How can financial stress impact the fiscal and monetary policies

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Abstract

The relationship between economic policies and the financial system has received more attention from economists after the subprime mortgage crisis in 2008. The COVID-19 global pandemic has also resulted in economic disruptions and uncertainties that affected economic policies and financial markets. Policy makers' countercyclical responses included fiscal and monetary stimuli to tackle economic downturns. The actions of economic policy depends on its regulatory and discretionary components. These can have different time paths. There is a possibility that the rule component is anti-cyclical and the discretionary component is pro-cyclical. This paper studies the responses of fiscal and monetary policies during episodes of instability in the domestic financial market in Brazil between February 2000 and November 2020. We investigate the presence of nonlinearities in fiscal and monetary policy responses. The main hypothesis is that stress events can lead to asymmetric reactions from policymakers. We estimate Threshold-VAR models on Brazilian monthly data for period 2010-2020 to assess the existence of asymmetries in economic policy responses. We therefore consider an adapted the Financial Stress Index to capture periods of financial turmoil. Results indicate nine periods of financial stress, the last due to COVID-19. We implement Generalized Nonlinear Impulse Response functions to accommodate regime changes in the system. The results suggest that in the growth phases, the fiscal policy acted in an expansionary way in the fiscal impulse, but in a contractionary way in the fiscal rule. The monetary authority, in turn, performed in an anti-cyclical way in all estimated models.

Keywords: Fiscal Policy, Financial Stress Index, Threshold VAR

JEL classification: C53; E43; G17.

Área 4 - Macroeconomia, Economia Monetária e Finanças

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1. Introduction

Countercyclical policies are a well-known issues and broadly studied in economic literature, and play a significant role in smoothing the business cycle. When the economic activity is booming, everyone is doing well. On the other hand, in periods of downturn, policymakers are expected to be able to present prompt and appropriate responses to fiscal and monetary policies to reduce undesirable impacts on the economy. Conventional countercyclical measures include lowering interest rates, reducing taxes, and raising government spending, which may stimulate consumption, avoid sharp hikes in unemployment rates and maintain current levels of wealth. However, policymakers cannot use countercyclical policies all the time, e.g., in upwards periods, procyclical policies may take place, which has the opposite effect of countercyclical policies.

As a rule, the government should save in periods of expansion and spend on contractions. It is not difficult, however, to observe fiscal policies that deepen the current cycle, i.e., increasing spending proportional to product and cutting taxes in economic growth and the opposite in recessions. One can investigate the government budget and extract information regarding the fiscal policy path. The expected conclusion would be countercyclical in both mandatory and discretionary spending, which is considered symmetric fiscal policy. In this paper, we analyze the response of the Brazilian economic policies to different scenarios in order to investigate the presence of nonlinearities in fiscal and monetary policy responses. In other words, is Brazil's fiscal policy countercyclical as a rule and as an impulse? Before responding to this question, it is necessary to understand the path of fiscal policy in Brazil and how one can identify periods of economic downturns in the economy. Brazil is one of the emerging markets that can constitute an important case study for this type of research as it has one of the largest public debt in the world among the developing countries.

Shortly before the 2008 financial crisis, Brazil became investment grade, thanks to a long period of fiscal and monetary policy effort. This was achieved due to measures adopted since 1999 onwards, including the adoption of the inflation targeting, flexible exchange rate, and the advent of the fiscal responsibility law (Holland, 2019). However, there is a consensus that Brazil has a chronic fiscal problem (Giambiagi, 2021), which worsened after the global recession 2007-2010, caused by the financial crisis originated in the US mortgage bond markets subprime (Tourinho & O.Brum, 2020). This fiscal problem manifests itself in the acceleration of gross public debt growth. After remaining relatively stable, around 60% of GDP from 2007 to 2013, the debt/GDP ratio retaked growth trajectory and reached 82.8% in October 2017 and could get more than 90% in 2022. The increase in fiscal deficits and public debt linked to expansionary fiscal policy during aggregate demand downturns associated with crisis has also led to a discussion of financial markets's perceptions of fiscal sustainability.

Furthermore, in 2015, one of the biggest economic recessions in the history of Brazil began, witch resulted in the deterioration of fiscal results. This, led to the downgrade of Brazil to speculative grade. Specifically, between 2014 and 2017, Brazil experienced an unprecedented fiscal deterioration, which was caused by several factors. The lack of fiscal control, the resulting political instability, and the measures that became necessary to deal with the problem are mainly responsible for the economic recession of 2014-2016, which was the second-largest in the country in the post-war period.

The government's credibility after these crises can penalize sovereigns with low fiscal space (Augustin *et al.* , 2021). As a consequence, the government's financing capacity may be affected. The government's difficulty in selling its bonds reduces its liquidity and may weaken the balance sheet of financial institutions that hold this type of asset. Also, perception from market participants of an increase in sovereign risks can affect financial stability represented by credit risk and the degree of solvency of banks (Montes *et al.* , 2021). Financial institutions may experience a reduction in their ability to lend due to falling government bond prices.

There is a consensus in the economic literature on the role of fiscal institutions in attenuating economic fluctuations. Countercyclical fiscal policies - including discretionary expansionary budget measures and through automatic stabilizers - have usually helped to reduce recessions in advanced and emerging market economies during crisis episodes. The analysis of policy responses to financial instability and financial crises constitute another area of intense interest for academics and market practitioners.

Recently, a large body of literature on the linkage between economic activity, financial markets, financial stability, and financial crisis has emerged (e.g., Slingenberg & De Haan, 2011; Oet *et al.* , 2015; Monin, 2019; Sandahl *et al.* , 2011; Illing & Liu, 2003; Claessens *et al.* , 2012). In particular, Balakrishnan *et al.* (2011) uses the Financial Stress Index (FSI) to investigate periods of turbulence in financial markets between advanced

economies and emerging economies. At the peak of the 2008 crisis in advanced economies, there was a considerable reaction in emerging economies, with a sharp rise in FSI in these countries. Moriyama (2010) investigate the effects of the global crisis on financial conditions and economic activity in emerging countries. The author points out that the increase of economic stress identified by FSI may explain about half of the decline in real GDP growth in these countries.

