Uncertainty and the effectiveness of fiscal policy in the United States and Brasil: SVAR Approach

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The paper analyses the interference of uncertainty on the effectiveness of fiscal policy. This issue is investigated through the lens of a Structural Vector Auto Regressive (SVAR) model for the United States and Brazil. Imposing government spending shocks, the models highlight a positive effect on economic activity. The results suggest Keynesian effects on consumption and GDP. To assess the effects of uncertainty, the models use two indices: the Economic Policy Uncertainty Index (EPU) and the World Uncertainty Index (WUI). The findings indicate that the fiscal effects are considerably less intense when uncertainty reaches high levels, consistent 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, The United States, Brazil.

1. Introduction

The global financial crisis (2007-2008) and the outbreak of the COVID 19 pandemic stimulated a renewed academic debate on the effectiveness of fiscal instruments. Regarding the period after the financial crisis, governments worldwide adopted expansionary fiscal policies to mitigate adverse shocks. The sudden spread of the coronavirus pandemic brought to light the threat of a recession of unusual features, surrounded by new and old uncertainties. A global trend is that, after these shocks, a fiscal policy response can recover economies repressed by a unique combination of supply and demand shocks. Despite this trend, there is no established consensus since the results of the fiscal impulse can be dubious and partially innocuous. This ineffectiveness can be analysed in the light of factors such as uncertainty.

Inspired by the works of Aastveit et al. (2013) and Blanchard & Perotti (2002), we investigate these issues through the lens of a SVAR model. The findings suggest that fiscal stimulus is less intense when uncertainty is high, indicating an uncertainty transmission channel consistent with the Real Options approach.

Throughout economic history, with a greater or lesser degree of contagion and persistence, the economies are affected by shocks of uncertainty, panic and resulting economic slowdown. According to Baum & Koester (2011), monetary policy alone cannot foster economic activity, particularly because many countries reached the Zero Lower Bound (ZLB)\(^1\).

The United States (U.S.) reacted with new actions to overcome or at least mitigate the effects of the international crisis (2007/2008) and recession. Stimulus packages were developed, emphasising fiscal policy, such as the American Recovery and Reinvestment Act\(^2\) in 2010 (Page, 2011) and Biden’s Economic Plan (2021). Among other objectives, the plans aim to preserve and create jobs, promote economic recovery, and invest in transportation and infrastructure to provide long-term benefits. Similar stimuli were implemented within the European Economic Area, Canada and Japan (Caldara & Kamps, 2017).

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.

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1 Depending on the degree of accommodation of monetary policy (greater or lesser), a fiscal stimulus can have different effects on fiscal multipliers. In the case of ZLB, we observe a scenario with the interest rate reaching the lower limit of zero.

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

Considering this, experts analyse 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 vary 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.

In addition to the conjunctural and structural factors, the fiscal instruments (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.

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 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 signalled through the 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.

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. 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.

Regarding the need to contain the state's growth, Rezende & Cunha (2013) indicate that although there is an understanding of the need for reforms, there are considerable divergences in scope and especially in the way they are carried out. For the authors, the issue 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) points out 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 stabilisation agenda that is too rigid and not feasible to accomplish.

Just as the role of fiscal policy, uncertainty shocks (international crises, political instability and corruption) arouse 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 the economy and welfare. There is an even greater shortage of research for emerging countries, especially Brazil (Gechert & Rannenberg, 2018; Barboza & Zilberman, 2018). Bloom (2014) suggests that high levels

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3 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.
of uncertainty make consumers and investors more cautious and disrupt the effectiveness of public policies, especially in developing economies.

In this sense, decision-making by economic agents involves the formation of expectations supported by the quality and quantity of information available. Therefore, the construction of 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 them may vary.

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. Baker et al. (2016) develop 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. (2022) provide a new index, the World Uncertainty 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.

Figures 2 and 3 provide an overview of an uncertainty indicator for the U.S. (1985 - 2019) and Brazil (1996 - 2018). The graphs present the different moments with high and low uncertainty. In this case, uncertainty is measured by the EPU. We also added the growth of the real Gross Domestic Product (GDP).

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4 Low Uncertainty ≤ 2nd quartile and High Uncertainty ≥ 3rd quartile.
5 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.
This paper investigates the effects of uncertainty shocks on the effectiveness of fiscal policy for the U.S. and Brazil. They are the two largest democracies in the Western Hemisphere. The first stands out as one of the most prominent economies and a key player in world geopolitics. Despite Brazil being among the ten largest economies in the world (the largest in Latin America) and a strategic partner of the OECD, there is still a relative scarcity of research.

Our 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. In this sense, the main contribution is to analyse 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.

In order to achieve these objectives, two models are examined for each country. First, they present standard fiscal multipliers and examine the effects of fiscal policy on economic performance. The second model investigates how the intensity of the multipliers is affected when it controls the effects of the interaction of uncertainty with fiscal policy shocks. For this purpose, the paper employs the EPU and WUI.

The findings point to the presence of Keynesian effects. For both countries increases in public spending positively affect household consumption and the level of economic activity. They also point to the crowding-out effect of public spending on private investment in the U.S.

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

For many years we have observed the two main strands of economic thought (New Classical and Keynesian) arguing about the dynamics of the economic system. The first advocates that the economy must be governed by market self-regulation for rapid and effective development and has its origins in the work of Adam Smith. Therefore, the market economy efficiently coordinates the allocation of resources. On the other hand, the second strand focuses its attention on the limitations of capitalism, especially in periods of massive unemployment. For adherents of this vision, such manifestations are not of an efficient system, condemning society to social problems that result from unemployment.

For Greenwald & Stiglitz (1987), Keynes reconciled the two perspectives, advocating that government intervention could correct market failures and the economy would return to operating as in the Classical view. Later this was called the Neoclassical Synthesis by Samuelson.

Therefore, the different perspectives are transferred to Classical or New Classical models and Keynesian models, providing quite different predictions about the outcome of a fiscal stimulus. The
Classical approach advocates that an increase in government spending produces a decline in private consumption. In contrast, the Keynesian model indicates that consumption should increase, multiplying the effects of expanding government spending on GDP. The root of these opposed results rests mainly on the assumptions of how the consumer behaves.

In this sense, Galí et al. (2007) emphasise the two central versions and the effects of fiscal stimulus. For the New Classical version, the households behave in a Ricardian fashion (infinitely-lived) and consumption decisions are based on an intertemporal budget constraint. Therefore, a fiscal stimulus decreases the present value of disposable income and reduces consumption owing to a negative wealth effect. 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 and not on resources throughout their lifetime.

