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Uncertainty and the Effectiveness of Fiscal Policy in the United States and Brazil: SVAR approach

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Abstract

This paper analyses the harmful interference of uncertainty on the effectiveness of fiscal policy. We investigate this issue through the lens of a Structural Vector Auto Regressive (SVAR) model for the United States and Brazil.

Imposing government spending shocks, we find a positive effect on economic activity. The results suggest Keynesian effects on consumption and GDP. To assess the effects of uncertainty, we used the Economic Policy Uncertainty Index (EPU) and the World Uncertainty Index (WUI). Our findings indicate that the fiscal effects are considerably less intense when uncertainty reaches high levels, consistently with the Real Options approach. The results suggest that agents are more cautious when the high uncertainty overshadows the outline of the economic scenario. In this sense, uncertainty disturbs agents' decisions and decreases consumption, investment and economic activity.

Keywords: Fiscal Policy, Uncertainty, SVAR, United States, Brazil.

JEL-codes: E27, E62, H30.

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1 Introduction

Throughout economic history, we have observed, with a greater or lesser degree of contagion and persistence, that economies have been affected by shocks of uncertainty, panic and resulting economic slowdown. According to Baum and Koester (2011) monetary policy alone cannot foster economic activity, particularly because many countries have reached the zero lower bound.

The United States and European countries have reacted with new actions to overcome or at least mitigate the effects of the international crisis and recession. Stimulus packages were developed, with emphasis on fiscal policy, such as the American Recovery and Reinvestment Act (2009)[2]. Among other objectives, the Act purposes to preserve and create jobs, promote economic recovery and invest in transportation and infrastructure to provide long-term benefits.

In this sense, governments and researchers were encouraged to redefine the role of fiscal policy and the number of publications on fiscal multipliers increased considerably after the global financial crisis (2007).

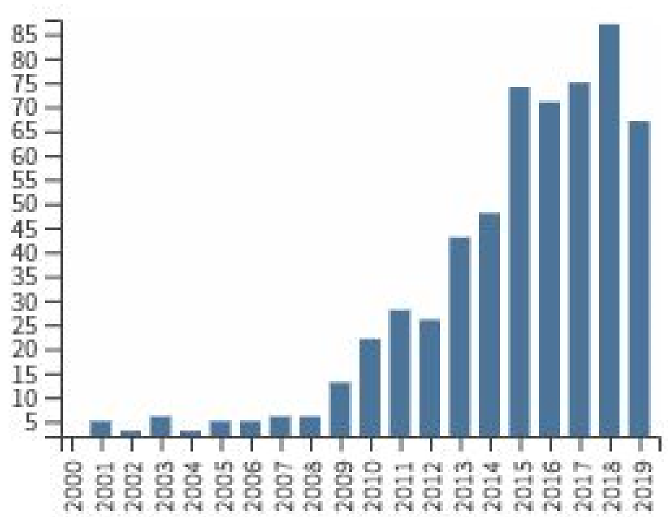

Figure 1: Fiscal Multipliers (Total Publications by Year). Source: Web of Science (All Data Base).

Despite the crises observed over the years (financial instability, trade disputes or viral pandemics) have different roots, we see similarities in negative effects on agents' confidence and how uncertainty overshadows consumption and investment decisions in different countries.

[2]"Making supplemental appropriations for job preservation and creation, infrastructure investment, energy efficiency and science, assistance to the unemployed, and State and local fiscal stabilization. Source: https://www.congress.gov/bill/111th-congress/house-bill/1/text

Considering this, experts have debated the best strategy for fiscal policy and whether traditional instruments to stimulate the economy should be used. Therefore, some questions come to the centre of the debates. How does uncertainty affect the effectiveness of fiscal policy? Are these effects different in emerging economies? How does the transmission of fiscal policy occur in times of high and low uncertainty? What are the real effects of a fiscal policy?

These questions are central to economic theory. However, the responses are not convergent, especially when the uncertainty arising from international crises or political instability has the potential to significantly slow the global economy.

Despite the renewed interest in the role of fiscal instruments, the size and persistence of multipliers varies considerably. This stems from the nature of the fiscal variables, conjunctural factors (recessions or expansion), structural characteristics (trade openness, labour market rigidity, exchange rate regime and debt level) and data frequency and reliability.

Reichling and Whalen (2012) find multipliers for US data between 0.75 to 2.25 for macroeconomic forecasting models and between 0.3 and 3.5 for time series models. In addition to the conjunctural and structural factors, the type of fiscal instrument (tax, consumption and investments) affect the intensity of the multiplier. In this sense, fiscal multipliers for infrastructure spending and different types of public investment are larger than those for government consumption (Whalen and Reichling, 2015).

Ramey (2019) analysed the state of knowledge about fiscal policy ten years after the global financial crisis. The author indicates that multipliers on general government purchases (developed countries) are positive and less than or equal to one. Thus, the estimates across the leading approaches suggest a range of 0.6 to 1. However, the range could be larger for countries with different structure, such as the exchange rate regime.

For Brazil, the academic debate returned only a few years later and one of the most debated issues is fiscal balance. One of the challenges of the Brazilian economy is to promote reforms, including that of social security. For Auerbach (1996), one of the goals of tax reform should be to generate the right environment to stimulate investment and promote the positive effects of well-being. The Brazilian government has signalled[3] (official news agency) that, with the reforms approved, confidence will be restored and, consequently, there will be conditions for the expansion of investments and consumption in a sustained manner.[4]

[3] https://agenciabrasil.ebc.com.br/economia/noticia/2019-09/com-reformas-crescimento-economico-sera-sustentavel-diz-campos-neto.

[4] https://www.em.com.br/app/noticia/economia/2019/07/14/internas$_{e}conomia,1069532/adolfo - sachsida - acredita - que - economia - pode - voltar - a - crescer - de - 3 - a - 4.shtml$.

In other words, the expansion would be possible due to the reduction of public expenditure and the deficit/GDP. With the improvement of insolvency conditions, the government would create a shock of confidence in the agents that would invest and consume more, boosting the economy[5]. Unfortunately, the economic team bet (at the time of the implementation of the public spending ceiling) that private investment would offset the cut in public spending, but this was not confirmed, even before the COVID-19 pandemic.

This bet may be closely linked to the Ricardian equivalence hypothesis, and for some authors (Vieira, 2006; Candelária, 2012) the Brazilian economy does not have agents with a Ricardian profile. Even if Brazilians had a Ricardian profile, some economists do not believe it would be enough to solve the problem of insufficient demand, due to conjectural factors (high unemployment and indebtedness of the population) and structural factors (the composition of the tax burden and the lower participation in GDP of dynamic sectors such as transformation and communication) that would prevent this resumption. Therefore, economic reforms and fiscal adjustments are necessary conditions, but they are not enough for stable and sustainable growth.

Rezende and Cunha (2013) argue that although there is an understanding of the need for reforms, there is considerable divergence in scope and especially in the way it is conducted. For the authors, the need to contain the growth of the State is discussed through the imposition of legal limits, without observing the role that the public budget plays in modern democracies.

In the same vein, Pires (2016) argues that long-term structural reforms are important to maintain fiscal sustainability, but it is difficult to maintain harmony between short-term recovery and a public debt stabilization agenda that is too rigid and too little feasible to be fulfilled.

Just as the role of fiscal policy, uncertainty shocks (international crises, political instability and corruption) have aroused the interest of researchers. Even with the growing empirical and theoretical interest there are few studies about uncertainty shocks on fiscal policy and their implications for economy and welfare. There is an even greater shortage of research for emerging countries, especially Brazil (Gechert and Rannenberg, 2018; Barboza and Zilberman, 2018). Bloom (2014) suggests that high levels of uncertainty make consumers and investors more cautious and disrupts the effectiveness of public policies, especially in developing economies.

Decision-making by economic agents involves the formation of expectations, supported by the quality and quantity of information available. In this sense, the construction of

[5]The constitutional amendment (2016) - "ceiling on public spending", has controlled the growth of public spending, repressed public investment and fiscal policy but did not stimulate the economy. In this sense, different experts have questioned the theories of the neoclassical school.

expectations is influenced by uncertainty, given that many events do not have very clear information, while others are unpublished, so they do not have a defined probability. Uncertainty appears in the literature as a key variable to understand the dynamics of economic agents' decisions. However, the definition, the scope of the effects and ways of measuring it may vary.

Knight (1921) draws a distinction between risk and uncertainty, where uncertainty is a random variable associated with a state with an uncertain future in a probabilistic space that is not perfectly established, whereas the risk would have the space clearly determined. Keynes (1936) also highlighted the importance of uncertainty in economic dynamics, where individuals in uncertainty are not guided or decide through probabilistic models, but are influenced by what they determined to be ”animal spirits”.

The concept of uncertainty was expanded with the work of Savage (1954), where he instituted a more practical perspective when establishing subjective probabilities. However, the behaviour in the face of uncertainty was the target of several criticisms. Ellsberg (1961) in addition to demonstrating that some of Savage's assumptions were not stable also criticized the theory of utility and argued that individuals react differently when faced with situations involving ignorance of the future.

Therefore, economic uncertainty concerns a situation where the consumer or investor needs to decide without having the perfect information about the future in question. In light of this, studies use different measures to examine the effects of uncertainty on the consumer or financial market. Bloom et al. (2016) developed an indicator (Economic Policy Uncertainty - EPU) that offers a proxy for movements in economic policy uncertainty over time. This index accounts for the number of times words associated with economic uncertainty or political uncertainty appear in widely circulated newspapers. As Barbosa (2018) points out, the hypothesis is that economic agents are attentive to the media to calculate the degree of uncertainty in the economy.

Ahir et al. (2018) developed a new index, the World Uncertanty Index (WUI). Unlike the EPU, two factors facilitate comparability between countries. The index is based on a single source (economic and political developments) and the reports follow a standardised process.

Antonakakis et al. (2013) examined the volatility of the stock market return as a way of measuring uncertainty and analysed the correlation with the indicator and economic policy uncertainty of Baker et al. (2012). They use the S&P500 returns, the VIX[6] and Economic Policy Uncertainty Index.

[6] VIX calculates market expectation of volatility by stock index option prices. It represents the expectation of 30-day forward-looking volatility.

Figures 2 and 3 provide an overview of an uncertainty indicator for the United States (1985 - 2019) and Brazil (1996 - 2018). The graphs present the different moments with high and low uncertainty[7]. In this case, uncertainty is measured by the Economic Policy Uncertainty Index (EPU)[8]. We also added the growth of the real Gross Domestic Product (GDP).

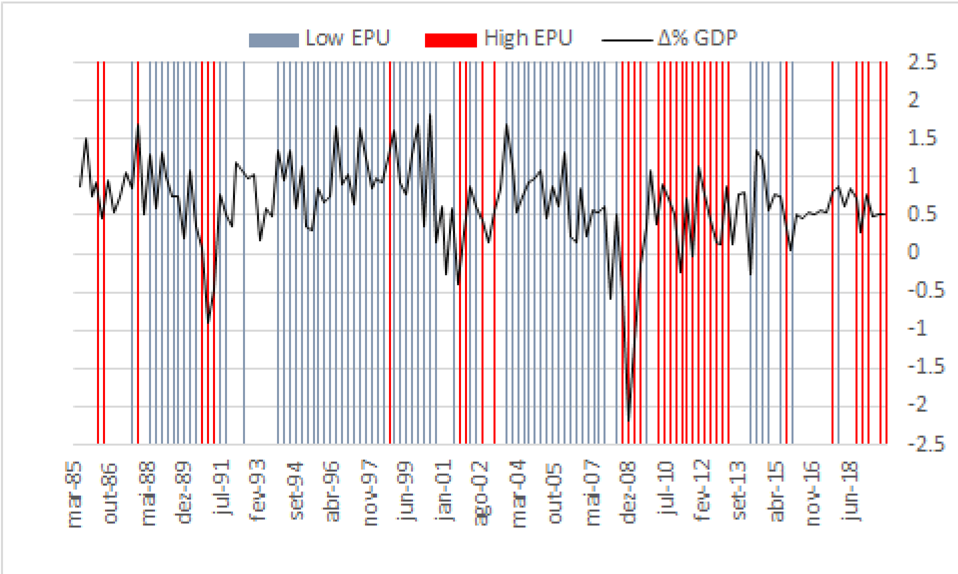

Figure 2: Uncertainty and GDP Growth - USA: 1985-2019. (right axis, % GDP). Source: FRED and Economic Policy Uncertainty.

We investigate the effects of uncertainty shocks on effectiveness of fiscal policy for the United States and Brazil. The aim is not to compare the two economies, but to analyse, in the light of the same methodological approach, whether uncertainty disturbs agents' decisions and affects the effectiveness of public spending. Inspired by the works of Aastveit et al. (2013) and Blanchard and Perotti (2002), we investigate these issues through the lens of an SVAR model.

In this sense, our main contribution is to investigate how private agents react under conditions of uncertainty and how the different levels of uncertainty affect fiscal multipliers. As far as we know, this work is the first to quantify the extent to which the effectiveness of fiscal policy changes with the level of uncertainty and influences fiscal multipliers for Brazil.

[7]Low $\leq$ 2nd quartile and High $\geq$ 3rd quartile.

[8]"To measure policy-related economic uncertainty, we construct an index from three types of underlying components. One component quantifies newspaper coverage of policy-related economic uncertainty. A second component reflects the number of federal tax code provisions set to expire in future years. The third component uses disagreement among economic forecasters as a proxy for uncertainty." Source: https://www.policyuncertainty.com/methodology.html.