Empirical studies have found historical evidence that periods of greater financial instability and economic downturns are relatively frequently related (Cardarelli *et al.* , 2011; Baxa *et al.* , 2013). Researchers also present results involving the relationship between economic policies and financial stress. Li & St-Amant (2010), for instance, seek to identify linkage among monetary policy, business cycle, and evolution of Canada's financial sector. They conclude that a contractionary monetary policy has a more significant effect on the product when the economy is in deep financial stress. Park & Mercado Jr (2014), for instance, extends the existing literature on the use of FSI in understanding the channels of financial transmission in emerging market economies. Using FSI of 25 emerging markets from 1992 to 2012, their results suggest regional and nonregional emerging markets FSIs significantly increase in domestic financial stress.

Stona *et al.* (2018) investigate the differences in macroeconomic dynamics during instabilities in the Brazilian financial market from 2000 to 2015. The authors introduced the Brazil Financial Stress Index as a proxy for financial stress and assessed its interaction with real activity, inflation, and monetary policy. Their main results suggest an expansionary monetary policy can worsen the scenario in an adverse situation. Also to Brazil, Wichmann & Portugal (2013) assess the existence of asymmetries in economic policy responses through economic cycles from 2001 to 2010. They suggest the rule is faster and less asymmetric than the other policies, while the monetary policy responds more strongly to variations in the output gap.

Despite these studies on economic policy responses in Brazil, we aim to investigate the fiscal policy responses, as well as monetary policy, in periods of crisis using the FSI as a threshold variable to identify two states of nature: low-stress regime (economic growth) and high-stress regime (economic downturn) (Afonso *et al.* , 2018; Galvão & Owyang, 2018; Alessandri & Mumtaz, 2017).

We use a threshold VAR VAR (TVAR) analysis to assess whether the response of Brazilian fiscal and monetary policies were contractionary (countercyclical) in moments of growth and expansionary in periods of downturn. From a policy point of view, this modeling approach has more advantages as it allows for monitoring the financial stability measure and its regime changes over time.

To the best of our knowledge, there is a literature gap in this field using threshold vector autoregression methodology VAR (TVAR) in this framework (Soave, 2020; Evgenidis & Tsagkanos, 2017; Li & St-Amant, 2010). In the empirical literature, the main modeling tools used to capture nonlinearities in the response of fiscal and monetary policies are Markov-switching Vector Autoregression (MS-VAR) and smooth transition vector autorregressions (STVARs) models. Regime-switching models often impose exogenous switches. In contrast, TVARs explicitly model the threshold variable as endogenous. This allows one to study regime switches, which result from shocks hitting another variable within the system (Ferraresi *et al.* , 2015). The structural changes in TVAR models take place when a prespecified threshold variable exceeds an observable critical value. In this paper we use the financial stress index as the transition variable and link it directly to the conditions of the financial sector. Another advantage is that TVARs are very simple to estimate: a TVAR is a non-linear multivariate system of equations that models non-linearity additively and can consequently be estimated by ordinary least squares (OLS). However, once estimated, the state-dependent dynamics of TVARs allows for nonlinear and asymmetric impulse response functions.

Some questions can emerge to address our research: have the fiscal and monetary authorities had different responses given the financial market conditions between February 2000 and November 2020? Our main objective is to estimate the economic cycle responses of Brazilian fiscal policy during episodes of instability in the domestic financial market. Such events can lead to asymmetric reactions of policymakers. We also seek to identify how the fiscal policies behave in periods of high turbulence in the financial markets, investigate the existence of nonlinearities in fiscal and monetary policy caused by financial stress and estimate the fiscal and monetary authorities' responses concerning the economic cycle during periods of financial stress.

We estimate five specifications to estimate fiscal impulse and fiscal rule. The results suggest the fiscal policy in Brazil is majority procyclical in impulse and countercyclical in rule in periods of low stress regime (economic growth), which means the fiscal policy was asymmetric. In periods of high stress regime, the results

also show asymmetric in impulse and rule. The monetary policy was overwhelmingly countercyclical in high stress regime, however we do not find conclusions on low stress regime. Our finds, which are robust to many alternative empirical specifications, have important policy implications specially for countries that have relaxed their fiscal rules in response to the Covid-19 pandemic.

The outline of the paper is as follows. Section 2 introduces the Financial Stress Index. Section 3 and 4 present the methods for filtering impulse fiscal policy and the *threshold*-VAR (TVAR), respectively. Section 5 presents the dataset and our empirical findings, and lastly, section 6 concludes.

2. Financial Stress Index

An episode of financial stress can be defined as a period of interruption in financial markets' normal functioning (Hakkio *et al.* , 2009), such as generated by the uncertainties brought the COVID-19. A period of financial stress has at least one of these features: increased uncertainty about the value of fundamental assets (Zhang *et al.* , 2020; Bakas & Triantafyllou, 2020), increased uncertainty about other investors' behavior (Bogdan *et al.* , 2021), increased information asymmetry between lenders and borrowers, less willingness to hold risky assets, decreased desire to keep assets less liquid (flight to liquidity), see Davig *et al.* (2010) for detailed descriptions.

Balakrishnan *et al.* (2011) developed an index of financial stress for emerging markets based on the existing index of Cardarelli *et al.* (2009) for developed countries. This index is composed of five variables, namely: "banking-sector beta", stock market returns, stock market volatility, sovereign debt spreads, and exchange market pressure index EMPI. The β_t of the banking-sector is obtained as follows:

$$\beta_{i,t} = \frac{cov(r^M_{i,t}, r^B_{i,t})}{\sigma^2_M}, \tag{1}$$

where r^M_t represents the annual rates of return of the general stock market and r^B_t the rates of return of the shares of companies in the banking-sector, the covariance and variance were calculated based on a 12-month moving window. When $\beta_t > 1$, it is clear that the banking-sector presents greater volatility than the rest of the market[1]. The return of the stock market consists of the year-on-year change of the stock index multiplied by -1. Thus a decline in stock prices implies an increase in stock market stress.