Burda & Wyplosz (2013), examine different studies and point out that the Ricardian approach has many controversial consequences and there are contrary to and in favour of this hypothesis. The authors highlight studies for Germany, the U.S., and Belgium (1974-1994) that do not support the Ricardian hypothesis. Evans & Hasan (1994) investigate whether Canadian consumers behave like Ricardian agents, and the tests indicate 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) investigates 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) study the effects of government spending in the Chilean economy. The article provides evidence that consumption and GDP increase when the government raises spending and reveals large and robust fiscal multipliers. The presence of non-Ricardian households can explain the evidence and such existence is a crucial factor in understanding the government spending channel.

Some researchers (Issler & Lima, 2000; Vieira, 2006) do not accept the hypothesis of Ricardian equivalence for the Brazilian economy. Candelária (2012) uses 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.

According to the 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.
Studies for the U.S. suggest fiscal multipliers between 0.75 and 2.25 for macroeconomic forecasting models and between 0.3 and 3.5 for time series models (Reichling & Whalen, 2012). Ramey (2019) analyses 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 lower 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 structures, such as the exchange rate regime.

Kilponen et al. (2019) indicate that 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 & Rannenberg, 2018). This perspective is referenced by the seminal article by Blanchard & Perotti (2002) for the U.S. economy. After this paper, the structural VAR (SVAR) approach was highlighted in the literature on fiscal multipliers and different authors added new variables to the system (Baum et al., 2012; Auerbach & Gorodnichenko, 2012; Huidrom et al., 2020).

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

\[ \mathcal{M}^{\text{Impact}} = \frac{\Delta Y(t)}{\Delta G(t)} \]  \hspace{1cm} (1)

\[ \mathcal{M}^{\text{Fixed horizon}} = \frac{\Delta Y(t+N)}{\Delta G(t)} \]  \hspace{1cm} (2)

\[ \mathcal{M}^{\text{Peak}} = \max(N) \frac{\Delta Y(t+N)}{\Delta G(t)} \]  \hspace{1cm} (3)

\[ \mathcal{M}^{\text{Cumulative}} = \frac{\sum_{i=0}^{N} \Delta Y(t+i)}{\sum_{i=0}^{N} \Delta G(t+1)} \]  \hspace{1cm} (4)

Despite extensive research (theoretical and empirical), there is still considerable disagreement about the size of fiscal multipliers. Batini et al. (2014) show 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 show that multipliers may exceed 1 under strong deceleration.

In the same vein, Caldara & Kamps (2017) indicate that the use of fiscal policy to stimulate the economy is a source of wide debate and lack of consensus in the literature. The authors propose that the divergence of results derives from different assumptions about fiscal rules. Thus, they suggest a different approach through an identification based on SVAR proxy with non-fiscal instruments to estimate the coefficients. The findings indicate that increased spending stimulated output more than reduced taxes.
In a recent paper, Kilponen et al. (2019) estimate the magnitude and sign of fiscal multipliers (short and long run) for European countries. A key result is that under the standard monetary policy the short-run multipliers present values smaller than one in the majority of simulations. 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 ZLB describes small impacts on the multipliers in the case of a transient measure adopted by a single country of the 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 the EA, the ZLB has an intense response on short-run government consumption multipliers (larger than one).

For developing economies there is still a relative scarcity of studies. Batini et al. (2014) and Gechert & Rannenberg (2018), argue that little is known about the size of fiscal multipliers for emerging economies, 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 it can be very negative in the long run.

Corroborating those perspectives, studies from the IMF 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 developed countries.

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

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

In opposite direction, Sanches & Carvalho (2019) develop a Structural VAR based on Blanchard & Perotti’s (2002) approach. They examine 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.

In general, the literature relies on two main approaches to derive fiscal multipliers: empirical approach and theoretical models such as Dynamic Stochastic General Equilibrium (DSGE) models. An advantage of DSGE models is that they describe each interaction of many microeconomic decisions, thus the
behaviour of the economic system. However, multipliers from DSGE models tend to be sensitive to model assumptions and features, and there is no consensus about the best modelling.

On the other hand, empirical models are often based on econometric estimation, examining the interactions of a few variables. However, the SVAR methodology also has some limitations in capturing purely exogenous fiscal shocks. To address this issue, some studies develop a narrative approach, using direct estimates of fiscal measures and official documents. There are also some attempts to combine the narrative approach and SVAR.

The following is a summary table of other contributions to fiscal multipliers. In the Brazilian case, we selected an article with public investment because of the relevance of the study and the magnitude of the results.

### Table 1. Examples of Fiscal Multiplier Analyses

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<tr>
<td><strong>Sample</strong></td>
<td>U.S.</td>
<td>U.S.</td>
<td>Developing and High Income (44 countries)</td>
<td>OECD countries</td>
<td>-</td>
<td>Eurozone</td>
<td>Brazil</td>
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<tr>
<td><strong>Method</strong></td>
<td>Narrative Approach</td>
<td>VAR</td>
<td>SVAR</td>
<td>SVAR</td>
<td>DSGE</td>
<td>SVAR</td>
<td>VAR</td>
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<tr>
<td><strong>Fiscal Shock</strong></td>
<td>Defence Spending</td>
<td>Government Spending</td>
<td>Government Expenditure</td>
<td>Government Expenditure</td>
<td>Government Expenditure</td>
<td>Primary Expenditure</td>
<td>Public Investment</td>
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<tr>
<td><strong>Multiplier (Impact)</strong></td>
<td>0.4 to 0.6</td>
<td>-</td>
<td>0.37 (High Income) -0.21 (Developing Economies)</td>
<td>-</td>
<td>1.07</td>
<td>-</td>
<td>0.81 (Expansion) / 2.19 (Recession)</td>
</tr>
<tr>
<td><strong>Multiplier (Cumulative)</strong></td>
<td>-</td>
<td>0.6 to 1.1</td>
<td>0.80 (High Income) 0.18 (Developing Economies)</td>
<td>0.33</td>
<td>0.90</td>
<td>0.64</td>
<td>0.24 (Expansion) / 7.02 (Recession)</td>
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<tr>
<td><strong>Key Findings</strong></td>
<td>Based on U.S. defence spending news, the authors observed a lower multiplier for temporary changes in government spending.</td>
<td>The author constructed two new variables that measure anticipations and fiscal events. The results highlight that the size of fiscal multipliers depends on key factors, such as the exchange rate regime and debt/GDP levels.</td>
<td>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.</td>
<td>The author points out that the model indicates a positive response of private consumption to public spending, unlike other models that do not consider a transmission channel of public spending impulses.</td>
<td>The government expenditure had a positive sign on economic activity and the tax multipliers presented a negative effect. In addition, fiscal multipliers presented higher values for economies with higher levels of public debt.</td>
<td>The author follows the approach of Auerbach &amp; Gorodnichenko (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.</td>
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Regarding the different results, Gechert & Rannenberg (2018) highlight that factors such as high uncertainty, 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 degree of monetary accommodation to fiscal shocks.