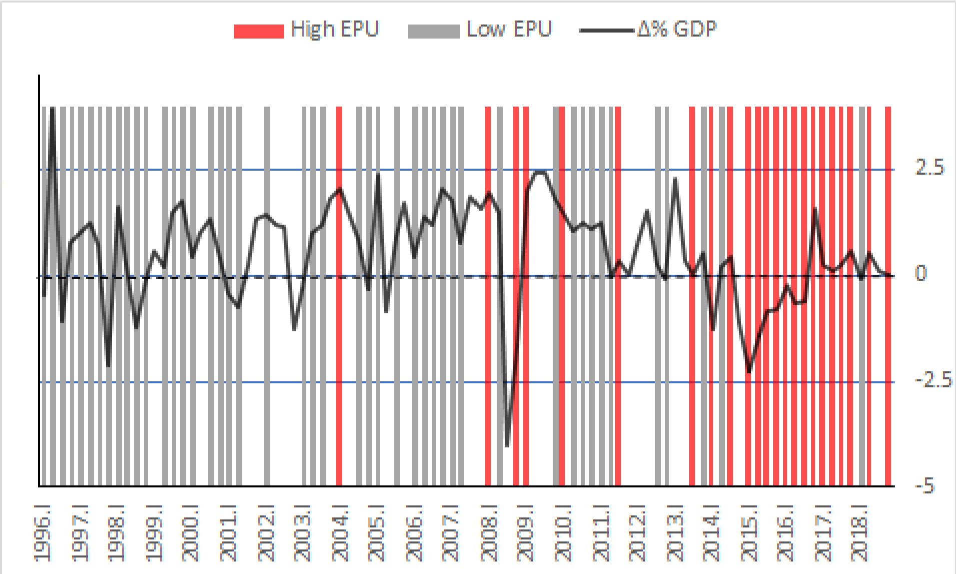

Figure 3: Uncertainty and GDP Growth - Brazil: 1996-2018. (right axis, % GDP). Source: IBGE and Economic Policy Uncertainty.

To achieve these objectives, two models are examined for each country. First, we calculate standard fiscal multipliers and examine the effects of fiscal policy on economic performance. In the second model, we investigate how the intensity of the multipliers is affected when we control the effects of the interaction of uncertainty with fiscal policy shocks. In this sense, we use two uncertainty indices: Economic Policy Uncertainty Index (EPU) and World Uncertainty Index (WUI).

Our models indicated the presence of Keynesian effects. For both countries, increases in public spending have a positive effect on household consumption and the level of economic activity. We also find indications of the crowding-out effect of public spending on private investment in the United States.

Another important finding is that the assumption of low effectiveness of fiscal policy was verified when the projection of economic scenarios is uncertain. The impact and persistence of fiscal policy are considerably less intense when uncertainty reaches high levels. Observing the causal chain of events, an increase in uncertainty makes agents more cautious postponing consumption and investment decisions. This behaviour spreads throughout the economy and, even with fiscal stimulus, the effects on GDP are less intense.

This paper is organised as follows. Section 2 is the literature review. Section 3 presents the data. Section 4 depicts the methodology and model specification, Section 5 describes the empirical models and results, and Section 6 concludes.

2 Literature

Fiscal policy can be described as a set of rules associated with government instruments such as investments, spending, taxes and resource allocation. From the theoretical perspective, Gali et al. (2007) argue that there are basically two central versions of the effects of fiscal stimulus. In the first version, if the households behave in a Ricardian fashion (infinitely-lived) and consumption decisions are based on an intertemporal budget constraint, a fiscal stimulus decreases the present value of income and reduces consumption due to a negative wealth effect (Gali et al., 2007). On the other hand, if households are not Ricardian (Keynesian framework) a fiscal expansion may lead to an increase in consumption, because in this case consumption depends on current disposable income.

According to Keynesian approach, changes in fiscal instruments initially affect the consumption of specific groups. This change in consumption, in turn, will affect demand from other groups and ultimately aggregate demand. However, the degree of change in aggregate demand depends on the fiscal multipliers and the conditions under which the economy operates.

Burda and Wyplosz (1997), examine different studies and point out that the Ricardian approach has many controversial consequences and there is contrary and in favour of this hypothesis. They highlight studies for Germany, United States, and Belgium (1974-1994) that do not support the Ricardian hypothesis. Evans and Hasan (1994) investigated whether Canadian consumers behave like Ricardian agents, and the tests indicated that the hypothesis that consumers act in Ricardian fashion cannot be rejected.

Studies for emerging countries are scarce, but it is possible to observe a pattern in the results. Khalid (1996) studied Ricardian equivalence and empirical evidence for developing economies. The results suggest that temporary increases in public spending may have some expansionary effect on aggregate demand.

Céspedes et al. (2012) studied the effects of government spending in the Chilean economy. The article provides evidence that consumption and GDP increase when government raises spending and reveals large and robust fiscal multipliers. The evidence can be explained by the presence of non-Ricardian households. Such existence has been cited as a crucial factor to understand the channel of government spending.

Some researches (Reis et al., 1998; Issler and Lima, 2000; Vieira, 2006) do not accept the hypothesis of Ricardian equivalence for the Brazilian economy. Candelaria (2012) used data from 1997 to 2009 and rejected the Ricardian profile hypothesis for agents in Brazil. The study confirms that a fiscal stimulus increases consumption and generates benefits for the population.

As argued by Kilponen et al. (2015), fiscal multipliers can be obtained through different approaches, and a crucial point is how the multiplier is measured. The Vector Auto Regression (VAR) model is a prominent approach to fiscal studies, and multiplier values are extracted from standardised fiscal impulses (Gechert and Rannenberg, 2018). This perspective is referenced by the seminal article by Blanchard and Perotti (2002) for the US economy. After this paper the SVAR approach was highlighted in the literature on fiscal multipliers and different authors added new variables to the system (Baum et al.,2012; Auerbach and Gorodnichenko, 2012; Huidrom et al.,2019).

The effects of fiscal policy can be calculated using different multipliers.

$$\mathscr{M}^{\text{Impact}} = \frac{\Delta Y(t)}{\Delta G(t)} \tag{1}$$

$$\mathscr{M}^{\text{Fixed horizon}} = \frac{\Delta Y(t+N)}{\Delta G(t)} \tag{2}$$

$$\mathscr{M}^{\text{Peak}} =_{N}^{Max} \frac{\Delta Y(t+N)}{\Delta G(t)} \tag{3}$$

$$\mathscr{M}^{\text{Cumulative}} = \frac{\sum_{i=0}^{N} \Delta Y(t+i)}{\sum_{i=0}^{N} \Delta G(t+1)} \tag{4}$$

Despite extensive research (theoretical and empirical) there is still considerable disagreement about the size of fiscal multipliers. Batini et al. (2014) argue that simulations for advanced economies suggest that first-year multipliers range from 0 to 1 (under normal conditions). In the same line, Mineshima et al. (2014) report that first year multipliers have an average of 0.75 for public spending and 0.25 for public revenue. However, there is divergence and several studies have shown that multipliers may exceed 1 under strong deceleration.

Kilponen et al. (2019) estimate of the magnitude and sign of fiscal multipliers (short and the long run) for European countries. A key result is that under standard monetary policy the short-run multipliers presents values smaller than one in the majority of simulation. Transitory decreases in government consumption are associated with larger short-run GDP effects than transitory increases in the tax rate on capital income, households' labour income, and consumption. In addition, two-year-long zero lower bound (ZLB) describes small impacts on the multipliers in the case of a transient measure adopted by a single country of European Area (EA) and cross-country reverberations are less intense. On the other hand, when the same fiscal effect is concomitantly introduced by members of EA, the ZLB has an intense response on short-run government consumption multipliers (larger

than one).

Gechert and Rannenberg (2018) highlight that structural factors such as high uncertainty, more flexible labour market, high trade openness, flexible exchange rate regime and high debt reduce the fiscal multipliers. In addition, temporary factors can affect the multipliers such as the business cycle and degree of monetary accommodation to fiscal shocks.

As stressed by Batini et al. (2014) little is known about the size of fiscal multipliers for emerging economies. Dechert and Rannenberg (2018), point out that there are few studies for developing countries, especially for Brazil and the results are divergent. According to Ilzetzki et al. (2013), emerging countries with high levels of debt (above 50% of GDP) have a negative fiscal multiplier on impact and can be very negative in the long run.

Corroborating those perspectives, studies from the IMF (2008) conclude that such multipliers are negative, especially in the long run. For some authors (Ilzetzki et al., 2013; Ilzetzki, 2011) the response of output to increases in government consumption is negative on impact and the multipliers of emerging and low-income economies are smaller than in advanced economies. They also conclude that the response is also considerably less persistent than in advanced countries.

However, Carrière-Swallow et al. (2018) analysed the effects of fiscal consolidation on economic activity for 14 economies in Latin America and the Caribbean (1989-2016) and concluded that the fiscal multipliers are very similar to those found for developed countries.

For Brazil, Peres (2006) found small but significant positive fiscal multipliers. On the other hand, Mendonça et al. (2009) find evidence of non-Keynesian effects of fiscal policy (1995-2008). Mathenson and Pereira (2016) estimated the multipliers for the Brazilian economy, and they found that government spending has not a persistent and significant effect on output since 2009.

In opposite direction, Sanches and Carvalho (2019) developed a Structural VAR based on Blanchard and Perotti (2002)'s approach. They analyse the multipliers in two different samples, pre-crisis (1997 - 2014) and full sample (1997 - 2017). The results point to a larger and more persistent multiplier of primary federal spending on GDP for the full sample compared to the pre-crisis sample.

The following is a summary table of other contributions to the value of fiscal multipliers, and we highlight the papers on government spending. In the Brazilian case, we selected an article with public investment due to the relevance of the study and the magnitude of the results.

Table 1: Examples of Fiscal Multiplier Analyses

Study	Blanchard and Perotti (2002)	Ramey (2008)	Ilzetzki et al (2011)	Auerbach and Gorodnichenko (2012)	Born et al (2012)	Afonso and Leal (2019)	Orair and Siqueira (2016)
Sample	USA	USA	Developing High Income (44 countries)	OECD countries	OECD countries	Eurozone	Brazil
Period	1960-1997	1939 to 2008 and 1969 to 2008	1960-2007	1985-2008	1985-2011	2001-2016	1995-2015
Method	SVAR	VAR	SVAR	SVAR	SVAR	SVAR	VAR
Fiscal Shock	Government Expenditure	Government Expenditure	Government Expenditure	Government Expenditure	Government Expenditure	Primary Expenditure	Public Investment
Impact Multiplier	0.84	-	0.37 (High Income) and -0.21 (Developing Economies)	-	1.25 (Fixed Exchange Rate) and 0.45 (Floating Exchange Rate)	-	0,81 (Expansion) and 2,19 (Recession)
Cumul. Multiplier	1.29	0.6 to 1.1	0.80 (High Income) 0.18 (Dev. Economies)	0.33	1.0 (Fixed Exchange Rate) and 0.55 (Floating Exchange Rate)	0.64	0,24 (Expansion) and 7.02 (Recession)
Key Findings	Government spending has a positive effect on economic activity and an increase in taxes has the opposite effect. The results suggest small multipliers, close to one.	The author constructed two new variables that measure anticipations and fiscal events. The results indicate that components of consumption fall after a positive shock to government spending.	The results highlight that the size of fiscal multipliers depends on key factors, such as: exchange rate regime and debt/GDP levels.	The results suggest that fiscal policy may be effective and foster output during a recession. In addition, the negative impacts (high inflation) are also less likely in this scenario.	Government spending multipliers showed more intense results under fixed exchange rate regimes. The New Keynesian Model provides an adequate description of the facts observed.	The government expenditure had a positive sign on economic activity and the tax multipliers presented negative effect. In addition, fiscal multipliers presented higher values for economies with higher levels of public debt.	The author follows the approach of Auerbach and Gorodnichenhko (2012). The results show that fiscal multipliers can achieve high values (recession) and persistent response (GDP). On the other hand, the expansion results are quite different.

As mentioned above, multipliers may vary significantly due to factors such as monetary policy response, openness level, labour market flexibility and exchange rate regime. Thus, they play a crucial role in determining the result of the multiplier. Regarding economic uncertainty and the effects on multipliers, the impact of multipliers in times of uncertainty is difficult to predict.

Since seminal works by Knight (1921) and Keynes (1936), several empirical and theoretical researches have been conducted to strengthen our understanding of uncertainty and the effects on investment, consumption, asset prices and output growth. Many authors, with different approaches, have studied how the uncertain events discourage the investments and GDP. In this sense, Bernanke (1993) emphasises that uncertainty creates an incentive to delay investment and hiring new employees.

Manteu and Serra (2017) evaluate three possible transmission channels of uncertainty. The first is associated with the real options approach, where agents can postpone decisions

to avoid the costs associated with errors. The second channel refers to precautionary savings. In this case, the greater the uncertainty regarding income in the future can induce households to reduce current consumption in order to increase reserves for the future. This behaviour decreases the marginal propensity to consume and the size of fiscal multipliers. In the last channel, economic agents may demand higher risk premiums. In this scenario, asset prices decrease and financing costs increase.

The literature provides different approaches for measuring uncertainty and examining the effects on GDP, well-being and agents' decisions. One of the challenges of assessing the effects of uncertainty on agents' decisions and economic performance is the definition of what we qualify as uncertainty, since it cannot be observed directly. However, it can be represented by different proxies, which highlight different dimensions of uncertainty, each with advantages and limitations.

These indicators can be represented by the expectations of participants in the financial markets and the volatility of indices in those markets. One of the criticisms is that its coverage may be restricted to the financial environment, not capturing more general impacts on the economy. In this group of indicators, we highlight volatility of the stock market return and the market expectation of volatility by stock index option prices (VIX).

Another possibility is to capture the effects of uncertainty by terms contained in the news media or newspapers. A possible imperfection of the index is the bias and imprecision of the analysis of the facts. The Economic Policy Uncertainty (EPU) and World Uncertainty Index (WUI) are prominent representatives.