The third variable is the volatility of the stock market. Higher volatility of the stock market can cause an increase in uncertainty and cause an increase in financial stress. Balakrishnan *et al.* (2011) estimated such volatility using a GARCH specification (1,1) for an auto-regressive process variance with 12 lags. However, we use the Exponentially Weighted Moving Average (EWMA) volatility models, considering the six-month moving average of the square of the stock index's monthly growth rate.

The fourth variable is the sovereign debt spreads. It is defined by the EMBI+ (Emerging Market Bond Index Plus) and is a proxy for country risk. An increase in EMBI+ implies a perception, on the part of the market, that investing in a particular economy has become riskier, which, in turn, can lead to an increase in financial stress. Lastly, the EMPI+ captures depreciation of exchange rate and declines in international reserves, and is defined for country i in month t as:

$$EMPI_{i,t} = \frac{(\Delta e_{i,t} - \mu_{i,\Delta e})}{\sigma_{i,\Delta e}} - \frac{(\Delta RES_{i,t} - \mu_{i,\Delta RES})}{\sigma_{i,\Delta RES}}, \tag{2}$$

where $\Delta e_{i,t}$ and $\Delta RES_{i,t}$ represents changes in the domestic exchange rate and international reserves, respectively, while $\mu_{i,\Delta e}$ e $\sigma_{i,\Delta RES}$ represents the mean and standard deviation of the variable i. It is clear that the EMPI+ consists of the sum of variables $\Delta e_{i,t}$ and $\Delta RES_{i,t}$ standardized. Domestic currency depreciation as reductions in international reserves pressure the foreign exchange market and, as a result, increase financial stress.

To yield the aggregate Financial Stress Index for an individual country the five components are standardized and summed up:

$$FSI_t = \beta_t + SMR_t + SMV_t + EMBI_t + EMPI_t. \tag{3}$$

[1]In the final FSI calculation, betas were only considered when their value was greater than one and when the returns of the banking-sector's shares were less than the returns of the market as a whole.

In order to proceed the evaluation of fiscal policy, next section introduces five methods to filtering the fiscal policy.

3. Methods for Filtering Impulse Fiscal Policy

When analyzing the path of economic policy, whether fiscal or monetary, it is important to keep in mind that it has automatic and discretionary components (Tornell & Lane, 1999; Talvi & Vegh, 2005; Ilzetzki, 2011). These components can present different path, so that it is possible that procyclicity is present in only one of the components. For example, there is a possibility that the rule component is countercyclical and the discretionary component is procyclical.

The definition of the rule says that the balance increases (decreases) when the output gap rises (lowers). The fiscal impulse can have a greater degree of asymmetry, predominantly countercyclical in the financial stress regime and procyclical in regimes without stress monetary policy can have countercyclical response during regimes with stress (Sorensen *et al.* , 2001; Hercowitz & Strawczynski, 2004; Balassone *et al.* , 2010). The central bank can be more tolerant of the economy's heating during periods without financial stress, accepting a little more inflation.

3.1. The OECD method

In the methodology used by OECD (Girouard & André, 2006), the cyclically adjusted balance, concerning the potential product, $B^\star$, is defined as follows:

$$B^\star = \frac{[T^\star - G^\star + X]}{Y^\star}, \tag{4}$$

where $G^\star$ represents the cyclically adjusted current primary government expenditure, $T_i^\star$ represents the cyclically adjusted component of government revenue, X represents non-tax revenue minus capital and interest expenditures, and $Y^\star$ represents the level of potential output. Cyclically adjusted components are calculated from current revenue from tax collection (T) and government spending (G).

The revenue is adjusted by the ratio between the potential product ($Y^\star$) and the current product (Y) and by the elasticity of the revenue concerning the output gap ($\epsilon_{t,y}$). Spending, on the other hand, is adjusted by the ratio between structural unemployment ($U^\star$) and current unemployment (U) and by the elasticity of current primary expenditure in relation to the ratio between structural unemployment and current ($\epsilon_{g,u}$). Algebraically, we have:

$$\frac{T^\star}{T} = \left(\frac{Y^\star}{Y}\right)^{\epsilon_{t,y}}, \tag{5}$$

$$\frac{G^\star}{G} = \left(\frac{U^\star}{U}\right)^{\epsilon_{g,u}}. \tag{6}$$

Substituting equations (5) and (6) in (4), the cyclically adjusted balance is obtained, that is

$$B^\star = \frac{\left[T\left(\frac{Y^\star}{Y}\right)^{\epsilon_{t,y}} - G\left(\frac{U^\star}{U}\right)^{\epsilon_{g,u}} + X\right]}{Y^\star}. \tag{7}$$

The first difference of $B^\star$ in equation (7) represents the fiscal impulse, that is

$$FI_t^{OECD} = \Delta B^\star. \tag{8}$$

3.2. The IMF (2006) method

In the IMF (2006) method (IMF, 2006), it is necessary to define cyclically neutral expenses and revenues to obtain the components of rule and discretion through this methodology. As noted by Heller *et al.* (1986), expenditure is considered to be cyclically neutral when it responds proportionally to increases in potential output. On the other hand, cyclically neutral revenue responds proportionally to variations in the observed product. Algebraically, we can represent these relationships as follows:

$$G_t^* = \frac{G_0}{Y_0^p} Y_t^p, \tag{9}$$

$$T_t^* = \frac{T_0}{Y_0^p} Y_t, \tag{10}$$

where G and T represent government expenditures and revenues, Y represents the product, and Y^p the potential product. It is necessary to choose a base year where the observed product is equal to the potential to calculate the cyclically neutral components ($G^\star$ and $T^\star$). To obtain cyclically adjusted government spending and revenue, one can subtract the cyclically neutral components of spending and revenue, that is $G_t^{ca} = G_t - G_t^*$ and $T_t^{ca} = T_t - T_t^*$.