Thus, in highly indebted economies and where monetary policy is constrained, an increase in public spending may increase default, decreasing demand. Therefore, the multiplier can change from positive to non-significant, or even negative (Alloza, 2017). Along the same line, Zubairy (2014) assesses, through DSGE models, the fiscal effects and highlights the role of monetary policy. The author finds that the response of the monetary authority is critical in determining the movements of the interest rate. In turn, this affects the size of fiscal multipliers, through intertemporal impacts.

Regarding the effect of uncertainty on fiscal multipliers, the magnitude and persistence are still imprecise. 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 risk would have its space determined. Keynes (1936) also highlights the importance of uncertainty in economic dynamics, where individuals in uncertainty are not guided or decide through probabilistic models but are influenced by what the author determined as "animal spirits".

Savage (1954) expands the concept of uncertainty and indicates a more practical perspective by 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 criticised the theory of utility and argued that individuals react differently when faced with situations involving ignorance of the future.

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

Manteu & Serra (2017) evaluate three possible transmission channels of uncertainty. The first is associated with the real options approach, in which agents can postpone decisions to avoid the costs associated with errors. The second channel refers to precautionary savings. In this case, the greater uncertainty regarding income in the future can induce households to reduce current consumption and increase reserves for the future. This behaviour decreases the marginal propensity to consume and the size of fiscal multipliers. In the second channel, economic agents may demand higher risk premiums. In this scenario, asset prices decrease, and financing costs increase.
The literature provides different approaches to 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 one 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 the volatility of the stock market return and the market expectation of volatility by stock index option prices (VIX index\(^6\)).

Another possibility is to capture the effects of uncertainty from terms contained in the economic reports, news media or newspapers, and EPU and WUI are prominent representatives. Although the EPU and WUI indices analyse the effects of uncertainty for different countries (developed and developing) and use terms such as uncertainty (and its variants) in the search, they differ in relevant aspects. Initially, the sources used are different. While the EPU uses a large set of newspapers\(^7\), the WUI is built using national reports from the Economist Intelligence Unit\(^8\) (EIU), which investigates the economic and political developments of countries. On the one hand, it reduces concerns about ideological bias and the consistency of the WUI facilitates comparability across countries as it uses a single source covering specific topics. In addition, reports follow a standardised process.

On the other hand, the WUI has one report per quarter (lower than the EPU index), which can generate large sampling noise. In order to increase reliability, the WUI is evaluated in different ways: (i) the narrative associated with the largest global spikes is analysed, and (ii) the relationship between WUI and other metrics (EPU index and stock market volatility) is tested.

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

In addition to these indicators, other sentiments act as drivers of the business cycle. In this sense, Nowzohour & Stracca (2020) analyse how uncertainty and consumer confidence influence the economic activity of 27 countries. They indicate three potential sentiment transmission mechanisms for

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\(^6\) VIX calculates market expectation of volatility by stock index option prices. It represents the expectation of 30-day forward-looking volatility.

\(^7\) For the U.S., the EPU index uses results from 10 large newspapers. For Brazil, the index is calculated in the same way as for the U.S. In this case, the EPU use text archives from the newspaper Folha de Sao Paulo.

\(^8\) The company is a leader in the field of country intelligence, providing reports for 189 countries.
economic performance: animal spirits, self-fulfilling prophecies, news and noise. Despite highlighting that the different measures are correlated within each country, they emphasise that consumer confidence has the closest co-movement with economic variables.

Therefore, the different indices highlighted can help to understand how countries recover from periods of crisis. Thus, Baker et al. (2012) point out that uncertainty explains the slow recovery in the U.S. They describe many potential factors behind the slow recovery since 2009. In this sense, after increasing uncertainty, entrepreneurs are reluctant to make decisions, discouraging private investment. In addition, households adopt a more cautious attitude and carefully evaluate their consumption and savings decisions.

Besides that, Baker et al. (2016) find signs 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 U.S. and Europe in recent years may have hampered macroeconomic performance.

The harmful effects of uncertainty are also investigated for euro area economies, with emphasis on Germany, France, Italy and Spain. Meinen & Röhe (2017) examine the influence and adverse effects of uncertainty on investment and output using five uncertainty proxies: the stock market volatility, a survey derived measure of expectations dispersion, a newspaper indicator based on 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.

Antonakakis et al. (2013) also compare the effects of two uncertainty indicators. They examine 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). The authors use the S&P500 returns, the VIX and Economic Policy Uncertainty Index. The findings point to the negative dynamic correlation between policy uncertainty and stock market returns. They also accentuate that, domestic shocks (price and income shocks) lead to a further increase in the negative correlation between policy uncertainty and stock market returns.

Thus, for Baker et al. (2012) uncertainty is classified as a potential element that defines the intensity and duration of a recessive period. They examine how time-varying uncertainty affects policy ineffectiveness and how expansive policy depends on uncertainty. The authors develop a DSGE 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.

Regarding the uncertainty transmission channel, Aastveit et al. (2013) and Aastveit et al. (2017) investigate the effects in the U.S. and whether uncertainty affects the effectiveness of the monetary
policy. The findings show that monetary policy influence on economic activity is faint when uncertainty is high. The authors use as the main measure of uncertainty the volatility of the stock market (U.S.), the VXO index of implied volatility (Chicago Board Options Exchange).

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 on the influence of uncertainty on the effectiveness of fiscal policy and even scarcer for emerging countries. For Brazil, we highlight the work of Barbosa (2018), which investigates the impact of macroeconomic uncertainty shocks on the main fiscal components of the Brazilian federal government. Despite the different contributions, the author does not analyse the impacts of a fiscal multiplier under conditions of uncertainty.

**Investment Strategies under Uncertainty: Real Options Approach**

Dixit & Pindyck (1994) stress that investors consider two essential factors in investment decisions: irreversibility and the possibility of postponing the decision to invest. This section illustrates the R.O. approach and one of the possible transmission channels of uncertainty that affect economic activity through an example. It uses a simple model to highlight how uncertainty affects an investment decision that can be postponed.