A third way of understanding the behaviour of uncertainty is associated with the discrepancy of the analyses and projections developed by specialists. A possible deficiency is contained in the limitations of applied questionnaires and not only observing the effects of uncertainty, but other aspects that obscure the conclusions.

These measures could help to understand how countries recover from crisis periods. Baker et al. (2012) point out that uncertainty explains the slow recovery in the USA. They describe many potential factors behind the slow recovery since 2009. One of them is the increase in uncertainty. It can hamper investment, the entrepreneurs become reluctant to make decisions. In addition, households adopt a more cautious attitude and carefully evaluate their consumption and savings decisions.

Besides that, Baker et al. (2016) found evidence (Unites States) that uncertainty shocks can be correlated to recessionary periods and reduce the incentive for investment and consumption. They suggest that high political uncertainty in the United States and Europe in recent years may have hampered macroeconomic performance.

Meinen and Röhe (2017) examine the influence and adverse effects of uncertainty on investment and output in the euro area, with emphasis on Germany, France, Italy and Spain. They study the effects of five uncertainty proxies: the stock market volatility, a survey

derived measure of expectations dispersion, a newspaper indicator based on Economic Policy Uncertainty (EPU) and two indicators following the concept of unpredictability. The analysis of the different uncertainty proxies is conducted based on descriptive evidence and a VAR model. The findings indicate that all the uncertainty measures analysed described countercyclical behaviour.

For some authors (Bloom et al., 2012) uncertainty is classified as a potential element that defines the intensity and duration of a recessive period. They examined how time-varying uncertainty affects the policy ineffectiveness and how the expansive policy depends on uncertainty. The authors developed a dynamic stochastic general equilibrium model with non-convex adjustment costs and advocate that uncertainty shocks are potential factors shaping business cycles. The findings suggest that uncertainty makes firms cautious and substantially changes the response of the economy to the stimulus.

Aastveit et al. (2013) investigated the transmission channels of uncertainty in the United States and studied whether uncertainty affects the effectiveness of monetary policy. The findings show that monetary policy influence on economic activity is faint when uncertainty is high. The authors use as main measure of uncertainty the volatility of stock market (United States), VXO index of implied volatility (Chicago Board Options Exchange).

For the Brazilian economy, the Organisation for Economic Co-operation and Development pointed out that a potential increase in political instability (political uncertainty) could jeopardize a scenario of confidence recovery in the coming years (OECD, 2017).

As noted, there are a considerable number of studies that assess the effects of different uncertainty proxies on economic performance. However, there are few studies for emerging countries. For Brazil, we highlight the work of Barbosa (2018). This paper investigates the impact of macroeconomic uncertainty shocks on the main fiscal components of the Brazilian federal government. Uncertainty is measured using the economic Policy Uncertainty Index (EPU). Despite the different contributions, the author does not analyse the impacts of a fiscal multiplier under conditions of uncertainty.

2.1 Investment Strategies under Uncertainty: Real Options Approach

Regarding the effects of uncertainty, the theoretical literature indicates that uncertainty has a negative effect on output. Different reasons as precaution (Keynes, 1936), incentive to postpone investments and consumption would reduce the fiscal effects on economic activity.

In this section, we use a simple model to highlight how uncertainty affects a decision that can be postponed. Dixit and Pindyck (1994) argue that investors consider two important factors in investment decisions: irreversibility and the possibility of postponing the decision to invest.

In this sense, when a firm invests (irreversible investment), it ”kills” the option to invest. Thus, it gives up the possibility of waiting for new information. This lost option value is an opportunity cost that must be included as a cost of the investment. Therefore, the Net Present Value (NPV) rule must be adjusted. (Dixit and Pindyck, 1994).

The presence of irreversibility (partial or total) of investments and the possibility of delay are very important characteristics of most investments. Associated with a scenario of uncertainty about the future, the opportunity to postpone investment is like a financial call option.

The following explanation is inspired by the classic book by Dixit and Pindyck (1994). Consider a firm that is deciding today (t=0) invest and that will produce for a long period (perpetuity) and the investment (ϕ) is irreversible. Installation and operation start today. The initial net benefit is equal to y_0 but could change next year: it will increase to y_1^H with probability p, or will decrease to y_1^L, with probability (1-p). Then, the net benefit will remain in the new level forever. σ denotes the degree of volatility or uncertainty in the next period. The expected net benefit, E(y), will be equal to p . $y_1^H + (1-p).y_1^L = y_0$.

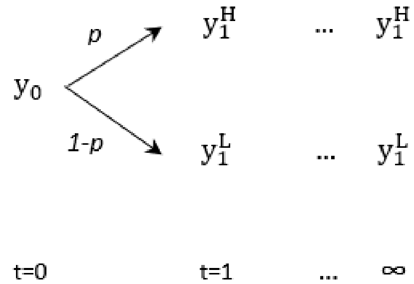

Figure 4: Uncertainty and Future Net Benefit

Therefore, the entrepreneur needs to decide whether to invest and the best time. The traditional perspective of the firm's decision is described as:

$$\mathrm{E}(\pi_0) = -\phi + \sum_{t=0}^{\infty} \frac{\mathrm{p} \cdot [(1+\sigma) \cdot \mathrm{y}_0] + (1-\mathrm{p}) \cdot [(1-\sigma) \cdot \mathrm{y}_0]}{(1+\mathrm{r})^{\mathrm{t}}} \tag{5}$$

When NPV is greater than zero, the firm must invest. However, the expected NPV ($\mathrm{E}(\pi_0)$) rule ignores the option that the firm can wait until next year, observe economic conditions and only then decides whether to invest or not. Investing now means exercising the option and pay an opportunity cost equal to the option value. The value of the option to invest today is defined as Op_O :

$$\mathrm{Op}_0 = \mathrm{p} \cdot \left[\left(\frac{-\phi}{1+\mathrm{r}} \right) + \sum_{t=1}^{\infty} \frac{(1+\sigma) \cdot \mathrm{y}_0}{(1+\mathrm{r})^{\mathrm{t}}} \right] \tag{6}$$

After including the opportunity cost (Option), we have the following expression.

$$\mathrm{V}_0^{\mathrm{RO}} = -\phi + \sum_{\mathrm{t}=0}^{\infty} \frac{\mathrm{p}\cdot[(1+\sigma)\cdot \mathrm{y}_0] + (1-\mathrm{p})\cdot[(1-\sigma)\cdot \mathrm{y}_0]}{(1+\mathrm{r})^{\mathrm{t}}} - \mathrm{p}\cdot\left[\left(\frac{-\phi}{1+\mathrm{r}}\right) + \sum_{\mathrm{t}=1}^{\infty}\frac{(1+\sigma)\cdot \mathrm{y}_0}{(1+\mathrm{r})^{\mathrm{t}}}\right] \tag{7}$$

If Op_O is greater than NPV or $V_0^{R.O}$ less than zero, the firm must postpone the investment. Otherwise, the firm must invest. Next, we analyse how uncertainty affects the firms' decision making.

$$\frac{\partial V_0^{R.O}}{\partial \sigma} = \frac{y_0 \cdot (p-1)}{r} \leq 0 \tag{8}$$

As we can see, an increase in uncertainty (stable average) discourages investment and generates delay or postponement effect.

An initial question is how the firm reacts to an increase in net benefit. Higher benefit results from several possibilities, for instance, productivity or increased sales due to higher consumer income, stimulated by fiscal policy. Another relevant question is how the firm reacts to an increase in net benefit, when there is increasing uncertainty. The following expression indicates that, in these circumstances, the effect of an increase in net benefit from a fiscal stimulus is negative ($p < 1$).

$$\frac{\partial^2 V_0^{R,0}}{\partial \sigma \cdot \partial y_0} = \frac{p-1}{r} \leq 0 \tag{9}$$

When entrepreneurs are faced with a scenario of high uncertainty, they evaluate more than the stimulus on their sector. They examine the options available, such as the option to postpone the investment. Thus, the marginal incentive for investment can have a small impact. This result reflects the "caution effect" described by Dixit and Pindyck (1994) and highlighted by Aastveit et al. (2013) when analysing the effectiveness of monetary policy in the United States.

Alloza (2017), estimates the impact of government spending shocks on economic activity during periods of high and low uncertainty and during periods of boom/recession. The author highlights similar effects on household consumption. In an environment of high uncertainty, private agents are concerned with the economic slowdown and reduction of income levels in the future, in turn producing a decline in consumption and economic activity.

3 Data

The United States national accounts series are in billions of Chained 2012 Dollars (seasonally adjusted). The series are based on the natural log of government spending (consumption and investment), gross government investment, household consumption, private investment and output (GDP). They are available on Federal Reserve Bank of St. Louis FRED database.[9] The sample covers the period from 1985Q1 to 2019Q4, for a total of 140 observations.

The Brazilian series are in billions of national currency units and seasonally adjusted (chained 1995). The series are: the natural log of government spending (consumption), household consumption and GDP. The sample is smaller than the US series and covers the period from 1996Q1 to 2018Q4 (92 observations). The database is made available by the Brazilian Institute of Geography and Statistics (IBGE), Brazilian Institute of Economics (IBRE) and Institute of Applied Economic Research (Ipea).

Initially, we investigated the effects of public spending (consumption and investment) on private agents and GDP. Then, we examined the effects of uncertainty on the effectiveness of fiscal instruments on economic activity. This paper analyses the effect of two uncertainty indicators, Economic Policy Uncertainty Index (EPU)[10] and World Uncertainty Index (WUI)[11]

The following table summarises the main results of the statistical description and results of the unit root test (Augmented Dickey-Fuller Test).

Table 2: Descriptive Statistics and Tests (Brazil).

Statistic	EPU	WUI	Government Cons.	Household Cons.	GDP
Mean	137.4212	0.301440	10.74335	11.94864	12.39733
Median	120.3849	0.245974	10.77163	11.93401	12.42727
Maximum	459.8295	1.921885	10.93194	12.25304	12.64931
Minimum	32.38683	0.000000	10.39569	11.61642	12.08470
Std. Dev.	79.95826	0.284491	0.151837	0.214627	0.189602
Skewness	1.736519	2.451604	-0.272551	0.037117	-0.167325
Kurtosis	6.134445	13.08873	1.628711	1.334505	1.452639
Jarque-Bera	83.89915	482.3253	8.347349	10.65431	9.607546
Probability	0.000000	0.000000	0.015396	0.004858	0.008199
H0: Unit Root - Level	Not Accept	Not Accept	Accept	Accept	Accept
H0: Unit Root - 1st Diff	Not Accept	Not Accept	Not Accept	Not Accept	Not Accept

Source: Authors' calculations.

9 https://fred.stlouisfed.org/tags/series/.

10 http://www.policyuncertainty.com/methodology.html.

11 https://www.policyuncertainty.com/wui$_q$uarterly.htmlandwww.policyuncertainty.com/media/WUI$_m$imeo$_1$0$_2$9.pdf

Table 3: Descriptive Statistics and Tests (United States).

	EPU	WUI	Government Cons + Invest	Household Cons	Private Invest	GDP
Mean	110.6102	0.157439	7.917092	9.057025	7.605069	9.463960
Median	107.0523	0.113661	7.967325	9.114610	7.703491	9.511043
Maximum	235.0840	0.786741	8.111446	9.503900	8.155100	9.863695
Minimum	63.11824	0.000000	7.591178	8.521218	7.021869	8.964983
Std. Dev.	31.74531	0.151467	0.145360	0.288270	0.361460	0.261703
Skewness	0.981072	1.383172	-0.327951	-0.270005	-0.323559	-0.313530
Kurtosis	4.483418	5.198606	1.717736	1.726341	1.721002	1.783908
Jarque-Bera	35.29481	72.83809	12.10071	11.16394	11.98515	10.92050
Probability	0.000000	0.000000	0.002357	0.003765	0.002497	0.004252
H0: Unit Root - Level	Not Accept	Not Accept	Accept	Accept	Accept	Accept
H0: Unite Root 1st Diff	Not Accept	Not Accept	Not Accept	Not Accept	Not Accept	Not Accept

Source: Authors' calculations.

Figure 5: Brazil - Series. Source: Authors' calculations.

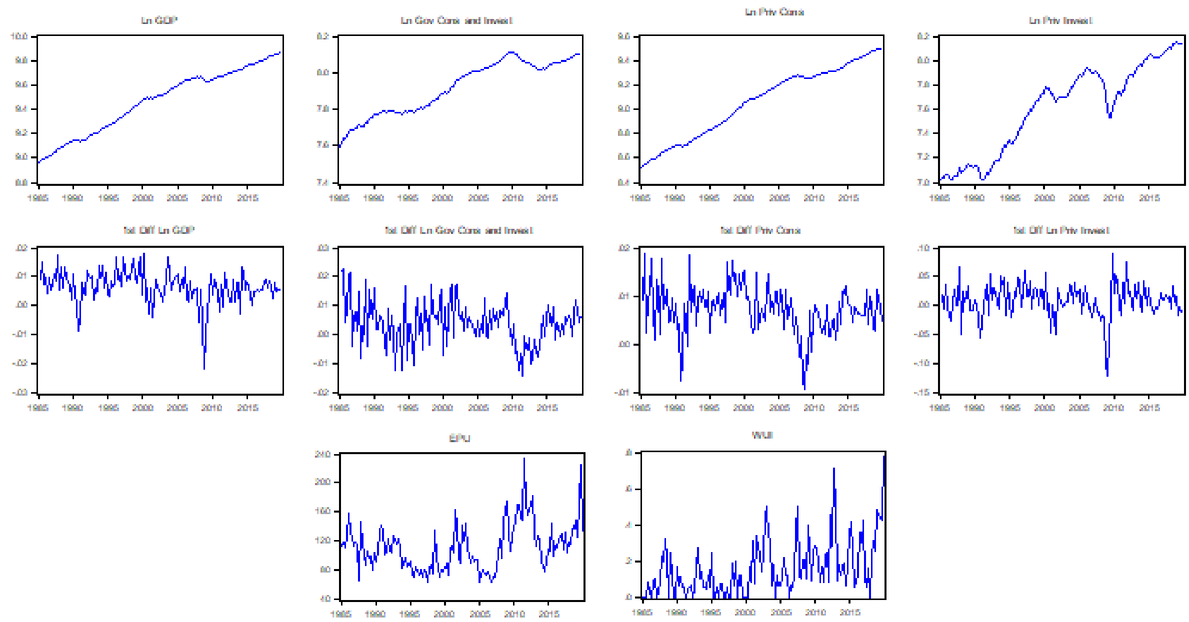

Figure 6: United States - Series. Source: Authors' calculations.