The fiscal impulse, that is, the net increase in government spending that does not depend on the cycle of economic growth, is obtained by varying the cyclically adjusted government budget balance (in relation to GDP):

$$FI_t = \left(\frac{\Delta G_t - \Delta G_t^*}{Y_t}\right) - \left(\frac{\Delta T_t - \Delta T_t^*}{Y_t}\right), \tag{11}$$

$$FI_t^{IMF(2006)} = \left[\Delta\left(\frac{G_t}{Y_t}\right) - \Delta\left(\frac{\left(\frac{G_0}{Y_0}\right)Y_t^P}{Y_t}\right)\right] - \left[\Delta\left(\frac{T_t}{Y_t}\right) - \Delta\left(\frac{\left(\frac{T_0}{Y_0^P}\right)Y_t}{Y_t}\right)\right]. \tag{12}$$

3.3. The Dutch method

Another way to calculate the fiscal impulse, called the Dutch method, is presented by Sidaoui *et al.* (2003). This method is a variation of the IMF (2006) method , considering that the base period for the calculation is the same as the immediately previous period:

$$FI_t^{\text{Dutch}} = \left[\Delta\left(\frac{G_t}{Y_t}\right) - \Delta\frac{\left(\frac{G_{t-1}}{Y_{t-1}^P}\right)Y_t^P}{Y_t}\right] - \left[\Delta\left(\frac{T_t}{Y_t}\right) - \Delta\frac{\left(\frac{T_{t-1}}{Y_{t-1}^P}\right)Y_t}{Y_t}\right]. \tag{13}$$

According to Chand (1992), an advantage of the Dutch method is that it does not depend on the choice of the base year; that is, the fiscal impulse is determined using the fiscal balance of the immediately preceding period as a reference.

3.4. The IMF (2008) method

The IMF (2008) builds a measure of fiscal impulse based on estimating a set of regressions considering real GDP growth as a proxy for the economic environment. In this methodology, the government balance sheet in period t can be expressed as a function of discretionary fiscal policy, P_t, and the prevailing economic environment in the period, E_t. Thus $B_t = B(P_t; E_t)$. The change in the fiscal balance concerning the previous year can be represented as follows

$$\Delta B_t = B\left(P_t, E_t\right) - B\left(P_{t-1}, E_{t-1}\right). \tag{14}$$

Adding and subtracting the term $B(P_t, E_{t-1})$, which represents what would be the fiscal balance resulting from a policy at time t if the economic environment remained unchanged between $t-1$ and t, we obtain

$$\Delta B_t = \Delta B_t^E + \Delta B_t^P. \tag{15}$$

The term ΔB_t^E represents the fiscal effects of changes in the economic environment from E_{t-1} to E_t. In this case, there are no discretionary changes in fiscal policy between time $t-1$ and time t, that is, P does not change.

The term ΔB_t^P captures changes in the balance sheet resulting from changes in discretionary policy. There is a change in fiscal policy, P, even though the economic environment remains unchanged.

As the balance sheet is the result of the subtraction between government revenues and expenses, to measure the fiscal impulse, it is necessary to estimate the following equations for these variables

$$T_t = \alpha_R + \beta_R\left(growth_t\right) + \gamma_R t + u_t, \tag{16}$$

$$G_t = \alpha_E + \beta_E\left(growth_t\right) + \gamma_E t + e_t, \tag{17}$$

where T is revenue as a percentage of GDP, G is government expenditure as a percentage of GDP, *growth* is real GDP growth, and t represents a time trend. The terms u and e indicate the residuals of the estimation.

Thus, cyclically adjusted income and expenditure are given by equations (18) and (19), which in turn show the value of these variables would be if the product's growth rate did not present variation in relation to time $t-1$.

$$T_t\left(growth_{t-1}\right) = \hat{\alpha}_R + \hat{\beta}_R\left(growth_{t-1}\right) + \hat{\gamma}_R t + \hat{u}_t, \tag{18}$$

$$G_t\left(growth_{t-1}\right) = \hat{\alpha}_E + \hat{\beta}_E\left(growth_{t-1}\right) + \hat{\gamma}_E t + \hat{e}_t. \tag{19}$$

Thus, the difference between equations (18) and (19) consists of the cyclically adjusted fiscal balance, which, when differentiated, provides a measure for the fiscal impulse.

$$FI_t^{\text{IMF(2008)}} = \left(\hat{\gamma}_R - \hat{\gamma}_E\right) + \left(\hat{u}_t - \hat{u}_{t-1}\right) - \left(\hat{e}_t - \hat{e}_{t-1}\right). \tag{20}$$

3.5. The Kalman Filter method

Another way of decomposing fiscal policy, to obtain its automatic component and its discretionary component, can be done considering that the government's weight to the deviations of the product wrt its potential level varies over time. Therefore, the Kalman filter (Kim *et al.* , 1999; Durbin & Koopman, 2012) is used. Considering that the fiscal policy consists of the variation of the government surplus, $B_t - B_{t-1} = \Delta\, B_t$, there is:

$$\Delta B_t = \rho_t + \varepsilon_t, \tag{21}$$

$$\rho_t = \beta_t \Delta gap_t, \tag{22}$$

$$\beta_t = \beta_{t-1} + \eta_t. \tag{23}$$

Equation (21) informs that fiscal policy is composed of two components, ρ_t and ε_t. The ρ_t component is a function of changes in the economic cycle (represented by the variation in the output gap, Δgap_t), as described in equation (22). The regression residues follow a normal distribution and are identical and normally distributed, that is, $\varepsilon_t \sim (0, \sigma_\varepsilon^2)$.

Unlike the OECD, IMF (2006), and IMF (2008) methodologies, here the impact of the economic cycle on fiscal policy is not constant; that is, the β_t of equation (23) is time-varying. The underlying intuition is that the tax authority can change the weight given to fluctuations in the output gap over time.