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. The 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 & Pindyck, 1994).

The presence of (partial or total) irreversibility of investments and the possibility of delay are relevant features in most investment projects. The opportunity to postpone investment acts as a financial call option associated with a scenario of uncertainty about the future.

The following explanation, inspired by the classic book by Dixit & Pindyck (1994), considers a firm that is deciding today (t=0) to invest and that will produce results 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 decrease to \( y_1^L \), with probability \( (1-p) \). Then, the net benefit will remain at the new level forever. \( \sigma \) denotes the degree of volatility or uncertainty in the next period. Thus, the expected net benefit, \( E(y) \), is equal to \( p \cdot y_1^H + (1 - p) \cdot y_1^L = y_0 \).
Therefore, the entrepreneur needs to decide whether to invest and when is the best time to do so. The traditional perspective of the firm's decision is described as:

\[ E(\pi_0) = -\phi + \sum_{t=0}^{\infty} \frac{p \cdot [(1+\sigma)\cdot y_0] + (1-p) \cdot [(1-\sigma)\cdot y_0]}{(1+r)^t} \]  

(5)

When NPV is greater than zero, the firm must invest. However, the expected NPV (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 paying an opportunity cost equal to the option value.

The value of the option to invest today is defined as \( O_{P_0} \).

\[ O_{P_0} = p \cdot \left[ \left( \frac{-\phi}{1+r} \right) + \sum_{t=1}^{\infty} \frac{(1+\sigma)\cdot y_0}{(1+r)^t} \right] \]  

(6)

After including the opportunity cost (option), the following expression is obtained as

\[ V_{0}^{RO} = -\phi + \sum_{t=0}^{\infty} \frac{p \cdot [(1+\sigma)\cdot y_0] + (1-p) \cdot [(1-\sigma)\cdot y_0]}{(1+r)^t} - p \cdot \left[ \left( \frac{-\phi}{1+r} \right) + \sum_{t=1}^{\infty} \frac{(1+\sigma)\cdot y_0}{(1+r)^t} \right] \]  

(7)

If \( O_{P_0} \) is greater than NPV or \( V_{0}^{RO} \) less than zero, the firm must postpone the investment. Otherwise, the firm must invest.

Next, we analyse how uncertainty affects the firms' decision making.

\[ \frac{\partial V_{0}^{RO}}{\partial \sigma} = \frac{y_0 \cdot (p-1)}{r} \leq 0 \]  

(8)

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

An important point is how the firm reacts to an increase in net benefit. Higher benefit results from several possibilities, for instance, productivity or increased sales because of higher consumer income, for example, 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 ($p < 1$).

$$\frac{\partial^2 y^R_0}{\partial \sigma \partial y_0} = \frac{p-1}{r} \leq 0$$  \hspace{1cm} (9)

Thus, when entrepreneurs are faced with a scenario of high uncertainty, they evaluate more than the stimulus in 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 & Pindyck (1994) and highlighted by Aastveit et al. (2013) when analysing the effectiveness of monetary policy in the U.S.

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

In order to assess the aforementioned effects, we use the following databases. The U.S. National Accounts series are in billions of chained 2012 Dollars (seasonally adjusted). The economic series are based on the natural log of government spending (consumption and investment), household consumption, private investment, and output (GDP). They are available on the Federal Reserve Bank of St. Louis (Fed) database\(^9\). The sample covers the period from 1985Q1 to 2020Q1, for a total of 141 observations.

The Brazilian series are in billions of national currency units and seasonally adjusted (chained 1995). The economic series are the natural log of government spending (consumption), household consumption and GDP. Due to the scarcity of quarterly data for Brazil, the sample is smaller than the U.S. sample. The sample covers the period from 1996Q1 to 2020Q1 (97 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).

\(^9\) [https://fred.stlouisfed.org/tags/series/](https://fred.stlouisfed.org/tags/series/)
To investigate the effects of public spending (consumption and investment) on private decisions, GDP, and the influence of uncertainty on the effectiveness of fiscal instruments on economic activity, we use two uncertainty measures: the EPU\textsuperscript{10} and WUI\textsuperscript{11}.

Tables A.1 to A.4 (Appendix) summarise the main results (the U.S. and Brazil) of the statistical description and results of the unit root test (Augmented Dickey-Fuller Test)\textsuperscript{12}. 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 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 lagged variables.

\[
Y_t = W + B_1 y_{t-1} + \cdots + B_p y_{t-p} + u_t \tag{10}
\]

Where:

- \(Y_t = (y_{1t} \ldots y_{Kt})'\) is the vector of endogenous variables:
- \(B_i = K \times K\) coefficients matrices;
- \(W = (v_1 \ldots v_K)'\) denotes the vector of constants;
- \(u_t = (u_1 \ldots u_K)'\) 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.

\textsuperscript{10}http://www.policyuncertainty.com/methodology.html.
\textsuperscript{11}https://worlduncertaintyindex.com/data/ and www.policyuncertainty.com/media/WUI_mimeo_10_29.pdf.
\textsuperscript{12}Eviews 11 and RStudio software were used for statistical tests and to run the models.
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:

$$AY_t = B Y_{t-1} + e_t, e_t \sim N(0,I)$$  \hspace{1cm} (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 $A^{-1}$:

$$A^{-1}AY_t = A^{-1}BY_{t-1} + A^{-1}e_t$$  
$$e_t \sim N(0,I)$$

$$Y_t = V Y_{t-1} + u_t$$  
$$u_t \sim N(0,\Sigma_u)$$  \hspace{1cm} (12)

From the last expression, we can deduce that:

$$V = A^{-1}B$$  
$$u_t = A^{-1}e_t$$  
$$\Sigma_u = A^{-1}I A^{-1\prime} = A^{-1}A^{-1\prime}$$  \hspace{1cm} (13)

The question is how to identify $A^{-1}$. For a model with three variables and one lag, we have 9 unknown elements 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. In this example, we need to impose three restrictions. For a more general case, the identification of the structural VAR requires that $(n^2 - 2)/2$ restrictions be imposed.

Lütkepohl (2005) and Enders (2008) show that the constraints on the coefficients described in Cholesky decomposition make $A^{-1}$ triangular\(^{13}\). They indicate 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

\(^{13}\) 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 $(n^2 - 2)/2$ A values equal to zero, which makes it a sufficient method to constrain the structural model.
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) emphasise 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, a SVAR model can mitigate this problem by imposing restrictions motivated by economic theory.