The series are non-stationary (level), except for the EPU (constant) and WUI. From the results obtained (Appendix), we can consider that the other series are stationary for the first differences of the original variables.

4 Model Specification

In this article, we study, based on the SVAR approach, the effects of fiscal stimulus and uncertainty shocks on macroeconomic variables such as GDP, private consumption and investment. The VAR and SVAR methods are justified by the choice of variables for the orthogonalization of impulses, necessary for the estimation of impulse response functions (IRFs). The following is a concise review of the methodology used.

The VAR model can be described as a system in which each variable is regressed on itself and other model variables lags.

$$Y_t = W + B_1 y_{t-1} + \ldots + B_p y_{t-p} + u_t \tag{10}$$

$Where:$

$Y_t = \begin{pmatrix} y_{1t} & \dots & y_{Kt} \end{pmatrix}'$ is the vector of endogenous variables;

$B_i = K \times K$coefficient matrices;

$W = \begin{pmatrix} v_1 & \dots & v_K \end{pmatrix}'$denotes the vector of constants;

$u_t = \begin{pmatrix} u_{1t} & \dots & u_{Kt} \end{pmatrix}'$represents the error vector;

p is the number of lags of endogenous variables.

We can estimate the model described (reduced-form) using ordinary least squares (OLS). Besides that, we can observe that the correlation of the residuals represents the contemporary relationship between the variables of our model.

The reduced-form system does not allow us to infer the structure and dynamics of economic variables. In addition, we cannot interpret u_t as structural shocks, because they are contemporaneously correlated. In this case, it is not possible to identify the exogenous shock of each endogenous variable of the model.

Since we are interested in fiscal shocks, we need a model that isolates the exogenous effect of each variable, which is possible with structural VAR (SVAR) models. Therefore, to investigate the effects of fiscal shocks and the behaviour of other variables, we need to establish orthogonal shocks and ascertain the economic significance of innovations. In other words, we are interested in a model with the following form:

$$AY_t = BY_{t-1} + e_t, \quad e_t \sim N(0, I) \tag{11}$$

In this model, the elements of e_t are serially uncorrelated and independent of each other. However, we cannot use OLS to estimate SVAR models, because regressors are correlated with the error term, and we would violate one of the hypotheses of the method. One of the problems is that matrix A presents the contemporary relationships of endogenous variables. The solution is to multiply SVAR by A^{-1}.

$$\begin{aligned} A^{-1}AY_t &= A^{-1}BY_{t-1} + A^{-1}e_t \\ e_t &\sim N(0, I) \\ \\ Y_t &= VY_{t-1} + u_t \\ u_t &\sim N(0, \Sigma_u) \end{aligned} \tag{12}$$

From the last expression we can deduce that:

$$V = A^{-1}B$$
$$u_t = A^{-1}e_t$$
$$\Sigma_u = A^{-1}IA^{-1\prime} = A^{-1}A^{-1\prime}$$

The question is how to identify A^{-1}. For a model with three variables and one lag, we have 9 unknowns and 6 values (the system is over-parameterized), and it is not defined. Therefore, it requires coefficient restrictions, which results in the identification of a structural system. To this specific example, we need to impose three restrictions. For a more general case the identification of the structural VAR requires that $(n^2\text{-}n)/2$ restrictions be imposed.

Enders (2008) and Lütkepohl (2005) have shown that the constraints on the coefficients described in Cholesky decomposition make A^{-1} triangular[12].

They argue that in addition to being sufficient, Cholesky decomposition shows that the ordering of variables in the structural model must be done so that the first variable affects all others contemporaneously. The second variable does not affect the first but influences all the others and so forth.

In general, choosing a different ordering of the variables generates distinct shocks and thus the impacts on the system depend on the way the variables are arranged in the vector.

Martin et al. (2013) argue that the recursive approach described above has essentially statistical foundations and imposes a rigid and strict structure. In this sense, the dynamics of the model may not be consistent with the structure of the process that we intend to investigate. On the other hand, an SVAR model can mitigate this problem by imposing restrictions motivated by economic theory.

In this paper, the SVAR approach is the crucial tool for estimating the dynamic relationships between economic variables. However, the focus is not on the estimated parameters, but the Impulse Response Functions (IRFs) arising from them. Therefore, the purpose of our structural model lies in the analysis and evaluation of the effects of uncertainty and fiscal policy instruments on other variables over time. To study the impacts of fiscal policy and uncertainty shocks on the level of economic activity, we adjusted the models according to the methodology proposed by Blanchard and Perotti (2002). The following is a simplified example to illustrate Blanchard and Perotti's (2002) approach.

[12] The proposed method (Cholesky factors) describes that an invertible matrix can be divided into two lower triangular factors. Furthermore, we can verify that the decomposition results in exactly $(n^2\text{-}n)/2$ A values equal to zero, which makes it a sufficient method to constrain the structural model.

The equation describes a basic model.

$$Zt = A(L,p)Zt_i + U \tag{13}$$

Zt =[GC, HC, GDP]' is a three-dimensional vector in the natural log of quarterly real government consumption (gc), real household consumption (hc) and real GDP (y). The term A(L, p) is a four-quarter distributed lag polynomial.

$$\begin{aligned} u_t^{gc} &= \alpha_{gcy} u_t^y + \beta_{gchc} e_t^{hc} + e_t^{gc} \\ u_t^{hc} &= \alpha_{hcy} u_t^y + \beta_{hcgc} e_t^{gc} + e_t^{hc} \\ u_t^y &= \gamma_{yhc} u_t^{hc} + \gamma_{ygc} u_t^{gc} + e_t^y \end{aligned} \tag{14}$$

Where, u_t^{gc}, u_t^{hc} and u_t^y are the unexpected movements in government consumption, private consumption and GDP, respectively. However, e_t^{gc}, e_t^{hc} and e_t^y are structural shocks that are not correlated with each other and do not depend on the dynamics of economic activity. As we can note, the reduced form residuals (gc, hc and gdp) have little economic relevance, because they are linear combinations of the underlying structural government consumption, private consumption, and GDP shocks.

The first equation highlights the unexpected movements in government spending can be due to the response to unexpected movements in GDP (α_{gcy}), the response to structural shocks to private consumption (β_{gchc}) and to structural shocks to government consumption, e_t^{gc}. The second equation has a similar interpretation with respect to unexpected fluctuations in household consumption. Finally, the last equation states that unexpected movements in GDP can be due to unexpected changes in government spending, household consumption and unexpected shocks (e_t^y).

The coefficients ($\alpha_{gcy}, \alpha_{hcy}, \gamma_{yhc}$ and γ_{ygc}) cannot be estimated without bias, since the residuals of the reduced form are correlated with the structural shocks in the above equations, so that the coefficients obtained by OLS are biased and inconsistent.

To recover the parameters, the hypothesis of identification for high frequency data is based on Blanchard and Perotti (2002). They argue that identification is obtained due to the time-lapse between the identification of the event, institutional relations and the effective action of fiscal policy. Thus, we emphasise that policymakers take more than a quarter to react in response to GDP shocks. After the shock, it is necessary to approve fiscal policy in other institutions and only after to implement the policy.

As our research data are quarterly, the argument and the hypothesis of identification are justified. Thus, there is no response from fiscal variables to output or private consumption

($\alpha_{gcy} = 0$ and $\beta_{gchc} = 0$). In addition, private decisions are contemporaneously affected by fiscal policy. It is justifiable for consumers and entrepreneurs to make their decisions after the announcement of government spending (Brinca, 2006).

However, private agents do not react instantly to output, either due to the presence of habits or the need for time to perceive the change (α_{hcy}=0). On the other hand, GDP is the result of these elements, and it is reasonable to assume that it is affected by them contemporaneously, but that it does not affect any variable.

5 Empirical Models and Results

5.1 Model 1: United States (1985Q1 – 2019Q4)

In our first model, the economic variables are the growth rates of general government spending (GG), private investment (PI) and output (GDP). In order to investigate other fiscal policy effects, we replace private investment with household consumption.

$$Y_t = C + \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_t \tag{15}$$

Where: C is a (3x1) vector of intercept terms;

Yt represents the $Y_t = [\Delta \ln GG_t, \Delta \ln PI_t, \Delta \ln GDP_t]$;

A is the matrix of autoregressive coefficients of order (3x3) and the vector of disturbances is $\varepsilon_t = \left[\varepsilon_t^{GG}, \varepsilon_t^{IP}, \varepsilon_t^{GDP}\right]$.

Table 4: Lag Order Selection Criteria (model 1 Gov Spending USA and Priv Invest).

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1327.398	NA	4.50e-13	-19.91576	-19.85057	-19.88927
1	1354.001	51.60585	3.45e-13	-20.18047	-19.91969*	-20.07450*
2	1361.058	13.37135	3.56e-13	-20.15125	-19.69488	-19.96580
3	1376.032	27.69661	3.25e-13	-20.24109	-19.58913	-19.97616
4	1387.759	21.16078*	3.13e-13*	-20.28209*	-19.43455	-19.93768
5	1394.734	12.27103	3.23e-13	-20.25163	-19.20850	-19.82774
6	1399.090	7.467242	3.47e-13	-20.18180	-18.94308	-19.67843

Source: Authors' calculations.

The model is stable, since all inverse roots of the characteristic polynomial lie within the unit circle. The assumptions associated with the residuals were verified (Appendix).

To understand the effects of each variable on the others, we simulated the Impulse Response Functions (IRF). An inspection of the IRFs indicates that public spending has a positive effect on GDP (impact) and private consumption (until the first quarter). The observed effects are statistically different from zero (95% confidence interval). They allow an assessment of fiscal policy in terms of immediate output response to a shock in the fiscal instrument to mitigate the effects of a political crisis or adverse shock. On the other hand, an analysis suggests that government spending does not encourage private investment.

The variance decomposition can be interpreted as the proportion of those movements due to shocks to itself and shocks to other variables. Thus, we can observe the percentage of the Mean Square Error of the prediction of one variable attributed to shocks on another variable.

In this case, the variance decomposition allows us to highlight the relevance of public spending on GDP and private investments. The contributions of 10% (GDP) are still substantial after 10 periods.

Our findings are in line with different studies for the United States. Blanchard and Perotti (2002) studied the effects of fiscal policy (1947Q1 to 1997Q4) using an SVAR model. They find that government spending shocks have a positive effect on GDP. In addition, increases in government spending have a strong negative (significant) effect on investment spending. Ramey (2008) and Fatás and Mihov (2001) found similar effects for the output, however the response of private investment to the government spending shock is insignificant in Fatás and Minhov.

Other papers based on SVAR models, such as Galí, López-Salido and Vallés, J. (2007), highlight multipliers greater than one. They also find positive effect on private consumption.

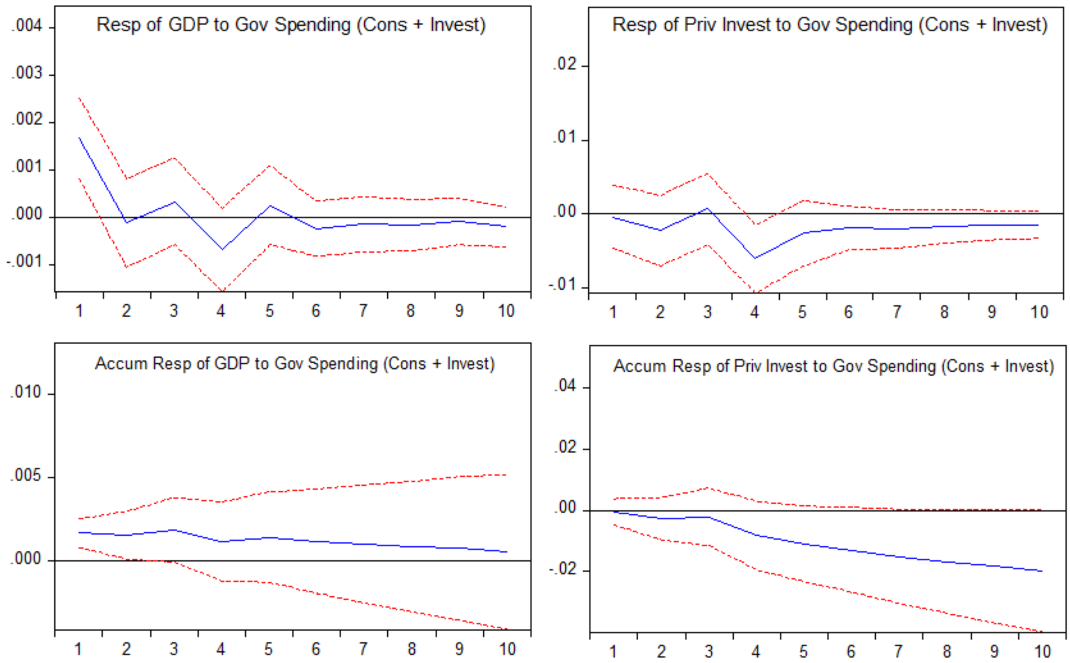

Figure 7: Impulse Response Function (model 1 Gov Spending USA - Consumption and Investment). Source: Authors' calculations.