4. Threshold VAR and Nonlinear Impulse Response Functions

In order to investigate the potencial presence of nonlinearities in the responses of fiscal and monetary policies we consider TVAR models with two regimes. The threshold vector autoregression (TVAR[2]) methodology is a vector autoregression extension that allows capture nonlinear relationships. Balke (2000) noted that TVAR is a relatively intuitive and straightforward to capturing nonlinearities generated, for instance, by changes in regimes and asymmetries. A TVAR model with two regimes can be represented as follows:

$$Y_t = \left(D^{(1)} + B^{(1)}(L)Y_{t-1}\right) I_t + \left(D^{(2)} + B^{(2)}(L)Y_{t-1}\right)(1 - I_t) + e_t, \tag{24}$$

where Y_t is the vector of endogenous variables, $B^{(1)}(L)$ and $B^{(2)}(L)$ are lag polynomial matrices, e_t are structural disturbances, and I_t it is an indicator function that assumes the value 1, when the threshold variable c_t (the financial stress index in our case), with d lags is less than the critical threshold value τ, and 0, otherwise. The parameter d is known as the delay parameter. Algebraically we have:

$$I_t = \begin{cases} 1, \text{ when } c_{t-d} < \tau \\ 0, \text{ when } c_{t-d} > \tau. \end{cases} \tag{25}$$

Thus, the model identifies two distinct regimes based on the values of c_{t-d} and τ. Thus, the indicator variable effectively separates the two regimes and allows regimes to switch endogenously.

[2]Examples of vector autoregression analysis considering the threshold effect can be found in Afonso *et al.* (2018), Calza & Sousa (2005), Atanasova (2003), Balke (2000), Galbraith (1996), and McCallum (1991) .

The equation (24) can present a nonlinear path throughout the autoregressive system's complete trajectory. However, by dividing this trajectory into two parts (that is, where it is less than the threshold value and where it is greater than the threshold value), the system has a linear path. However, the TVAR model is linear within each regime, but the changes in the parameters across regimes account for nonlinearities.

Tong (1978) noted there is a possibility that the system space is composed of at least two subspaces. Although such a system is linear in all segments, it will operate in a nonlinear manner if you consider the space as a whole. In autoregressive modeling with threshold effect (TAR), a threshold variable is defined to capture the system's movement from one space to another, see Tsay (1989).

The asymmetry of the model described by equations (24) and (25), which is captured by the threshold variable, allows the constants vector to switch between regimes.

The threshold variable c_t can be modeled into the Y_t vector, allowing the regime change to be endogenously determined by the system. Since the TVAR considers all endogenous variables, shocks in any of the vector variables Y_t can, through their impact on the variable, induce a regime change.

4.1. Econometric Specification

We estimated six TVAR models. They formed by the (Δgap_t) product gap variation, by inflation (π_t), the variation in the nominal interest rate (Δi_t), and changes in the fiscal policy's discretion and rule components, that is, the (if_t) fiscal impulse and the rule tax (rf_t).

In addition to the dataset, the cyclical and discretionary components of fiscal policy were in the estimations, as defined by the OECD, IMF (2006), and IMF (2008) methodologies, and by the Dutch versions and Kalman filter method (see section 3).

The TVAR model in equation (26) can be estimated as follow:

$$X_t = \left(A_0^{(1)} + A_0^{(1)}(L)X_{t-1}\right) I_t + \left(A_0^{(2)} + A_1^{(2)}(L)X_{t-1}\right)(1 - I_t) + e_t, \tag{26}$$

where X_t is the vector of endogenous variables (Δgap_t,π_t,Δi_t,if_t,rf_t), $A_0^{(s)}$ is the regime vector's constants $s = \{1, 2\}$, $A^{(s)}(L)$ is the coefficients matrix, and e_t is the error vector, as follow:

$$X_t = \begin{bmatrix} \Delta gap_t \\ \pi_t \\ \Delta i_t \\ if_t \\ rf_t \end{bmatrix}, \quad A_0^{(s)} = \begin{bmatrix} A_{10}^{(s)} \\ A_{20}^{(s)} \\ A_{30}^{(s)} \\ A_{40}^{(s)} \\ A_{50}^{(s)} \end{bmatrix}, \quad A^{(s)}(L) = \begin{bmatrix} A_{11}(L) & A_{12}(L) & \cdots & A_{15}(L) \\ A_{21}(L) & A_{22}(L) & \cdots & A_{25}(L) \\ \vdots & \vdots & \ddots & \vdots \\ A_{31}(L) & A_{32}(L) & \cdots & A_{35}(L) \end{bmatrix}, \quad e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{bmatrix}. \tag{27}$$

The indicator function I_t takes is 1 when the economy is under a stress regime in the financial markets and 0, otherwise. I_t is similar to equation (25):

$$I_t = \begin{cases} 1, \text{ when } fsi_{t-d} > \tau \\ 0, \text{ when } fsi_{t-d} \leq \tau. \end{cases} \tag{28}$$

4.2. Nonlinear impulse response functions

Once the estimation of the TVAR is accomplished, it is possible to evaluate whether or not the economic dynamics differ across regimes. In standard linear VARs, the response to a shock is computed assuming that a shock only hits the economy at a particular point in time but neither before nor during the forecasting horizon. Linear VARs are thus history-independent, and reactions to shocks are strictly proportional to the shock itself. However, these convenient properties do not hold within the class of nonlinear models, so Koop *et al.* (1996) developed a computation of Generalized Impulse Response Functions (GIRF).

In a threshold VARs, the reaction of an endogenous variable to a shock depends on the history, the state of the economy, the size of the shock under analysis at time 0, and the size and the sign of all the shocks hitting the economy within the period of interest. The GIRFs approach relies on the simulation of data depending on which regime the system is in at the time the shock hits the economy (the history Ω_{t-1} up to point t). The advantage of GIRFs is not only that it allows for the analysis of regime-dependent responses, but also that effects of shocks of different sizes and directions can be analyzed. Due to this history, and shock-dependence,

GIRFs lend themselves as an appropriate framework to explore the above-mentioned dimensions of nonlinearity such as regime-dependencies, asymmetries (positive vs. negative shocks), and shock nonlinearity (small vs. large shocks).

$$GIRF = E\left[X_{t+m} \mid \varepsilon_t, \varepsilon_{t+1} = 0, \ldots, \varepsilon_{t+m} = 0, \Omega_{t-1}\right] - E\left[X_{t+m} \mid \varepsilon_t = 0, \varepsilon_{t+1} = 0, \ldots, \varepsilon_{t+m} = 0, \Omega_{t-1}\right], \tag{29}$$

where X_{t+m} is a vector of variables at horizon k, Ω_{t-1} is the information set available before the time of shock t. This implies that there is no restriction regarding the symmetry of the shocks in terms of their sizes because the effects of a ε_t shock depend on the magnitude of the current and subsequent shocks. Moreover, in the high stress regime, the size of the fiscal shock matters since a small shock is less likely to induce a change in the regime. Likewise, the impulse responses depend also on the entire history of the variables that affect the persistence of the different regimes. Therefore, to get complete information about the dynamics of the model, the impulse responses have to be simulated for various sizes and the signs of the shocks. The algorithm proceeds as follows.