To study the impacts of fiscal policy and uncertainty shocks on the level of economic activity, we adjust the models according to the methodology proposed by Blanchard & Perotti (2002). The following is a simplified example to illustrate Blanchard & Perotti’s (2002) approach.

\[ Z_t = A(L, p)Z_{t-1} + U \]  
(14)

The equation describes a basic model.

\[ Z_t = \begin{bmatrix} GC, HC, GDP \end{bmatrix}' \] 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.

\[
\begin{align*}
    u_t^{gc} &= \alpha_{gc}y_t^y + \beta_{gchc}e_t^{hc} + e_t^{gc} \quad (15) \\
    u_t^{hc} &= \alpha_{hcy}u_t^y + \beta_{hcgc}e_t^{gc} + e_t^{hc} \quad (16) \\
    u_t^y &= \gamma_{yhc}u_t^{hc} + \gamma_{ygc}u_t^{gc} + e_t^y \quad (17)
\end{align*}
\]

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 notice, 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 that the unexpected movements in government spending can be due to the response to unexpected movements in GDP (\( \alpha_{gc}y \)), the response to structural shocks to private consumption (\( \beta_{gchc} \)) and to structural shocks to government consumption, \( e_t^{gc} \).

The second equation has a similar interpretation concerning unexpected fluctuations in household consumption. 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 ($\alpha_{gc\,y}$, $\alpha_{hc\,y}$, $\gamma_{y\,hc}$ and $\gamma_{y\,gc}$) cannot be estimated without bias, since the residuals of the reduced form are correlated with the structural shocks in the above equations, so 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 & Perotti (2002). They show that identification is obtained from 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 the fiscal policy in other institutions and only then 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 ($\alpha_{gc\,y}=0$ and $\beta_{gc\,hc}=0$). 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 because of the presence of habits or the need for time to perceive the change ($\alpha_{hc\,y}=0$). 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


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

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

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

$Y_t$ represents the $[\Delta lnGS_t; \Delta lnPI_t; \Delta lnGDP_t]$;

$A$ is the matrix of autoregressive coefficients of order (3x3) and the vector of disturbances is $\varepsilon_t = [\varepsilon_{t,GS}^{\epsilon}, \varepsilon_{t,PI}^{\epsilon}, \varepsilon_{t,GDP}^{\epsilon}]$. 

21
Table 2. Lag Order Selection Criteria (U.S. model 1 - Gov. Spending)

<table>
<thead>
<tr>
<th>Lag</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-19.76027</td>
<td>-19.69475</td>
<td>-1973365</td>
</tr>
<tr>
<td>1</td>
<td>-20.02659</td>
<td>-19.7645</td>
<td>-19.9210</td>
</tr>
<tr>
<td>2</td>
<td>-20.00119</td>
<td>-19.54256</td>
<td>-19.81482</td>
</tr>
<tr>
<td>3</td>
<td>-20.10054</td>
<td>-19.44536</td>
<td>-19.83431</td>
</tr>
<tr>
<td>4</td>
<td>-20.12354</td>
<td>-19.27181</td>
<td>-19.77744</td>
</tr>
<tr>
<td>5</td>
<td>-20.10228</td>
<td>-19.05399</td>
<td>-19.6763</td>
</tr>
</tbody>
</table>

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 simulate the IRFs. An inspection indicates that public spending has a positive effect on GDP (impact) and private consumption (until the first quarter). The effects observed are statistically different from zero (95% confidence interval). They allow an assessment of a 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 owing 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, this information allows us to highlight the relevance of public spending on GDP and private investments, and the contributions of 10% (GDP) are still substantial after 10 periods (Figure 6).

The findings are in line with different studies for the U.S. Blanchard & Perotti (2002) study the effects of fiscal policy (1947Q1 to 1997Q4) using a 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 (2011) and Fatás & Mihov (2001) point to similar effects on GDP, but the response of private investment to the government spending shock is insignificant in Fatás & Minhov. Other papers based on SVAR models, such as Galí et al. (2007), highlight multipliers greater than one. They also suggest a positive effect on private consumption.
Figure 5. Impulse Response Function - GDP and Priv. Investment (U.S. model 1 - Gov. Spending)

Source: Authors’ calculations.

Figure 6. Variance Decomposition (U.S. model 1 Gov. Spending, GDP and Priv. Investment)

Source: Authors’ calculations.

To analyse the effects of uncertainty and the effectiveness of fiscal policy, we adapt the model in line with Aastveit et al. (2013). They investigate the effectiveness of monetary policy for Canada, the U.S., the United Kingdom, and Norway. The authors find that monetary policy shocks have a lower effect when uncertainty is high, and these findings are consistent with the real options approach.

The authors estimate how uncertainty acts on endogenous variables in a SVAR model, and they use the same methodological approach as Towbin & 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 (GS), private investment (PI) and output (GDP). As in the previous model, we evaluate the fiscal effects on household consumption (HC).

Therefore, in this basic model, the specification is:

\[ Y_t = A + BX_t + \sum_{i=1}^{P} (CY_{t-i} + DY_{t-i}X_t) + \epsilon_t \]  \hspace{1cm} (19)

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

The vector of disturbances is \( \varepsilon_t = [\varepsilon_t^G, \varepsilon_t^P, \varepsilon_t^{GDP}] \). \( Y_t \) represents the vector of endogenous variables and \( X_t \) is the measure of uncertainty, EPU (level). Furthermore, the model allows the variable \( G S_t \) 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 3\(^{rd}\) quartile) and a low level of uncertainty (below the 2\(^{nd}\) 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.

\[
Y_t^{High} = \tilde{A}_0 + \tilde{B}_0^{High} \cdot \hat{X}_0 + \sum_{i=1}^{p} \left( \tilde{B}_i^{High} \cdot Y_{t-i} \cdot X_t \right) + \tilde{\epsilon}_t \tag{20}
\]

\[
Y_t^{Low} = \tilde{A}_0 + \tilde{B}_0^{Low} \cdot \hat{X}_0 + \sum_{i=1}^{p} \left( \tilde{B}_i^{Low} \cdot Y_{t-i} \cdot X_t \right) + \tilde{\epsilon}_t \tag{21}
\]

Thus, the models verify whether the results align with the Real Options approach. In other words, in the presence of high uncertainty private agents would be more cautious, postponing their investment decisions. Consequently, the effects of government spending are expected to be lower in an environment of high uncertainty.

