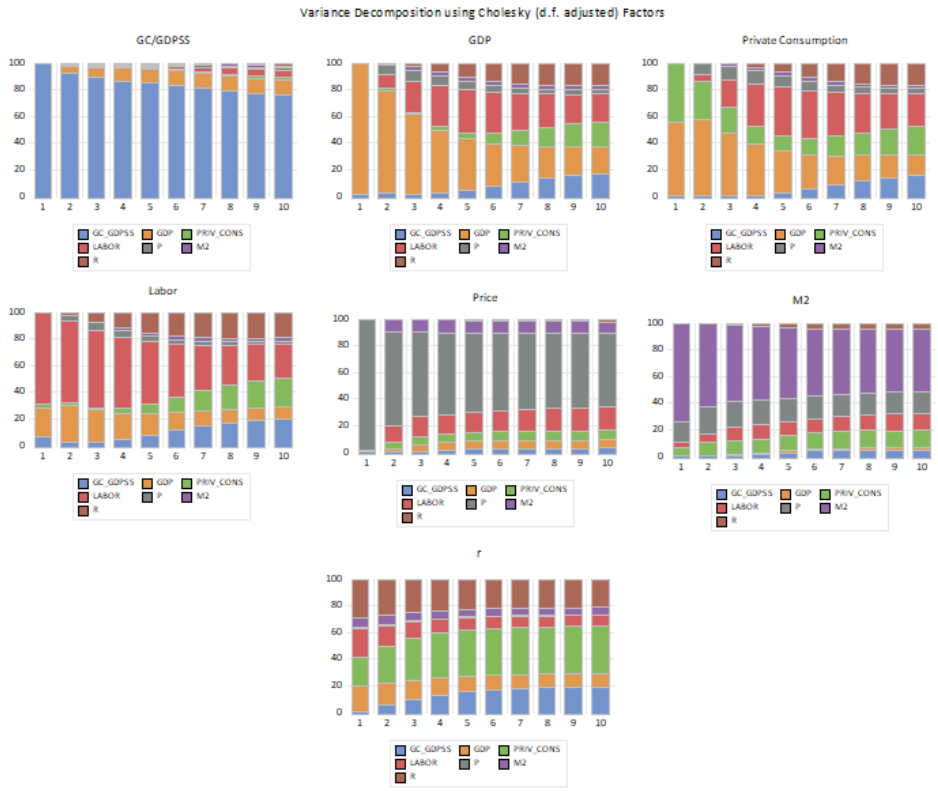

Figure A31: Variance Decomposition (Experiment 1 Gov Spending Brazil). Source: Authors' calculations.