The general idea is to simulate the model for any possible starting point over the time horizon of interest by feeding the system with bootstrapped shocks and repeating the exercise by adding a new shock of a specific size (1 or 2 times the standard deviation of the fundamental shock in the linear model). The procedure is done hundreds of times with a newly generated series of bootstrapped residuals. Finally, the responses to shocks specific to a particular regime are recovered by averaging the simulation results.

5. Data and Empirical Results

5.1. Data

We employ Brazilian monthly data for the period between February 2010 throughout November 2020. We obtained most of the series through the Time Series Management System of the Central Bank of Brazil (BACEN)[3]. The variables and their respective sources are specified below:

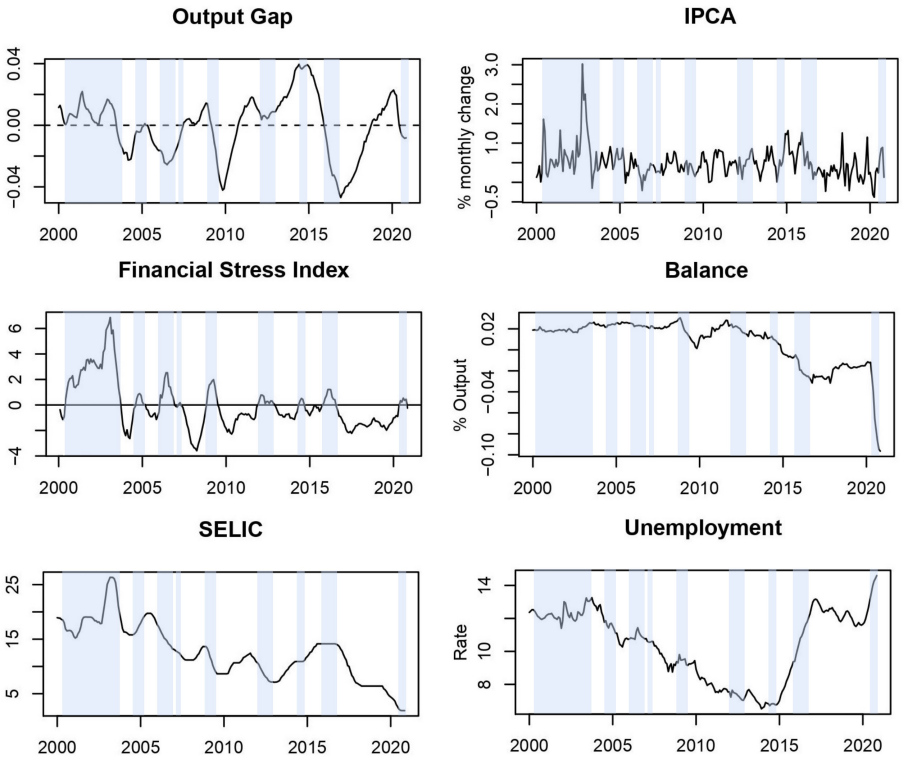
- Domestic product (y): we use the gross domestic product from the Central Bank (BACEN code: 4380).
- Primary surplus (B) represented by the primary result of the central government (in R$ million), as availability by the National Treasury of Brazil[4].
- Government spending (G) equivalent to the total federal government expenditure (in R$ million)(BACEN code: 7547).
- Government revenue (T) consists of total federal government revenue (in R$ million)(BACEN code: 7544).
- Domestic interest rate (i) represented by the annualized Over-Selic rate accumulated in the month, released by the Central Bank (BACEN code: 4189).
- Inflation rate (π) represented by the national broad consumer price index (IPCA), measured in monthly variation and calculated by The Brazilian Institute of Geography and Statistics (BACEN code: 433).
- Financial Stress Index (FSI): time series from January 2010 to December 2020, calculated by the authors.
- Ibovespa (IBOV)[5]: measures the performance of the domestic capital market.
- The Financials Index (IFNC) is compiled as a weighted average of a theoretical portfolio of stocks: measures companies' performance in financial sector.
- The (EMBI+): measured in base points and released by JPMorgan.
- Exchange rate average quotation of the US dollar (sale) published by the Central Bank (BACEN code: 3698).
- International reserves consist of international funds under the liquidity concept (in US$ million), published by the Central Bank (BACEN code: 3546).

[3] https://www3.bcb.gov.br/sgspub
[4] https://www.gov.br/tesouronacional/en?set_language=en
[5] http://www.b3.com.br/en_us/

5.2. Empirical Findings

We present the results of the benchmark TVAR model (henceforth mainstream) and five TVAR models that include the fiscal impulse methods - OECD, IMF (2006), Dutch, IMF (2008), and Kalman filter. These methods are described in Section 3. Our results are from 2000 February through November 2020, time interval that includes data related to COVID-19. Figure 1 presents their path over time, respectively, from February 2000 through November 2020. In the Financial Stress Index, values above zero are considered High Stress Regime, and below zero are regarded as Low Stress Regime. Shaded ranges are relative to FSI periods above zero. In these cases, we consider High Stress Regime or economic downturn. One can see nine periods of financial stress in which the last one was due to COVID-19. According to the threshold variable, we have 59.3% of observations in Low Stress Regime and 40.7% in High Stress Regime.