Figure 8: Impulse Response Function (model 1 Gov Spending USA - Consumption and Investment). Source: Authors' calculations.

Figure 9: Variance Decomposition (model 1 Gov Spending USA). Source: Authors' calculations.

5.2 Model 2: United States (1985Q1 – 2019Q4)

To analyse the effects of uncertainty and effectiveness of fiscal policy, we adapted the model in line with Aastveit et al. (2013). They investigated the effectiveness of monetary policy for Canada, the United States, the United Kingdom, and Norway. They found that monetary policy shocks have a lower effect when uncertainty is high. These findings are consistent with the real options approach.

The authors estimated how uncertainty acts together on endogenous variables in an SVAR model, and they used the same methodological approach as Towbin and Weber (2013), where uncertainty is an exogenous interaction variable. In our model we are interested in the interaction between uncertainty and other variables, especially the effects of fiscal policy on output.

The economic variables are the growth rates of general government spending (GG), private investment (PI) and output (GDP). As in the previous model, we evaluated the fiscal effects on household consumption (HC).

Therefore, in this basic model our specification is:

$$Y_t = A + BX_t + \sum_{i=1}^{p} (CY_{t-1} + DY_{t-1}X_{t-1}) + \varepsilon_t \tag{16}$$

Where:

A is a (3x1) vector of intercept terms; The vector of disturbances is $\varepsilon_t = \left[\varepsilon_t^{GG}, \varepsilon_t^{PI} \varepsilon_t^{GDP}\right]$. Y_t represents the vector of endogenous variables and X_t is the measure of uncertainty, Economic Political Uncertainty (level). Furthermore, the model allows the variable GG_t to interact with X_t. In this case, uncertainty is assumed to be exogenous.

To assess the interaction effects, we calculate the estimated IRF of fiscal policy shocks for a high level of uncertainty (above the 3rd quartile) and a low level of uncertainty (below the 2nd quartile). The standard reduced form VAR models (above) are used to identify a fiscal policy shock and investigate its effects at times of high and low uncertainty.

$$Y_t^{High} = \widehat{A_0} + \widehat{B_0}^{\text{High}}.\widehat{X_0} + \sum_{i=1}^{p} \left(\widehat{B_i}^{\text{High}}.Y_{t-i} \right) + \widehat{E_t} \tag{17}$$

$$Y_t^{Low} = \widehat{A_0} + \widehat{B_0}^{\text{Low}}.\widehat{X_0} + \sum_{i=1}^{p} \left(\widehat{B_i}^{\text{Low}}.Y_{t-i} \right) + \widehat{E_t} \tag{18}$$

We intend with this model to verify that the results are in line with the Real Options approach. In other words, in the presence of high uncertainty private agents would be more cautious, postponing their consumption and investment decisions. As a consequence, the effects of government spending are expected to be less, in an environment of high uncertainty.

The impulse response functions point to a rather curious effect when we divide the sample into high uncertainty (high EPU) and low uncertainty (low EPU). First, we observe that public spending, under high uncertainty, has a negative influence on private investment and maintain their negative cumulative effect for seven quarters. Thus, the IRF suggest that high uncertainty discourages firms. Finally, public expenditures seem to have a negative (insignificant) effect on GDP when the level of uncertainty is low[13].

[13] The model (high EPU) has two lags and the model for low EPU one lag.

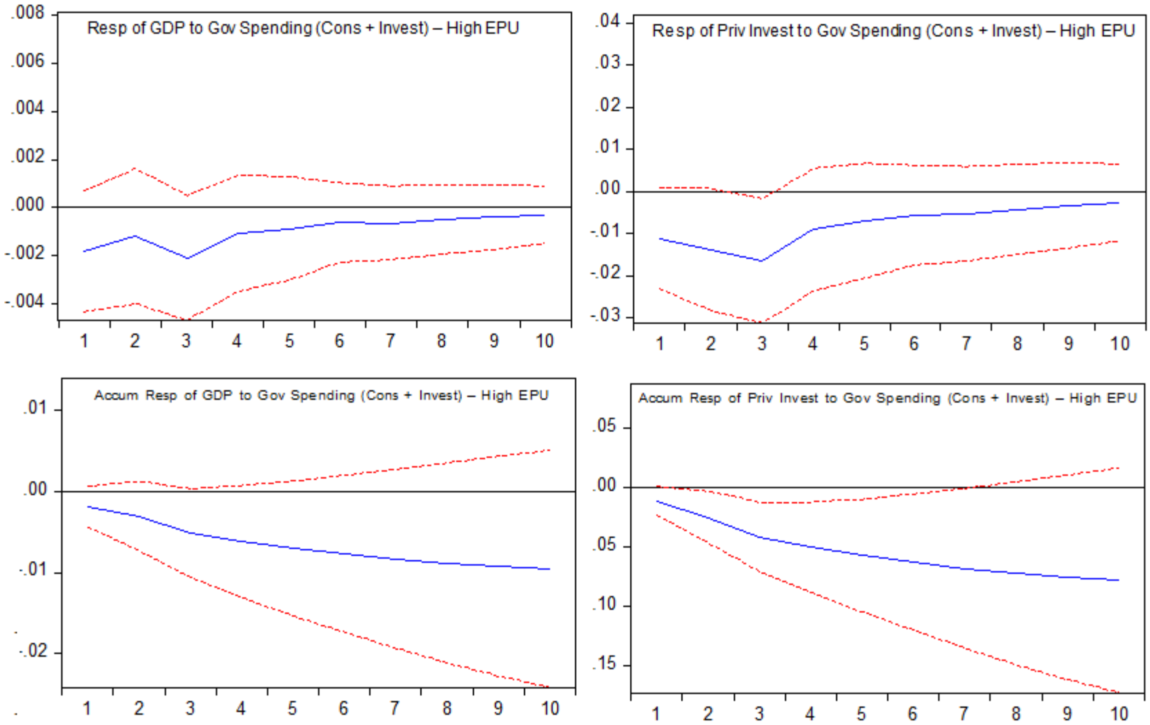

Figure 10: Impulse Response Function – High EPU (model 2 Gov Spending USA). Source: Authors' calculations.

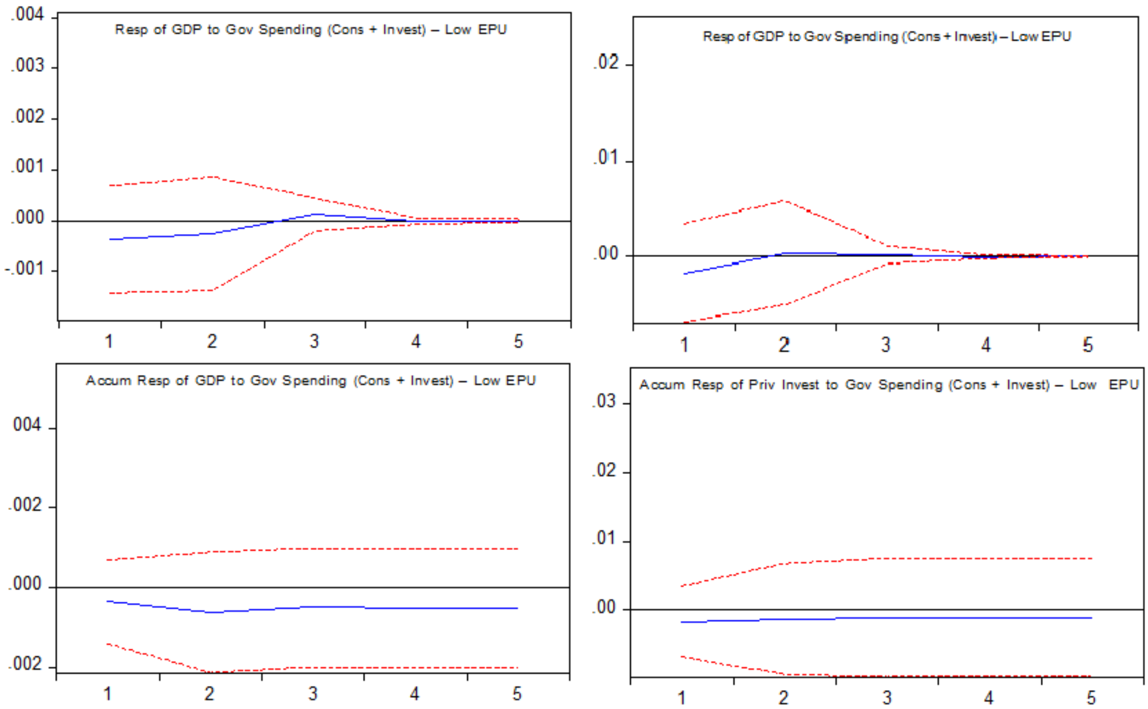

Figure 11: Impulse Response Function – Low EPU (model 2 Gov Spending USA). Source: Authors' calculations.

To assess confidence in the results, we changed the model[14] and replaced private investment with household consumption. Although the results on GDP are negative after the shock of government spending associated with EPU (High and Low), they are not statistically significant.

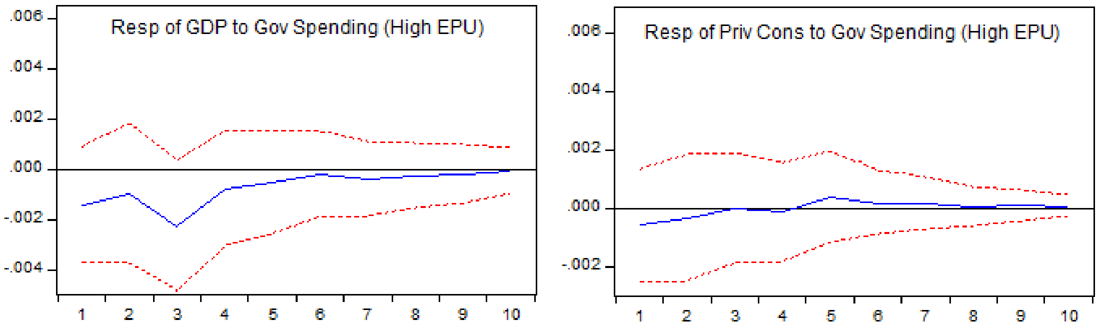

Figure 12: Impulse Response Function – GDP and Private Cons - High EPU (model 2 Gov Spending USA). Source: Authors' calculations.

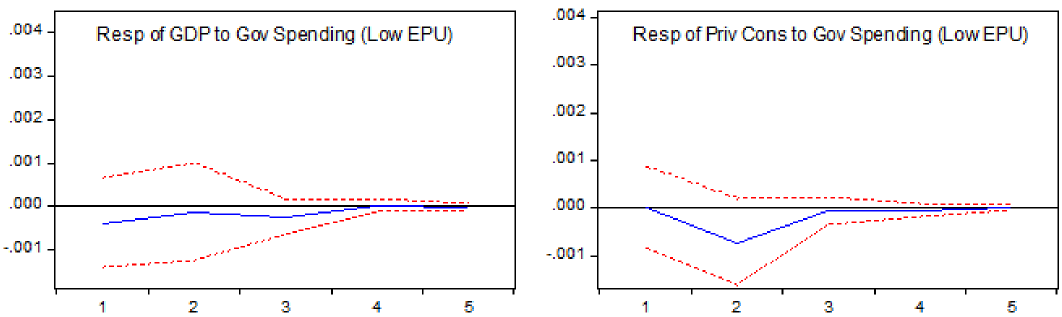

Figure 13: Impulse Response Function – GDP and Private Cons - Low EPU (model 2 Gov Spending USA). Source: Authors' calculations.

To deepen the analysis, we used the World Uncertainty Index (WUI) instead of the EPU and found that GDP responses to shocks of fiscal variables are in line with the literature[15]. As in the previous model, GDP and private investment show a negative effect after the fiscal shock associated with WUI (High). However, the responses are statistically significant in the impact on output and persist for another quarter for private investment. When we analyse the effects on household consumption, the results are more inaccurate and similar to the model with EPU.

[14] The number of lags is equal to two.

[15] The models that assess the effect of public spending on private investment have 3 lags (high WUI) and one lag (low WUI). The models that analyse the effects on private consumption have one lag .

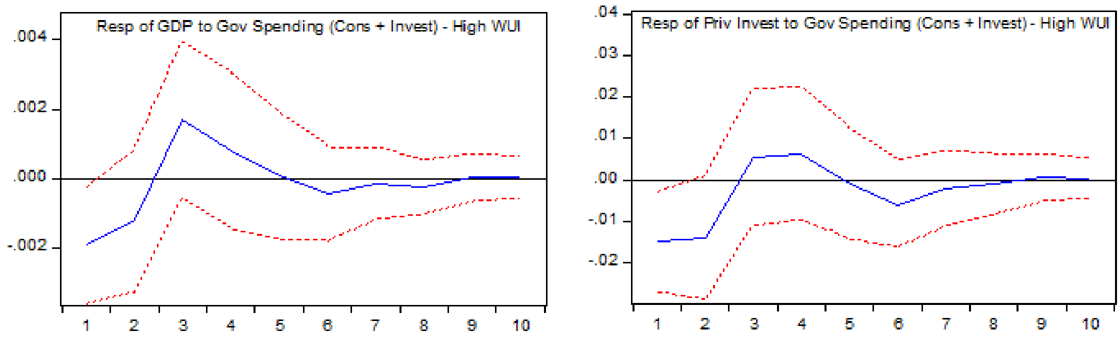

Figure 14: Impulse Response Function – GDP, Priv. Investment and High WUI (model 2 Gov Spending USA). Source: Authors' calculations.