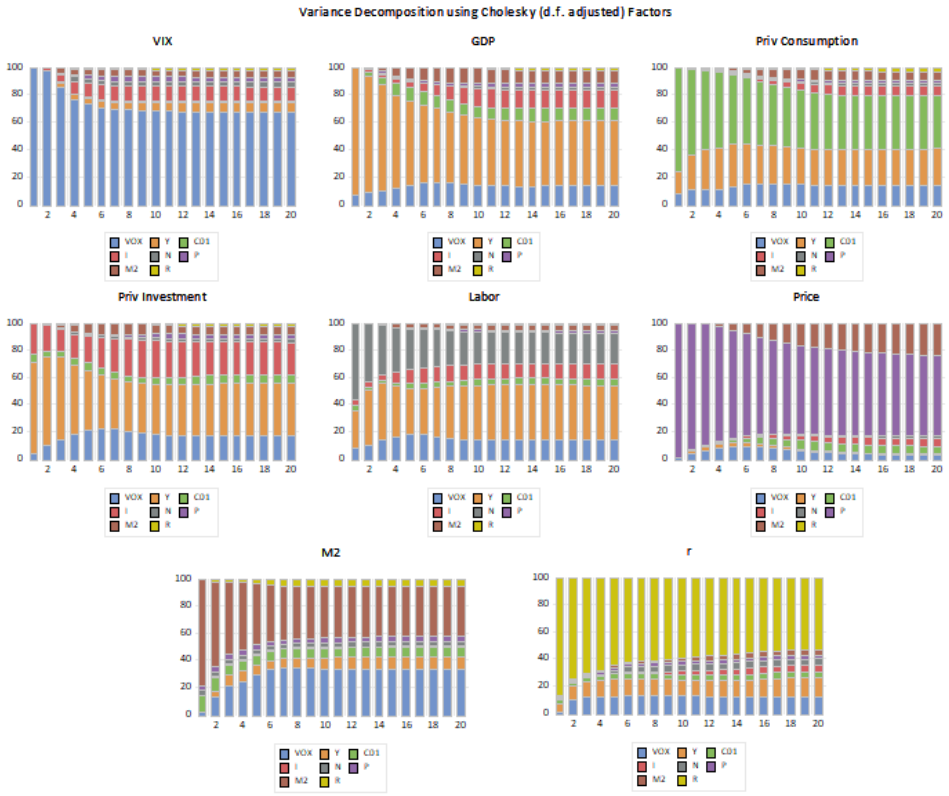

Figure A32: Variance Decomposition (Experiment 2 USA). Source: Authors' calculations.

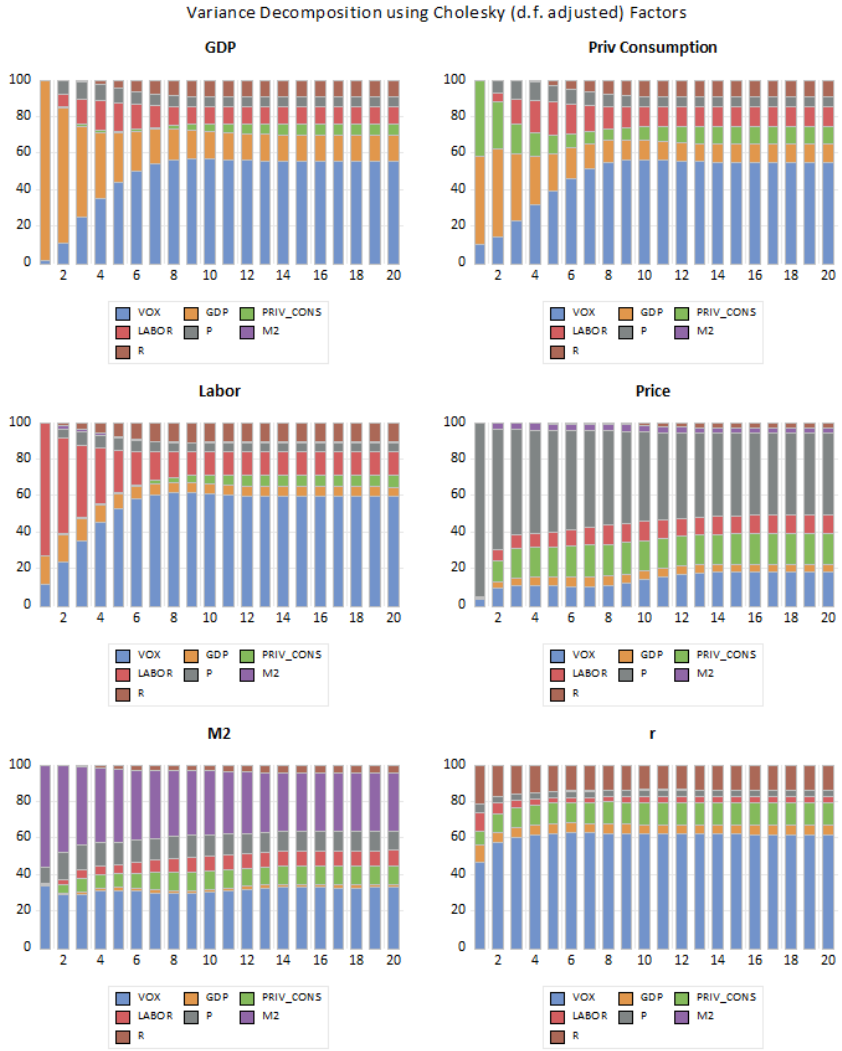

Figure A33: Variance Decomposition (Experiment 2 Brazil). Source: Authors' calculations.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Zeta(mean)	0.075089	0.024838	3.023164	0.0045
Zeta(-1)	0.923074	0.024826	37.18218	0.0000

R-squared	0.973935	Mean dependent var	0.149313
Adjusted R-squared	0.973230	S.D. dependent var	0.004897
S.E. of regression	0.000801	Akaike info criterion	-11.37098
Sum squared resid	2.38E-05	Schwarz criterion	-11.28567
Log likelihood	223.7342	Hannan-Quinn criter.	-11.34038
Durbin-Watson stat	1.279307		

Figure A34: Econometric Model - AR(1): The United States (Fiscal Shock). *Zeta represents the government consumption/GDPss ratio. Source: Authors' calculations.