The IRFs point to a rather curious effect when we divide the sample into high uncertainty (high EPU) and low uncertainty (low EPU)\(^{14}\). First, we observe that public spending, under high uncertainty, has a negative influence on private investment and maintains its negative cumulative effect for seven quarters. Regarding the low EPU scenario, it is not possible to have a definitive result owing to the statistically non-significant results (95%). Thus, only with a confidence band of 55%, the impacts are significant. Perhaps a larger sample would produce a conclusive result (Figure 9).

\(^{14}\) The model (high EPU) has one lag and the model for low EPU has one lag.
Figure 8. Impulse Response Function – GDP and Priv. Investment - High EPU (U.S. model 2 – Gov. Spending)

Source: Authors’ calculations.
Alloza (2017) estimates the impact of government spending shocks on (U.S.) GDP and points to similar GDP responses during periods of high and low uncertainty. In addition, some IRFs also present non-significant results. Riera-Crichton et al. (2014) investigate the effects of public spending in recession and expansion environments (OECD). In expansions (high confidence), the effect is not significantly different from zero on impact and for any horizon. Lastly, Blanchard & Perrotti (2002) analyse the influence of defence and non-defence spending for the U.S. They also point out statistically non-significant effects of non-defence public spending on GDP.
To assess confidence in the results, we changed the models 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 10. Impulse Response Function – GDP and Priv. Consumption - High EPU (U.S. model 2 - Gov. Spending)

Source: Authors’ calculations.

Figure 11. Impulse Response Function – GDP and Priv. Consumption - Low EPU (U.S. model 2 - Gov. Spending)

Source: Authors’ calculations.

The number of lags is equal to one.
To deepen the analysis, we use the WUI instead of the EPU, and we find that GDP responses to shocks of fiscal variables are in line with the literature\textsuperscript{16}. As in the previous model, GDP and private investment show a negative effect after the fiscal shock associated with high WUI. The responses are statistically significant on output (impact) 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.

**Figure 12. Impulse Response Function – GDP and Priv. Investment - High WUI (U.S. model 2 - Gov. Spending)**

\[\text{Source: Authors’ calculations.}\]

\textsuperscript{16} 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 13. Impulse Response Function - GDP, Priv. Investment - Low WUI (U.S. model 2 - Gov. Spending)

![Graph showing impulse response function for GDP, Priv. Investment - Low WUI.]

Source: Authors’ calculations.


![Graph showing impulse response function for GDP and Priv. Consumption.]

Source: Authors’ calculations.

The following table highlights the fiscal multipliers for model 1 and multipliers 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. Lastly, 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 effects 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 3. Fiscal Multipliers: Government Consumption and Investment - The U.S.

<table>
<thead>
<tr>
<th>Model (USA)</th>
<th>Scenario</th>
<th>Impact Multiplier</th>
<th>Cumul. Multiplier (t=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traditional</td>
<td>1.24</td>
<td>0.66</td>
</tr>
<tr>
<td>1</td>
<td>High EPU</td>
<td>0.56</td>
<td>-0.22</td>
</tr>
<tr>
<td>1</td>
<td>Low EPU</td>
<td>0.85</td>
<td>0.42</td>
</tr>
<tr>
<td>2</td>
<td>High EPU</td>
<td>-0.01</td>
<td>-0.01</td>
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<tr>
<td>2</td>
<td>Low EPU</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>High WUI</td>
<td>-3.18</td>
<td>-0.49</td>
</tr>
<tr>
<td>2</td>
<td>Low WUI</td>
<td>0.75</td>
<td>-8.90</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.

For the traditional scenario (model 1) the impact and accumulated multipliers are statistically different from zero until the third quarter (±2 S.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 & Perotti (2002). They describe that the bands are wide and the IRF of GDP becomes statistically insignificant after one year. The estimates are also in line with different studies that demonstrate that the general public spending multiplier (impact) is greater than one.

The findings also 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 – 2020Q1)

For Brazilian models, 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).

The basic specification is:

$$ Y_t = \zeta + \sum_{i=1}^{p} A_i Y_{t-i} + \epsilon_t \quad (22) $$
\( Y_t \) represents the (3x1) vector of endogenous variables \((\Delta \ln GC_t; \Delta \ln HC_t; \Delta \ln GDP_t)\), \( C \) denotes a (3x1) vector of intercept terms, \( A \) is the matrix of autoregressive coefficients (3x3), and lastly, the vector of disturbances is \( \varepsilon_t = [\varepsilon^{GC}_t, \varepsilon^{HC}_t, \varepsilon^{GDP}_t] \).

After specifying the appropriate number of lags (Akaike information), the tests verify that the model is stable, all inverse roots of the characteristic polynomial lie within the unit circle, the assumptions associated with the residues were verified, and there is no autocorrelation. They also indicate that p-value does not allow rejecting the null hypothesis of homoskedasticity for any assumed level of significance.

### Table 4. Lag Order Selection Criteria (Brazil - Model 1)

<table>
<thead>
<tr>
<th>Lag</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
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<td>-18.6188</td>
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<tr>
<td>1</td>
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<td>-18.6777</td>
</tr>
<tr>
<td>2</td>
<td>-18.7020</td>
<td>-18.1108</td>
<td>-18.4338</td>
</tr>
<tr>
<td>3</td>
<td>-18.6100</td>
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<td>-18.3833</td>
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<tr>
<td>5</td>
<td>-18.931</td>
<td>-17.5794</td>
<td>-18.3862</td>
</tr>
<tr>
<td>6</td>
<td>-18.8594</td>
<td>-17.2548</td>
<td>-18.0537</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.

Figure 15 depicts the IRFs of a government consumption shock. As in the results for U.S. models, public spending plays an important role in stimulating household consumption and economic activity. The IRFs indicate the positive effect of public consumption. The cumulative effects remain for household consumption and GDP, returning to equilibrium after 10 quarters.
The variance decomposition of GDP shows an increasing relevance of public spending over the quarters. We can see a similar conclusion for household consumption.