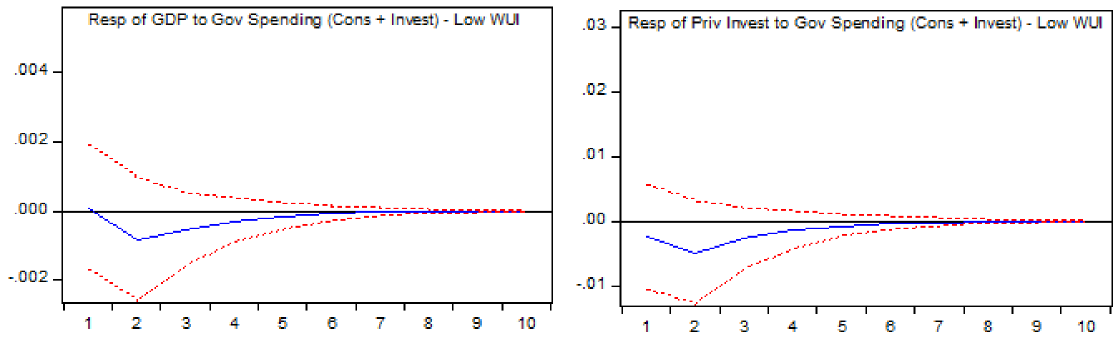

Figure 15: Impulse Response Function - GDP, Priv. Investment and Low WUI (model 2 Gov Spending USA). Source: Authors' calculations.

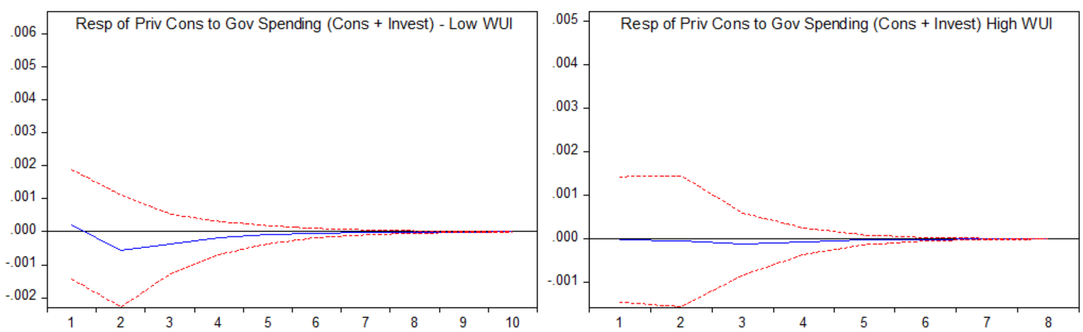

Figure 16: Impulse Response Function - Priv. Consumption High and Low WUI (model 2 Gov Spending USA). Source: Authors' calculations.

The following figure highlights the fiscal multipliers for model 1 and for models associated with the EPU and WUI indexes (model 2). Model 1 presents the multipliers in two different ways. The first uses the complete set of data, as observed in the traditional literature. The second presents the multipliers in two uncertainty scenarios: high and low

EPU. Finally, the results for model 2 are presented, considering the EPU and WUI, both for the high and low uncertainty scenarios.

As we can observe, the reflexes of uncertainty are transmitted to the multipliers. In an environment of high uncertainty, agents are more cautious and postpone some decisions. Therefore, a greater fiscal effort is needed to achieve the same results observed under conditions of economic normality.

Table 5: Fiscal Multipliers: Government Consumption and Investment- USA

Model (USA)	Scenario	Impact Multipier	Cumul. Multiplier (t=4)
1	Traditional	1.062	0.241
1	EPU - High	0.395	-0.216
1	EPU - Low	0.837	0.417
2	EPU - High	-0.009	-0.013
2	EPU - Low	-0.003	-0.004
2	WUI - High	-4.034	-0.768
2	WUI - Low	0.753	-8.897

Source: Authors' calculations.

For the traditional scenario (model 1), the impact and accumulated multipliers are statistically different from zero until the third quarter (±2S.E) and after that quarter the lower band is very close to the horizontal axis. Thus, the impulses are very similar to the findings of Blanchard and Perotti (2002). They describe that the bands are wide and the IRF of GDP becomes statistically insignificant after one year. Our estimates are also in line with different studies that demonstrate that public investment multiplier (impact) is greater than one.

Our findings suggest that the government spending shock has a positive effect on GDP, with typically Keynesian responses. Moreover, regardless of the uncertainty index used, the influence of high uncertainty on economic activity is negative, and a reduction in the effectiveness of fiscal multipliers.

5.3 Model 1: Brazil (1996Q1 – 2018Q4)

In this model, some adjustments were necessary, due to the unavailability of data for public and private investments. In this sense, government spending is associated with government consumption. The variables are the log differences of real output (GDP), Government Consumption (GC) and Household Consumption (HC).

Our basic specification is:

$$Y_t = C + \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_t \tag{19}$$

Here, C denotes a (3x1) vector of intercept terms, $_t$ represents the (3x1) vector of the three endogenous variables. A is the matrix of autoregressive coefficients of order (3x3).

$Y_t = [\Delta \ln GC_t, \Delta \ln HC_t, \Delta \ln GDP_t]$ The vector of disturbances is $\varepsilon_t = \left[\varepsilon_t^{GC}, \varepsilon_t^{HC}, \varepsilon_t^{GDP}\right]$.

The appropriate number of lags for the system is estimated with a model for stationary series. Based on Akaike Information the optimal lag is 5. The model is stable, all inverse roots of the characteristic polynomial lie within the unit circle, the assumptions associated with the residues was verified, and there is no autocorrelation. We also conclude that p-value does not allow rejecting, for any assumed level of significance, the null hypothesis of homoskedasticity.

Table 6: Lag Order Selection Criteria (Model 1 Brazil).

Lag	LogL	LR	FPE	AIC	SC	HQ
0	775.5900	NA	1.65e-12	-18.61663	-18.52920*	-18.58150
1	791.4227	30.13942	1.40e-12	-18.78127	-18.43156	-18.64078*
2	796.8253	9.893758	1.53e-12	-18.69458	-18.08259	-18.44872
3	802.9587	10.78904	1.64e-12	-18.62551	-17.75123	-18.27428
4	819.7708	28.35762	1.37e-12	-18.81375	-17.67719	-18.35715
5	832.4824	20.52241*	1.26e-12*	-18.90319*	-17.50434	-18.34121
6	838.6160	9.458971	1.36e-12	-18.83412	-17.17299	-18.16677
7	847.1815	12.59030	1.39e-12	-18.82365	-16.90023	-18.05093
8	857.9680	15.07519	1.36e-12	-18.86670	-16.68100	-17.98861

Source: Authors' calculations.

Figure 17 depicts the impulse response function of a government consumption shock. As in the results for US models, public spending plays an important role in stimulating household consumption and economic activity. The impulse response functions indicate the positive effect of public spending (consumption). The cumulative effects remain for more than 10 quarters for household consumption and GDP.

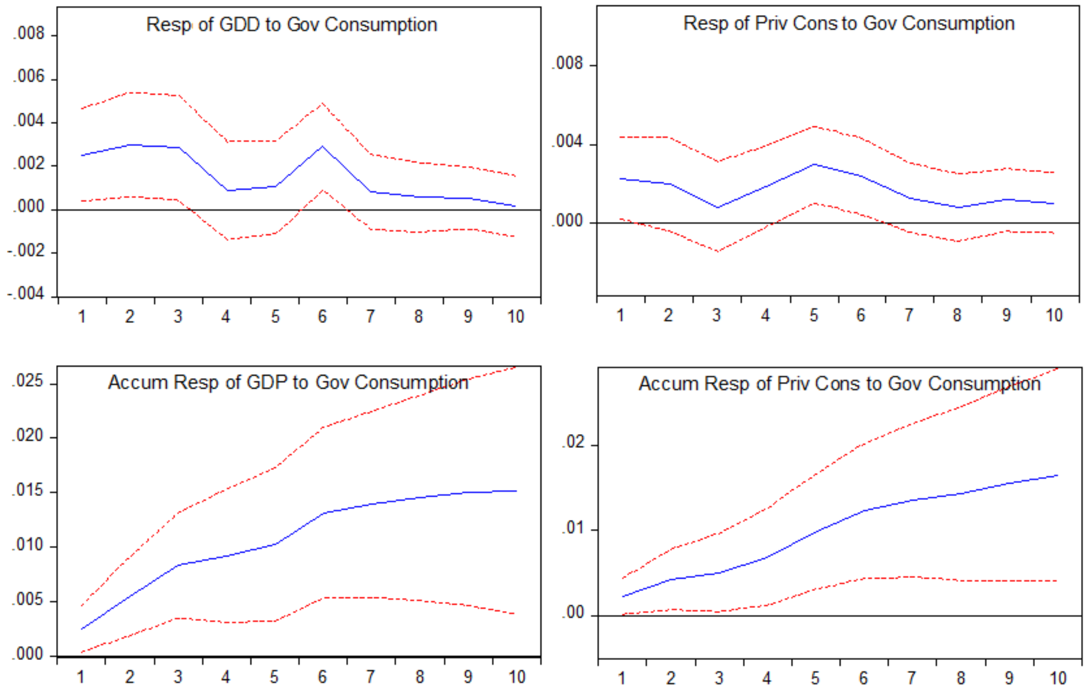

Figure 17: Impulse Response Function (Model 1 Brazil). Source: Authors' calculations.

The variance decomposition of GDP shows an increasing relevance of public spending over the quarters. We can see a similar conclusion for the household consumption.

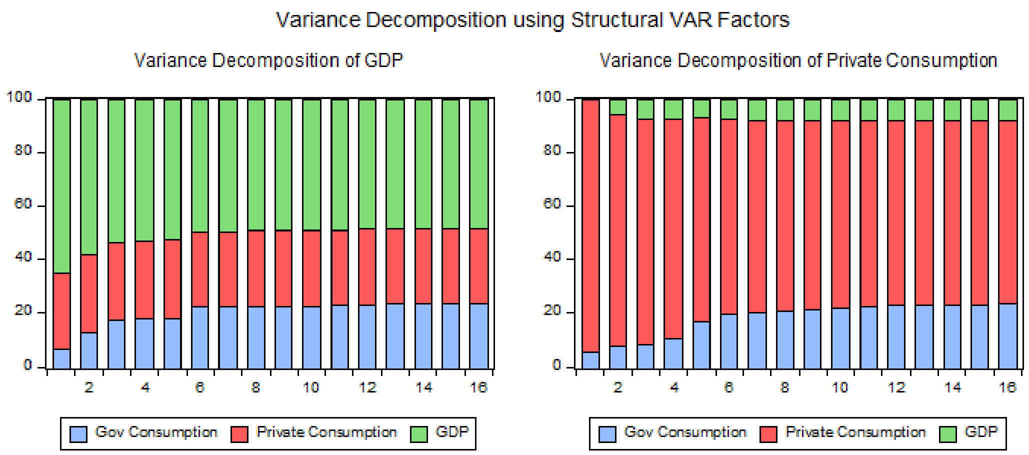

Figure 18: Variance Decomposition (Model 1 Brazil). Source: Authors' calculations.

The present paper differs from some studies that point to null or negative multipliers for developing economies. However, our estimates are in accordance with the results of Carrière-Swallow et al. (2018) and Peres (2006). The latter also used a model based on Blanchard and Perotti (2002). For data from 1994 to 2005, the author found Keynesian responses to GDP after government spending shocks.

5.4 Model 2: Brazil (1996Q1 - 2018Q4)

Similarly to the US models, we evaluate the effects of uncertainty on the Brazilian economy. Therefore, in this model our specification is:

$$Y_t = A + BX_t + \sum_{i=1}^{p} (CY_{t-1} + DY_{t-1}X_{t-1}) + \varepsilon_t \tag{20}$$

Where: A is a (3x1) vector of intercept terms; The vector of disturbances is $\varepsilon_t = \left[\varepsilon_t^{GC}, \varepsilon_t^{HC} \varepsilon_t^{GDP}\right]$.

$$Y_t^{high} = \widehat{A_0} + \widehat{B_0}^{\text{high}} . \widehat{X_0} + \sum_{i=1}^{p} \left(\widehat{B_i}^{\text{high}} . Y_{t-i} \right) + \widehat{E_t} \tag{21}$$

$$Y_t^{Low} = \widehat{A_0} + \widehat{B_0}^{\text{Low}} . \widehat{X_0} + \sum_{i=1}^{p} \left(\widehat{B_i}^{\text{Low}} . Y_{t-i} \right) + \widehat{E_t} \tag{22}$$

The first conclusion that we can make is that public consumption has a statically-significant expansionary impact when uncertainty is low. After examining the simulations, we observe that government consumption maintains their cumulative effect on GDP and households consumption. Conversely, when the uncertainty index is high the effects on economic activity as well as on private consumption are negative (statically-insignificant). Thus, the results suggest that the high uncertainty does not encourage household consumption[16].

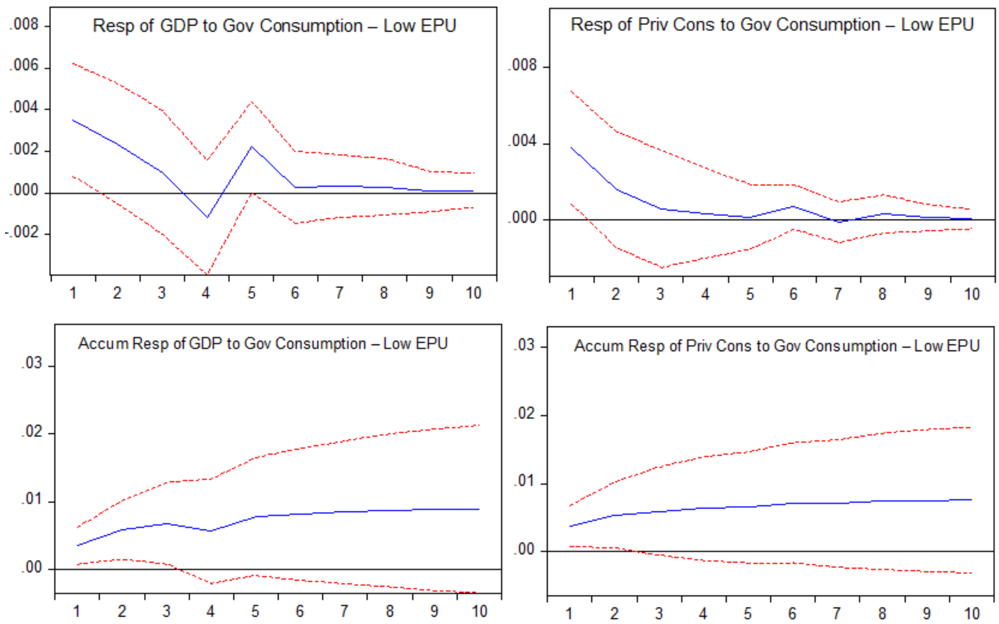

Figure 19: Impulse Response Function (model 2 EPU Low -Brazil). Source: Authors' calculations.