Figure 1: Main Time Series (2000 - 2020)



Note: This figure shows the main time series used from February 2000 through November 2020. In the Financial Stress Index, values above zero are considered High Stress Regime, and below zero are regarded as Low Stress Regime. Shaded ranges are relative to FSI periods above zero. In these cases, we consider High Stress Regime or economic downturn. One can see nine periods of financial stress in which the last one was due to COVID-19.

Table 1 reports the stationarity tests of time series used in our models until now. The tests are Augmented Dickey–Fuller test (ADF), Kwiatkowski–Phillips–Schmidt–Shin tests (KPSS), and Phillips-Perron tests (PP). All entries are least 90% of statistical significance. The variables IPCA, SELIC, Balance, and FSI represent the inflation rate, the realized interest rate, the primary surplus, and the Financial Stress Index, respectively. The Output gap, interest rate, and Balance are in first difference.

We tested the presence of nonlinearities in the six models defined in the previous section. These results are reported in Table 2 where Panel (A) reports the TVAR lag selection based on Bayesian information criterion (BIC), in which bold entries represent the chosen model, and Panel (B) reports LR Linearity Tests. The null hypothesis is of model linearity. The Maximum likelihood Ratio (LR) test suggests the existence of nonlinearities in all tested cases, according to the p-values. According to the Bayesian information (BIC) criterion, the threshold variable lag and the lags included in the models was one. Given that indication, we estimated the model to obtain the GIRFs and their associated confidence intervals.

Table 1: Stationarity Tests

Time Seriess	ADF	KPSS (4L)	KPSS (12L)	PP (4L)	PP (12L)
Output Gap	-4.449	0.048	0.036	-5.987	-5.872
IPCA	-5.601	0.444	0.321	-7.670	-7.474
SELIC	-5.764	0.064	0.066	-5.445	-4.448
Balance	-4.357	0.445	0.383	-9.579	-9.502
FSI	-3.173	1.233	0.639	-3.499	-3.035
Impulse (OECD)	-4.035	0.398	0.338	-9.819	-9.869
Impulse (IMF, 2006)	-2.697	0.520	0.421	-9.628	-9.755
Impulse Dutch	-4.404	0.422	0.341	-15.33	-15.52
Impulse IMF (2008)	-3.431	0.376	0.335	-12.47	-12.55
Impulse Kalman	-5.492	0.281	0.293	-17.11	-17.17

Note: This table reports the stationarity tests of time series used in our models until now. The tests are Augmented Dickey–Fuller test (ADF), Kwiatkowski–Phillips–Schmidt–Shin tests (KPSS), and Phillips-Perron tests (PP) . All entries are least 90% of statistical significance. The variables IPCA, SELIC, Balance, and FSI represent the inflation rate, the realized interest rate, the primary surplus, and the Financial Stress Index, respectively. The Output gap, interest rate, and Balance are in first difference.

Table 2: TVAR Lag Selection and LR Linearity Tests

Panel A: TVAR Lag Selection						
Lags	Mainstream	OECD	IMF (2006)	Dutch	IMF(2008)	Kalman
1	−2967.48	−3854.63	−5397.54	−3520.83	−3717.31	−3432.98
2	−2805.52	−3596.53	−5139.86	−3274.91	−3453.29	−3190.22
3	−2631.22	−3326.57	−4869.88	−3025.66	−3184.16	−2932.60
4	−2421.30	−3038.85	−4568.23	−2747.67	−2900.44	−2668.71
Panel B: LR Linearity Tests						
LR Test	47.525	60.623	51.970	86.080	57.418	56.685
p-value	0.000	0.000	0.000	0.000	0.000	0.000

Note: Panel (A) reports the TVAR lag selection based on Bayesian information criterion (BIC), in which bold entries represent the chosen model. Panel (B) reports LR Linearity Tests. The null hypothesis is of model linearity.

In Table 2 (Panel A), we present results of Bayesian information criteria to select the TVAR lags. Also,a formal test was performed to confirm the nonlinearity of fiscal and monetary responses. The LR test shown in Table 2 (Panel B) indicated that modelling with regime-switching is the most appropriate, as the null hypothesis of linearity was rejected. This result may justify the use of the TVAR model.

To clarify the possible policy sets, we have summarized them in Table 3. This table reports a summary of possible regimes and policies. It is expected from economic policy contractionary response in growth, and expansionary in downturn, representing a countercyclical policy. The opposite is applicable to procyclical policy. The fiscal (impulse) rule is the expansion or contraction of government spending that (not) depends on the economic cycle. During growth (downturn) periods, the government should act countercyclically by adopting a contractionary (expansionist) fiscal policy.

Table 3: Set of Possibles Regimes and Policies

	Regimes			
	Low Stress (0) / Growth		High Stress (1) / Downturn	
Policies	Countercyclical	Procyclical	Countercyclical	Procyclical
Expected	Contractionary	–	Expansionary	–
Nonconventional	–	Expansionary	–	Contractionary

Note: This table reports a summary of possible regimes and policies. It is expected from economic policy contractionary response in growth, and expansionary in downturn, representing a countercyclical policy. The opposite is applicable to procyclical policy.

In GIRFs results, a negative (positive) response to an output gap shock means that fiscal or monetary policy was countercyclical (procyclical). Also, the definition of asymmetry used here is related to the dependence of fiscal policy on the business cycle.

The first set of results was the TVAR mainstream, reported in Figure 2, shows the generalized impulse response functions (GIRF) of the TVAR Mainstream where confidence bands (95%) were obtained from the empirical distribution of simulated GIRFs assuming normality. These results suggest the policies were countercyclical in all regimes. Also, the results of TVAR mainstream suggest that fiscal policy was countercyclical both in times of growth and in times of crisis. In the growth phase of the economic cycle (low-stress regime), the balance response to a shock in the output gap was statistically significant only at the beginning of the period. On the other hand, at times of downturn in the economic cycle (high-stress regime), the fiscal response to a shock in the gap had more statistical significance than the low-stress regime. Overall, this result is in line with what is expected from the countercyclical fiscal policy: expansionary in crises and contractionary in growth.