The present paper differs from some studies that point to null or negative multipliers for developing economies. However, the estimates are in line with the results of Carrière-Swallow et al. (2018) and Peres (2006). The latter also used a model based on Blanchard & Perotti (2002). For data from 1994 to 2005, the authors point to Keynesian responses to GDP after government spending shocks.
5.4. Model 2: Brazil (1996Q1 - 2020Q1)

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

\[ Y_t = A + BX_t + \sum_{i=1}^{p} (CY_{t-1} + DY_{t-1}X_{t-1}) + \varepsilon_t \]  \hspace{1cm} (23)

Where \( A \) is a (3x1) vector of intercept terms, and the vector of disturbances is \( \varepsilon_t = [\varepsilon_t^{GC}, \varepsilon_t^{HC}, \varepsilon_t^{GDP}] \).

\[ Y_t^{High} = \tilde{A}_0 + \tilde{B}^{High}_0 \cdot X_0 + \sum_{i=1}^{p} (\tilde{B}^{High}_i \cdot Y_{t-i}X_t) + \tilde{\varepsilon}_t \]  \hspace{1cm} (24)

\[ Y_t^{Low} = \tilde{A}_0 + \tilde{B}^{Low}_0 \cdot X_0 + \sum_{i=1}^{p} (\tilde{B}^{Low}_i \cdot Y_{t-i}X_t) + \tilde{\varepsilon}_t \]  \hspace{1cm} (25)

The IRFs suggest that public consumption has a statistically significant expansionary impact when uncertainty is low. After examining the simulations, government consumption maintains the cumulative effect on GDP and household 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 high uncertainty does not encourage household consumption\(^{17}\).

**Figure 17. Impulse Response Function – GDP and Priv. Consumption - Low EPU (Brazil - model 2 - Gov. Consumption)**

![Image](image_url)

Source: Authors’ calculations.

\(^{17}\) Based on Akaike Information, the optimal lag is 1 (High EPU) and 3 (Low EPU).
As in the U.S. model, we replaced the EPU index with the WUI\textsuperscript{18} and the results indicate that fiscal innovations (Low WUI) stimulate economic activity. However, when public consumption is associated with the WUI-High, it has more subtle effects on economic activity.

\textbf{Figure 19. Impulse Response Function – GDP and Priv. Consumption – Low WUI (Brazil - model 2 - Gov. Consumption)}

Source: Authors’ calculations.

\textsuperscript{18} High WUI - two lags, and Low WUI - three 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.
The results with EPU and WUI present important 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 qualitatively similar results to those in the U.S. In other words, an uncertain environment creates a reducing effect on consumption, spreading out into the economy.

The table below highlights the multipliers for the models investigated. The results point to evidence that periods of high uncertainty and precaution are factors that can influence the effectiveness of fiscal policy.

Table 5. Fiscal Multipliers: Government Consumption – Brazil

<table>
<thead>
<tr>
<th>Model (Brazil)</th>
<th>Scenario</th>
<th>Impact Multiplier</th>
<th>Cumul. Multiplier (t=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traditional</td>
<td>1.05</td>
<td>3.41</td>
</tr>
<tr>
<td>1</td>
<td>High EPU</td>
<td>-2.24</td>
<td>-8.71</td>
</tr>
<tr>
<td>1</td>
<td>Low EPU</td>
<td>0.72</td>
<td>1.68</td>
</tr>
<tr>
<td>2</td>
<td>High EPU</td>
<td>-0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>Low EPU</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>2</td>
<td>High WUI</td>
<td>2.99</td>
<td>1.31</td>
</tr>
<tr>
<td>2</td>
<td>Low WUI</td>
<td>9.01</td>
<td>7.99</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations.
6. Concluding Remarks

In recent years, the effects of fiscal multipliers have aroused the 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 attention stems from the fact that uncertainty shocks can encourage agents to postpone investment and consumption decisions, explaining economic fluctuations. This paper contributes to this debate by highlighting the channels and effects of uncertainty, which combined with fiscal stimulus, interfere with economic growth.

The findings indicate the presence of Keynesian effects. For traditional models, increases in public spending have a positive effect on household consumption and economic activity. The findings also point to the crowding-out effect of public expenditures on private investment in the U.S. 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, the findings confirm that innovations in the uncertainty indicators foreshadow declines in economic activity. In addition, there is evidence that fiscal policy is less effective in this context. Thus, the results indicate that uncertainty shocks dampen private investment and household consumption, in line with the Real Options approach. Therefore, increasing uncertainty silences fiscal stimulus as we observed in the results of the IRFs.

For U.S. data, the effects of uncertainty are clear when it reaches high levels. However, low uncertainty does not 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, the results point to cautious individuals when the high uncertainty overshadows the definition of an economic scenario.

Despite this evidence, the essay has limitations. Thus, further investigations, which consider a larger sample of developing countries, can confirm the findings and provide new information on the effects of uncertainty and fiscal policy in emerging countries.

Lastly, the findings 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.
7. References


Ramey, V. A. (2019). Ten years after the financial crisis: What have we learned from the renaissance in fiscal research?. *Journal of Economic Perspectives, 33*(2), 89-114.


## Appendix

### Table A.1. Descriptive Statistics and Tests. Raw Data - Level (Brazil)

<table>
<thead>
<tr>
<th></th>
<th>EPU</th>
<th>WUI</th>
<th>Gov Consumption</th>
<th>Priv Consumption</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>139.3714</td>
<td>0.309076</td>
<td>47269.75</td>
<td>160742.6</td>
<td>249363.2</td>
</tr>
<tr>
<td>Median</td>
<td>122.3339</td>
<td>0.250156</td>
<td>46827.43</td>
<td>160676.6</td>
<td>254891.7</td>
</tr>
<tr>
<td>Maximum</td>
<td>459.5965</td>
<td>1.021895</td>
<td>55927.81</td>
<td>209022.8</td>
<td>312493.3</td>
</tr>
<tr>
<td>Minimum</td>
<td>32.36883</td>
<td>0.000000</td>
<td>32712.99</td>
<td>110898.7</td>
<td>175524.0</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>78.74477</td>
<td>0.280275</td>
<td>7002.853</td>
<td>34835.26</td>
<td>48257.81</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.675893</td>
<td>2.363533</td>
<td>-0.241019</td>
<td>0.050222</td>
<td>-0.142471</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>5.043782</td>
<td>12.90032</td>
<td>1.514371</td>
<td>1.307565</td>
<td>1.405944</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>62.5400</td>
<td>485.4610</td>
<td>9.85951</td>
<td>11.61745</td>
<td>10.58498</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.007228</td>
<td>0.003001</td>
<td>0.005020</td>
</tr>
<tr>
<td>H0: Unit Root - Level</td>
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<td>Rejected</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H0: Unit Root - 1st Diff</td>
<td>Rejected</td>
<td>Rejected</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Observations</td>
<td>97</td>
<td>97</td>
<td>97</td>
<td>97</td>
<td>97</td>
</tr>
</tbody>
</table>

Source: IBGE and authors’ calculations.