[16]Based on Akaike Information, the optimal lag is 1 (High EPU) and 3 (Low EPU).

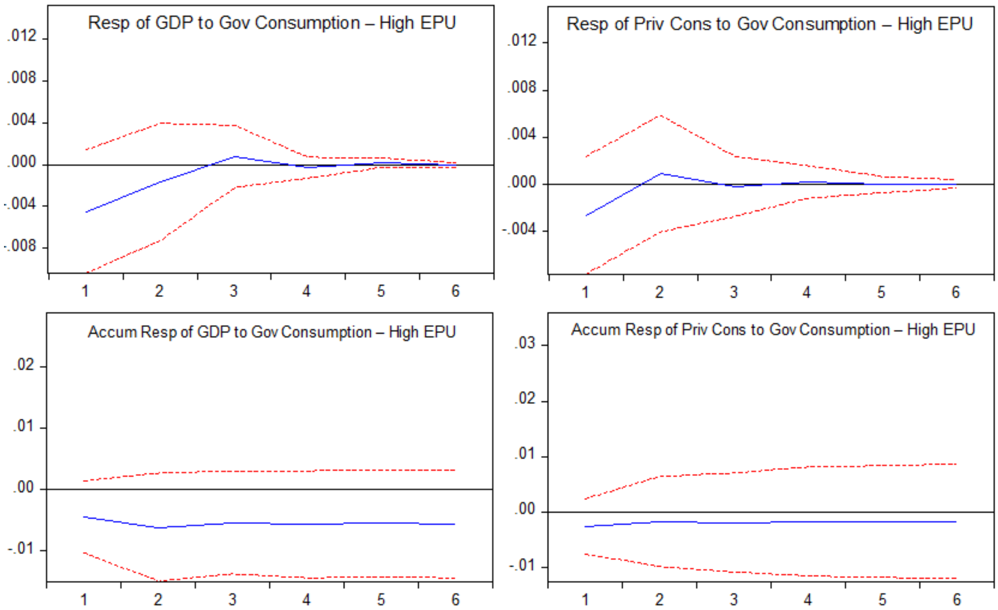

Figure 20: Impulse Response Function (model 2 EPU High - Brazil). Source: Authors' calculations.

As in the United States model, we replaced the EPU index with the World Uncertainty Index (WUI)[17]. The results indicate that fiscal innovations (Low WUI) have positive effects on economic activity. However, when public consumption is associated with the WUI-High, it has more subtle effects on economic activity.

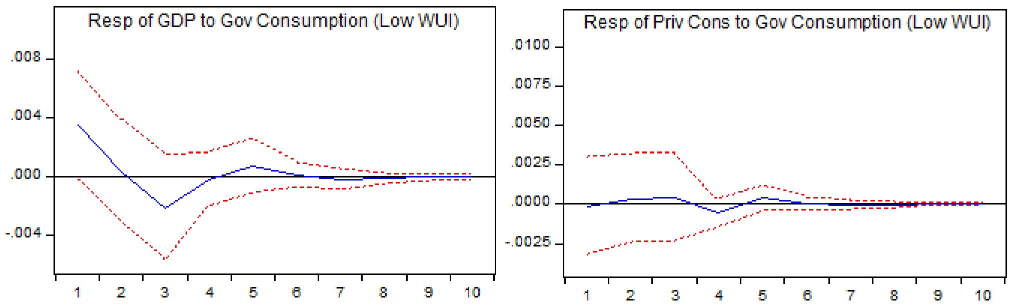

Figure 21: Impulse Response Function (model 2 WUI Low - Brazil). Source: Authors' calculations.

[17]High WUI - three lags, and Low WUI - two lags. As in previous models, these models are stable, since all inverse roots are within the unit circle. The assumptions associated with the residuals were verified

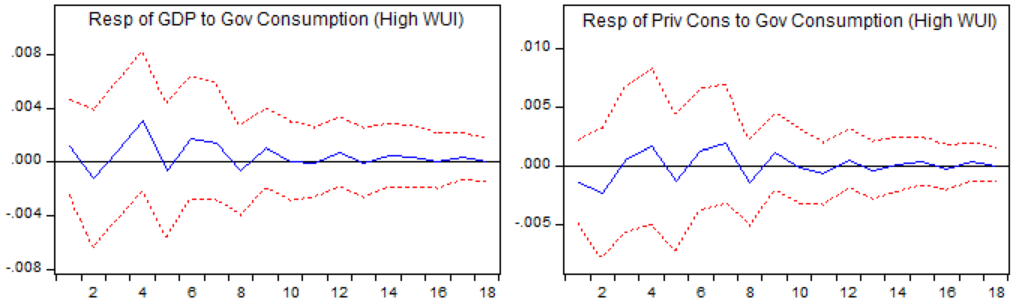

Figure 22: Impulse Response Function (model 2 WUI High - Brazil). Source: Authors' calculations.

The results with EPU and WUI present quite clear indications. When there is a high level of uncertainty, the effect of government consumption on private consumption and GDP is low or close to zero. Therefore, high uncertainty inhibits consumption and output. On the other hand, when we observe a more predictable scenario, the effects of fiscal shocks are positive and with statistically significant results.

Regarding the effects of uncertainty on consumer decisions and GDP, we find qualitative similar results to those in the United States. In other words, an uncertain environment creates a reducing effect on consumption, spreading out into the economy.

The figure below highlights the multipliers for the models investigated. The results presented point to evidence that moments of high uncertainty and the increased precaution of agents are factors that can influence the effectiveness of fiscal policy.

Table 7: Fiscal Multipliers: Government Consumption - Brazil

Model (Brazil)	Scenario	Impact Multipier	Cumul. Multiplier (t=4)
1	Traditional	1.054	4.589
1	EPU - High	-2.134	-22.40
1	EPU - Low	0.915	2.413
2	EPU - High	-0.010	0.023
2	EPU - Low	0.018	0.047
2	WUI - High	0.871	2.614
2	WUI - Low	8.636	0.000

Source: Authors' calculations.

6 Conclusion

In recent years, the effects of fiscal multipliers have aroused interest of policymakers and researchers. Despite being a crucial issue, there is no consensus for advanced economies and emerging countries. At the same time, the different uncertainty measures have received considerable attention. This is motivated because high uncertainty may encourage agents to postpone investment and consumption decisions. This paper contributes to this debate by highlighting the channels and effects of uncertainty that, combined with fiscal stimulus, interfere with economic growth.

Our findings indicate the presence of Keynesian effects. For traditional models, increases in public expenditures have a positive effect on household consumption and economic activity. We also find indications of the crowding-out effect of public expenditures on private investment in the United States. For both countries, fiscal multipliers are positive in the first quarter (impact) with 95% confidence. Contrary to what many studies indicate, emerging countries with a high debt/GDP ratio may have positive fiscal multipliers.

As emphasised in the literature, our findings confirm that innovations in the uncertainty indexes foreshadow declines in economic activity. In addition, there is evidence that fiscal policy is less efficient in this context. We found evidence that uncertainty shocks dampen private investment and household consumption, in line with the Real Options approach. Thus, the increase in uncertainty hampers fiscal stimulus, as we observed in the results of the impulse response functions.

For US data, the effects of uncertainty are clear when it reaches high levels. However, low uncertainty does not seem to stimulate individuals, suggesting that decisions are reviewed for more pessimistic scenarios. For Brazil, the results indicate that fiscal policy is more effective when uncertainty is low. Thus, our results point to cautious individuals when the high uncertainty overshadows the definition of an economic scenario.

Despite this evidence, our investigation has limitations. We believe that a study that considers a larger sample of developing countries, can confirm the findings and bring new information about the effects of uncertainty and fiscal policy in emerging countries.

The findings of this study can assist in the formulation or simulation of future fiscal strategies, considering non-Ricardian agents. Specifically, for the Brazilian case, to support the debate on the current rules of contingency to fiscal stimulus and the need to mitigate the effects of the COVID-19 pandemic.

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A Appendix

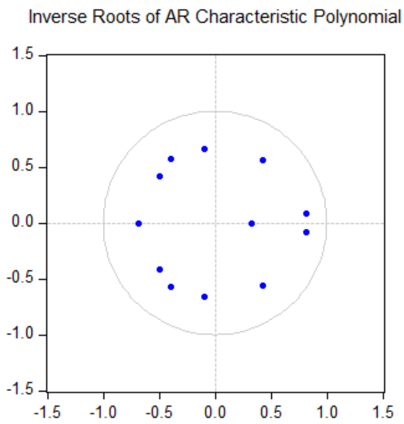

Figure A1: Model 1 USA

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	7.580015	9	0.5770	0.843033	(9, 284.9)	0.5770
2	11.64763	9	0.2339	1.304643	(9, 284.9)	0.2340
3	5.876766	9	0.7522	0.651667	(9, 284.9)	0.7522
4	18.62112	9	0.0286	2.111333	(9, 284.9)	0.0286

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	7.580015	9	0.5770	0.843033	(9, 284.9)	0.5770
2	17.79897	18	0.4690	0.991348	(18, 322.9)	0.4692
3	22.49626	27	0.7118	0.829678	(27, 324.8)	0.7123
4	41.44086	36	0.2453	1.163120	(36, 319.8)	0.2467

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A2: Model 1 USA - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.068704	0.106206	1	0.7445
2	-0.219754	1.086569	1	0.2972
3	-0.015135	0.005154	1	0.9428
Joint		1.197929	3	0.7535

Component	Kurtosis	Chi-sq	df	Prob.
1	2.854895	0.118437	1	0.7307
2	3.233910	0.307767	1	0.5791
3	3.854393	4.106175	1	0.0427
Joint		4.532379	3	0.2094

Component	Jarque-Bera	df	Prob.
1	0.224643	2	0.8938
2	1.394336	2	0.4980
3	4.111329	2	0.1280
Joint	5.730308	6	0.4541

*Approximate p-values do not account for coefficient estimation

Figure A3: Model 1 USA - VAR Residual Normality Tests

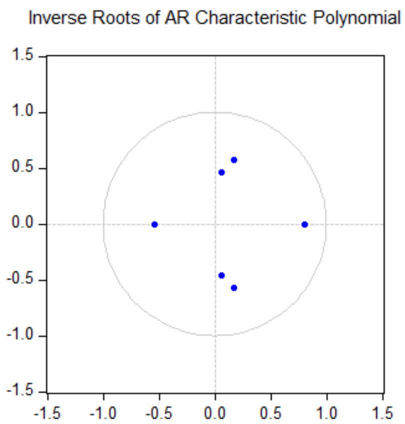

Figure A4: Model 2 (EPU-High) USA

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	9.811922	9	0.3659	1.118922	(9, 48.8)	0.3677
2	9.165912	9	0.4221	1.038627	(9, 48.8)	0.4239

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	9.811922	9	0.3659	1.118922	(9, 48.8)	0.3677
2	22.23431	18	0.2217	1.299191	(18, 48.6)	0.2303

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A5: Model 2 (EPU-High) USA - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.307153	0.518888	1	0.4713
2	0.145244	0.116027	1	0.7334
3	-0.451357	1.120475	1	0.2898
Joint		1.755390	3	0.6247

Component	Kurtosis	Chi-sq	df	Prob.
1	2.293471	0.686376	1	0.4074
2	2.475813	0.377811	1	0.5388
3	3.046144	0.002928	1	0.9568
Joint		1.067115	3	0.7850

Component	Jarque-Bera	df	Prob.
1	1.205264	2	0.5474
2	0.493838	2	0.7812
3	1.123403	2	0.5702
Joint	2.822505	6	0.8308

*Approximate p-values do not account for coefficient estimation

Figure A6: Model 2 (EPU-High) USA - VAR Residual Normality Tests

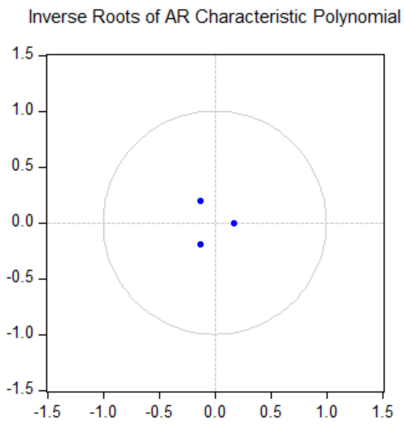

Figure A7: Model 2 (EPU-Low) USA

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	12.09612	9	0.2079	1.367467	(9, 143.7)	0.2082
2	7.552107	9	0.5798	0.840548	(9, 143.7)	0.5800

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	12.09612	9	0.2079	1.367467	(9, 143.7)	0.2082
2	21.66126	18	0.2474	1.223396	(18, 158.9)	0.2484

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A8: Model 2 (EPU-Low) USA - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	-0.165074	0.313369	1	0.5756
2	0.253483	0.738917	1	0.3900
3	0.058959	0.039976	1	0.8415
Joint		1.092262	3	0.7789