### Table A.2. Descriptive Statistics and Tests. Log-Level (Brazil)

<table>
<thead>
<tr>
<th></th>
<th>Gov Consumption</th>
<th>Priv Consumption</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>10.75231</td>
<td>11.96404</td>
<td>12.40889</td>
</tr>
<tr>
<td>Median</td>
<td>10.77953</td>
<td>11.87164</td>
<td>12.44859</td>
</tr>
<tr>
<td>Maximum</td>
<td>10.93182</td>
<td>12.25297</td>
<td>12.65235</td>
</tr>
<tr>
<td>Minimum</td>
<td>10.39553</td>
<td>11.61637</td>
<td>12.07553</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>0.152784</td>
<td>0.219131</td>
<td>0.191493</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.353968</td>
<td>-0.051025</td>
<td>-0.255995</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.655270</td>
<td>1.318802</td>
<td>1.474111</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>0.934112</td>
<td>11.46558</td>
<td>10.46982</td>
</tr>
<tr>
<td>Probability</td>
<td>0.009400</td>
<td>0.063238</td>
<td>0.085327</td>
</tr>
<tr>
<td>H0: Unit Root - Level</td>
<td>Not Rejected</td>
<td>Not Rejected</td>
<td>Not Rejected</td>
</tr>
<tr>
<td>H0: Unit Root - 1st Diff</td>
<td>Rejected</td>
<td>Rejected</td>
<td>Rejected</td>
</tr>
<tr>
<td>Observations</td>
<td>97</td>
<td>97</td>
<td>97</td>
</tr>
</tbody>
</table>

Source: IBGE, Economic Policy Uncertainty, World Uncertainty Index and authors’ calculations.

### Table A.3. Descriptive Statistics and Tests. Raw Data - Level (U.S.)

<table>
<thead>
<tr>
<th></th>
<th>EPU</th>
<th>WUI</th>
<th>Gov Spending (Cons+Invest)</th>
<th>Priv Investment</th>
<th>Priv Consumption</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>110.7575</td>
<td>0.161520</td>
<td>2776.272</td>
<td>2144.396</td>
<td>8957.152</td>
<td>13357.71</td>
</tr>
<tr>
<td>Median</td>
<td>107.5662</td>
<td>0.114188</td>
<td>2892.823</td>
<td>2218.370</td>
<td>9119.949</td>
<td>15538.67</td>
</tr>
<tr>
<td>Maximum</td>
<td>236.0640</td>
<td>0.785741</td>
<td>3347.857</td>
<td>3491.068</td>
<td>1341.914</td>
<td>19219.77</td>
</tr>
<tr>
<td>Minimum</td>
<td>63.11624</td>
<td>0.000000</td>
<td>1980.046</td>
<td>1120.880</td>
<td>5020.163</td>
<td>7824.247</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>31.68011</td>
<td>0.158881</td>
<td>393.8472</td>
<td>721.7754</td>
<td>2457.180</td>
<td>3432.495</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.99083</td>
<td>1.477678</td>
<td>-0.208170</td>
<td>0.039870</td>
<td>0.010801</td>
<td>-0.041231</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>4.471048</td>
<td>5.465993</td>
<td>1.581057</td>
<td>1.792493</td>
<td>1.723151</td>
<td>1.738745</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>34.73732</td>
<td>65.99514</td>
<td>12.64709</td>
<td>8.603535</td>
<td>9.585050</td>
<td>9.385571</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.001623</td>
<td>0.013546</td>
<td>0.008251</td>
<td>0.008161</td>
</tr>
<tr>
<td>H0: Unit Root - Level</td>
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</tr>
<tr>
<td>H0: Unit Root - 1st Diff</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Observations</td>
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<td>141</td>
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<td>141</td>
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<td>141</td>
</tr>
</tbody>
</table>

Source: Fed and authors’ calculations.
Table A.4. Descriptive Statistics and Tests. Log-Level (U.S.)

<table>
<thead>
<tr>
<th></th>
<th>Gov Spending (Cons+Invest)</th>
<th>Priv Consumption</th>
<th>Priv Investment</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.918503</td>
<td>9.059037</td>
<td>7.608664</td>
<td>0.466718</td>
</tr>
<tr>
<td>Median</td>
<td>7.969988</td>
<td>9.113219</td>
<td>7.704528</td>
<td>0.513261</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.116076</td>
<td>9.503900</td>
<td>8.155100</td>
<td>0.863695</td>
</tr>
<tr>
<td>Minimum</td>
<td>7.591178</td>
<td>8.521218</td>
<td>7.028699</td>
<td>0.964983</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.145806</td>
<td>0.283458</td>
<td>0.362087</td>
<td>0.262814</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.339542</td>
<td>-0.273469</td>
<td>-0.328266</td>
<td>-0.315731</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.721952</td>
<td>1.730999</td>
<td>1.725517</td>
<td>1.783999</td>
</tr>
<tr>
<td>Jarque-Bera Probability</td>
<td>12.21065</td>
<td>11.23177</td>
<td>12.07513</td>
<td>10.96699</td>
</tr>
</tbody>
</table>

Source: Fed, Economic Policy Uncertainty, World Uncertainty Index, and authors’ calculations.

Figure A.1. Brazil – Series (Log-Level and First Difference)

Source: Authors’ calculations.
Figure A.2. The U.S. – Series (Log-Level and Frist Difference)

Source: Authors’ calculations.

Figure A.3. Serial Correlation, Residual Normality and Unit Root Tests - Model 1 U.S.

Source: Authors’ calculations.
Figure A.4. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (EPU-High) U.S.

Source: Authors’ calculations.

Figure A.5. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (EPU-Low) U.S.

Source: Authors’ calculations.
Figure A.6. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (WUI-High) U.S.

Source: Authors’ calculations.

Figure A.7. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (WUI-Low) U.S.

Source: Authors’ calculations.
Figure A.8. Serial Correlation, Residual Normality and Unit Root Tests – Model 1 Brazil

![Graph showing serial correlation, residual normality, and unit root tests for Model 1 Brazil](image)

Source: Authors’ calculations.

Figure A.9. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (EPU-High) Brazil

![Graph showing serial correlation, residual normality, and unit root tests for Model 2 (EPU-High) Brazil](image)

Source: Authors’ calculations.
Figure A.10. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (EPU-Low) Brazil

Source: Authors’ calculations.

Figure A.11. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (WUI-High) Brazil

Source: Authors’ calculations.
Figure A.12. Serial Correlation, Residual Normality and Unit Root Tests - Model 2 (WUI-Low) Brazil

Source: Authors’ calculations.