Component	Kurtosis	Chi-sq	df	Prob.
1	3.487418	0.683033	1	0.4085
2	2.065126	2.512717	1	0.1129
3	2.686539	0.282490	1	0.5951
Joint		3.478240	3	0.3236

Component	Jarque-Bera	df	Prob.
1	0.996402	2	0.6076
2	3.251634	2	0.1968
3	0.322466	2	0.8511
Joint	4.570502	6	0.6000

*Approximate p-values do not account for coefficient estimation

Figure A9: Model 2 (EPU-Low) USA - VAR Residual Normality Tests

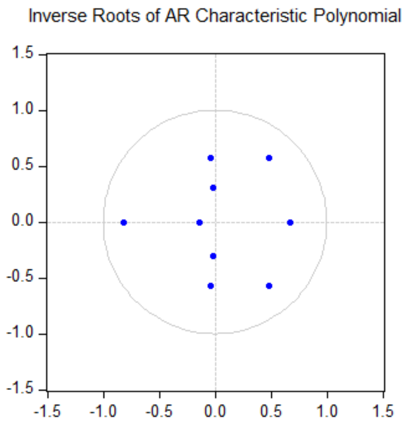

Figure A10: Model 2 (WUI-High) USA

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	8.241294	9	0.5100	0.927271	(9, 39.1)	0.5126
2	5.584605	9	0.7807	0.608545	(9, 39.1)	0.7821
3	5.970337	9	0.7429	0.653597	(9, 39.1)	0.7445

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	8.241294	9	0.5100	0.927271	(9, 39.1)	0.5126
2	13.37498	18	0.7688	0.711697	(18, 37.3)	0.7778
3	19.99051	27	0.8312	0.666917	(27, 29.8)	0.8544

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A11: Model 2 (WUI-High) USA - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	-0.620348	2.052436	1	0.1520
2	-0.011681	0.000728	1	0.9785
3	0.865343	3.993698	1	0.0457
Joint		6.046862	3	0.1094

Component	Kurtosis	Chi-sq	df	Prob.
1	4.223765	1.996802	1	0.1576
2	4.534811	3.140861	1	0.0764
3	3.574856	0.440613	1	0.5068
Joint		5.578276	3	0.1340

Component	Jarque-Bera	df	Prob.
1	4.049239	2	0.1320
2	3.141588	2	0.2079
3	4.434310	2	0.1089
Joint	11.62514	6	0.0709

*Approximate p-values do not account for coefficient estimation

Figure A12: Model 2 (WUI-High) USA - VAR Residual Normality Tests

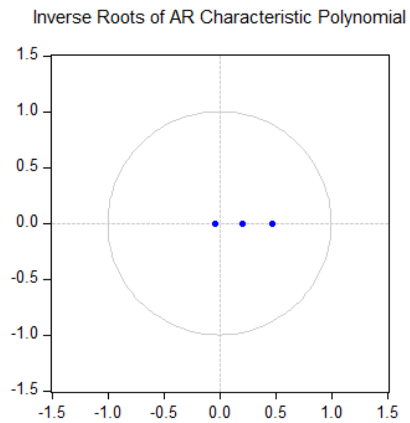

Figure A13: Model 2 (WUI-Low) USA

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	4.713891	9	0.8585	0.516510	(9, 82.9)	0.8587
2	5.778333	9	0.7619	0.637095	(9, 82.9)	0.7623

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	4.713891	9	0.8585	0.516510	(9, 82.9)	0.8587
2	15.61500	18	0.6194	0.863546	(18, 88.2)	0.6222

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A14: Model 2 (WUI-Low) USA - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	-0.110887	0.090170	1	0.7640
2	-0.670105	3.292967	1	0.0696
3	0.122064	0.109265	1	0.7410
Joint		3.492402	3	0.3217

Component	Kurtosis	Chi-sq	df	Prob.
1	3.466529	0.399023	1	0.5276
2	3.860859	1.358644	1	0.2438
3	3.045342	0.003769	1	0.9510
Joint		1.761437	3	0.6234

Component	Jarque-Bera	df	Prob.
1	0.489193	2	0.7830
2	4.651612	2	0.0977
3	0.113034	2	0.9451
Joint	5.253839	6	0.5117

*Approximate p-values do not account for coefficient estimation

Figure A15: Model 2 (WUI-Low) USA - VAR Residual Normality Tests

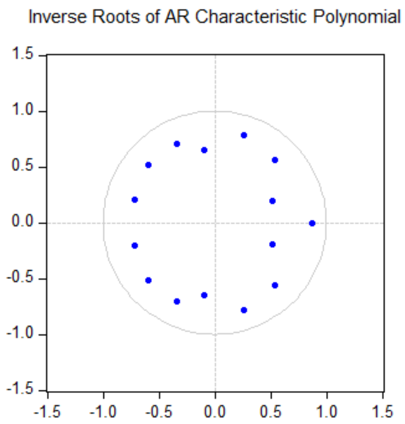

Figure A16: Model 1 Brazil

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	17.73257	9	0.0384	2.037246	(9, 158.3)	0.0385
2	17.33893	9	0.0437	1.989556	(9, 158.3)	0.0437
3	21.90708	9	0.0092	2.550183	(9, 158.3)	0.0092
4	16.24496	9	0.0619	1.857631	(9, 158.3)	0.0620
5	17.04789	9	0.0480	1.954371	(9, 158.3)	0.0481

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	17.73257	9	0.0384	2.037246	(9, 158.3)	0.0385
2	33.46687	18	0.0146	1.950514	(18, 175.8)	0.0148
3	40.36703	27	0.0473	1.557687	(27, 173.0)	0.0482
4	49.10739	36	0.0714	1.419246	(36, 166.2)	0.0738
5	69.50760	45	0.0110	1.660233	(45, 158.2)	0.0121

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A17: Model 1 Brazil - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.476400	3.253045	1	0.0713
2	-0.508539	3.706774	1	0.0542
3	-0.443807	2.823165	1	0.0929
Joint		9.782983	3	0.0205

Component	Kurtosis	Chi-sq	df	Prob.
1	3.346969	0.431389	1	0.5113
2	3.761691	2.078955	1	0.1493
3	5.449989	21.50877	1	0.0000
Joint		24.01911	3	0.0000

Component	Jarque-Bera	df	Prob.
1	3.684434	2	0.1585
2	5.785729	2	0.0554
3	24.33193	2	0.0000
Joint	33.80209	6	0.0000

*Approximate p-values do not account for coefficient estimation

Figure A18: Model 1 Brazil - VAR Residual Normality Tests

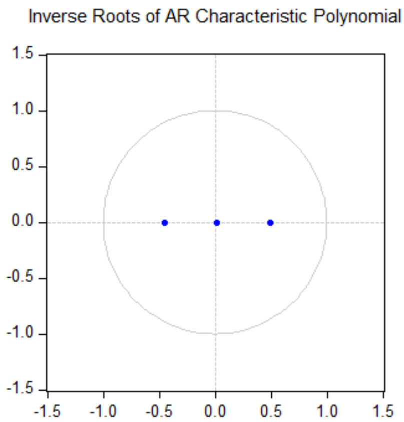

Figure A19: Model 2 (EPU-High) Brazil

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	6.543909	9	0.6845	0.718859	(9, 29.4)	0.6877
2	4.212793	9	0.8969	0.446220	(9, 29.4)	0.8981

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	6.543909	9	0.6845	0.718859	(9, 29.4)	0.6877
2	14.64772	18	0.6860	0.777746	(18, 25.9)	0.7059

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A20: Model 2 (EPU-High) Brazil - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.670758	1.649691	1	0.1990
2	-0.250252	0.229628	1	0.6318
3	-0.654145	1.568988	1	0.2104
Joint		3.448307	3	0.3275

Component	Kurtosis	Chi-sq	df	Prob.
1	3.329312	0.099409	1	0.7525
2	2.030450	0.861691	1	0.3533
3	2.698100	0.083548	1	0.7725
Joint		1.044649	3	0.7905

Component	Jarque-Bera	df	Prob.
1	1.749100	2	0.4170
2	1.091320	2	0.5795
3	1.652536	2	0.4377
Joint	4.492956	6	0.6103

*Approximate p-values do not account for coefficient estimation

Figure A21: Model 2 (EPU-High) Brazil - VAR Residual Normality Tests

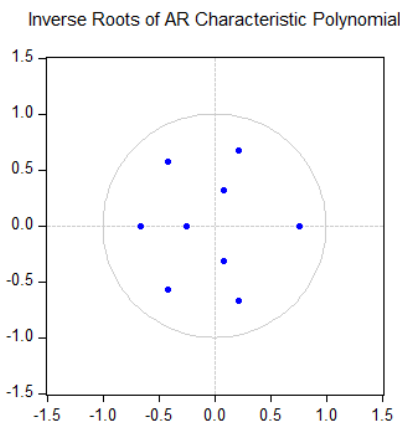

Figure A22: Model 2 (EPU-Low) Brazil

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	9.660089	9	0.3787	1.095058	(9, 61.0)	0.3799
2	10.84208	9	0.2867	1.240663	(9, 61.0)	0.2879
3	14.61374	9	0.1021	1.723531	(9, 61.0)	0.1029

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	9.660089	9	0.3787	1.095058	(9, 61.0)	0.3799
2	27.82766	18	0.0647	1.680028	(18, 62.7)	0.0676
3	34.09342	27	0.1633	1.337569	(27, 56.1)	0.1775

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A23: Model 2 (EPU-Low) Brazil - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.845627	4.886418	1	0.0271
2	-0.191955	0.251786	1	0.6158
3	-0.274701	0.515649	1	0.4727
Joint		5.653853	3	0.1297

Component	Kurtosis	Chi-sq	df	Prob.
1	5.422664	10.02672	1	0.0015
2	2.712570	0.141136	1	0.7072
3	3.040994	0.002871	1	0.9573
Joint		10.17073	3	0.0172

Component	Jarque-Bera	df	Prob.
1	14.91314	2	0.0006
2	0.392922	2	0.8216
3	0.518520	2	0.7716
Joint	15.82458	6	0.0147

*Approximate p-values do not account for coefficient estimation

Figure A24: Model 2 (EPU-Low) Brazil - VAR Residual Normality Tests

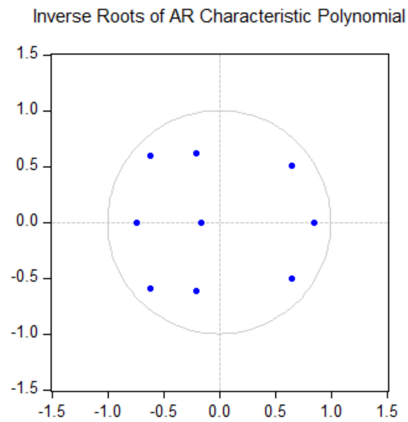

Figure A25: Model 2 (WUI-High) Brazil

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	6.423645	9	0.6969	0.676505	(9, 9.9)	0.7158
2	12.08203	9	0.2087	1.610301	(9, 9.9)	0.2352
3	10.17498	9	0.3365	1.250621	(9, 9.9)	0.3651

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	6.423645	9	0.6969	0.676505	(9, 9.9)	0.7158
2	17.55840	18	0.4851	0.684963	(18, 3.3)	0.7420
3	474.7965	27	0.0000	NA	(27, NA)	NA

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A26: Model 2 (WUI-High) Brazil - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	0.317614	0.336262	1	0.5620
2	-0.357538	0.426112	1	0.5139
3	0.496302	0.821052	1	0.3649
Joint		1.583427	3	0.6632

Component	Kurtosis	Chi-sq	df	Prob.
1	3.624615	0.325120	1	0.5685
2	2.313534	0.392697	1	0.5309
3	2.497395	0.210510	1	0.6464
Joint		0.928327	3	0.8186

Component	Jarque-Bera	df	Prob.
1	0.661383	2	0.7184
2	0.818809	2	0.6640
3	1.031563	2	0.5970
Joint	2.511754	6	0.8671

*Approximate p-values do not account for coefficient estimation

Figure A27: Model 2 (WUI-High) Brazil - VAR Residual Normality Tests

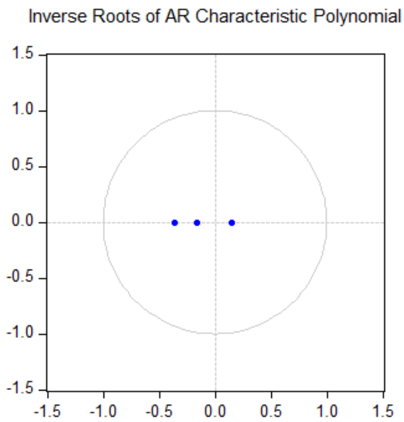

Figure A28: Model 2 (WUI-Low) Brazil

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	45.88952	9	0.0000	7.123212	(9, 58.6)	0.0000

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	45.88952	9	0.0000	7.123212	(9, 58.6)	0.0000

*Edgeworth expansion corrected likelihood ratio statistic.

Figure A29: Model 2 (WUI-Low) Brazil - VAR Residual Serial Correlation LM Tests

Component	Skewness	Chi-sq	df	Prob.*
1	-0.834921	3.950197	1	0.0469
2	-0.247076	0.345929	1	0.5564
3	-0.871201	4.300954	1	0.0381
Joint		8.597080	3	0.0352

Component	Kurtosis	Chi-sq	df	Prob.
1	4.133909	1.821478	1	0.1771
2	2.523681	0.321413	1	0.5708
3	3.312323	0.138190	1	0.7101
Joint		2.281081	3	0.5162

Component	Jarque-Bera	df	Prob.
1	5.771675	2	0.0558
2	0.667342	2	0.7163
3	4.439144	2	0.1087
Joint	10.87816	6	0.0922

*Approximate p-values do not account for coefficient estimation

Figure A30: Model 2 (WUI-Low) Brazil - VAR Residual Normality Tests