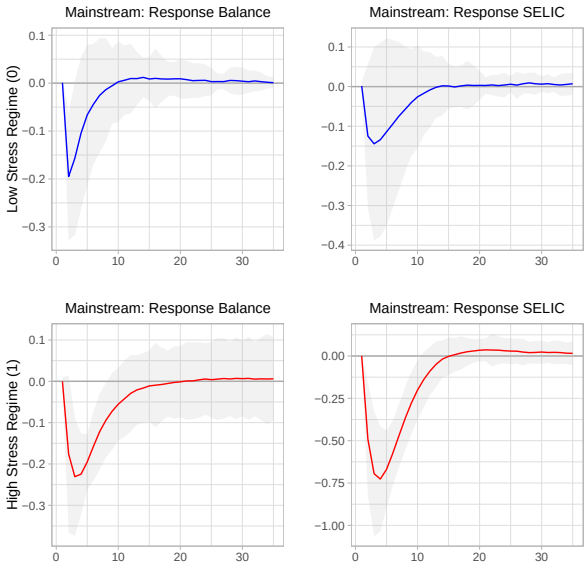
The monetary policy response to shocks in the output gap was countercyclical in both regimes. In the high financial stress regime, the monetary authority's response was statistically significant in more periods than the low-stress regime, which had no significant periods. This set of results suggests that monetary policy was expansionary at the time of financial stress.

The OECD TVAR results are reported in Figure 3. In the TVAR OECD model, the results show that the fiscal impulse was countercyclical only in the low-stress regime. That is, in periods of economic growth, the impulse response was contractionary. On the other hand, monetary policy was countercyclical only in the high-stress regime. In other words, it was expansionary in times of crisis.

Despite the countercyclical responses, the confidence intervals contain zero, so the results do not present statistical significance. In summary, the results of the TVAR OECD model show, in part, what would be expected from monetary and fiscal policy.

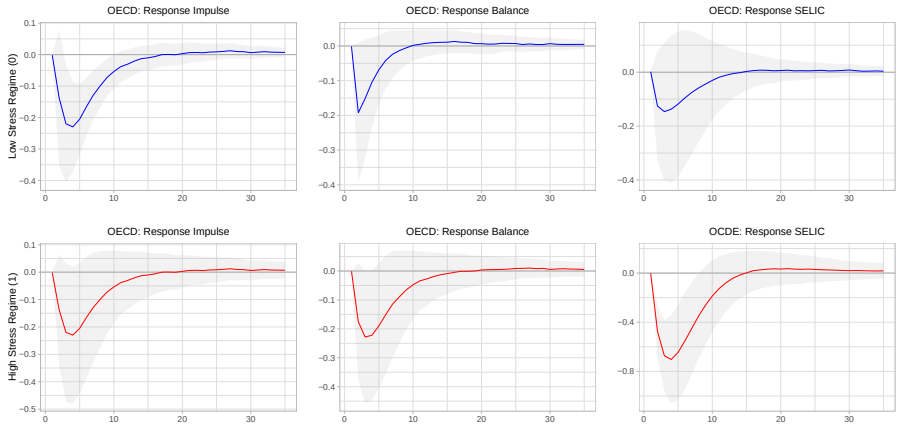
The IMF (2006) results suggest a procyclical path to fiscal impulse - see Figure 4. From the point of view of fiscal impulse, the results are opposite to the results of the TVAR OECD. The results of the TVAR IMF method suggest that the fiscal impulse was procyclical in both regimes. In contrast, in the low-stress regime, which corresponds to the growth cycle phase, the fiscal impulse had more significant periods. Overall, this result reveals that the fiscal impulse was expansionary during the growth phase of the cycle. On the other hand, the

Figure 2: Generalized Impulse Response Functions of the TVAR Mainstream.
Response of the Fiscal Balance and Interest Rate (SELIC) to One Unit Shock of Output Gap



Note: This figure shows the generalized impulse response functions (GIRF) of the TVAR Mainstream. Confidence bands (95%) obtained from the empirical distribution of simulated GIRFs assuming normality. These results suggest the policies were countercyclical in all regimes.

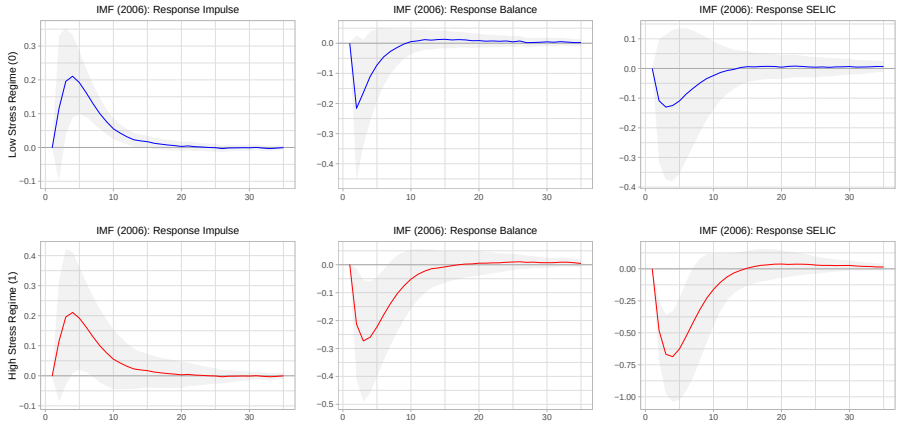
Figure 3: Generalized Impulse Response Functions of the TVAR OECD.
Response of the Fiscal Balance and Interest Rate (SELIC) to One Unit Shock of Output Gap



Note: This figure shows the generalized impulse response functions (GIRF) of the TVAR OECD. Confidence bands (95%) obtained from the empirical distribution of simulated GIRFs assuming normality. These results suggest the policies were countercyclical in all regimes. These results suggest the policies were countercyclical.

fiscal impulse was contractionary in the contraction phase of the cycle but with less significant periods.

Figure 4: Generalized Impulse Response Functions of the TVAR IMF (2006).
Response of the Fiscal Balance and Interest Rate (SELIC) to One Unit Shock of Output Gap

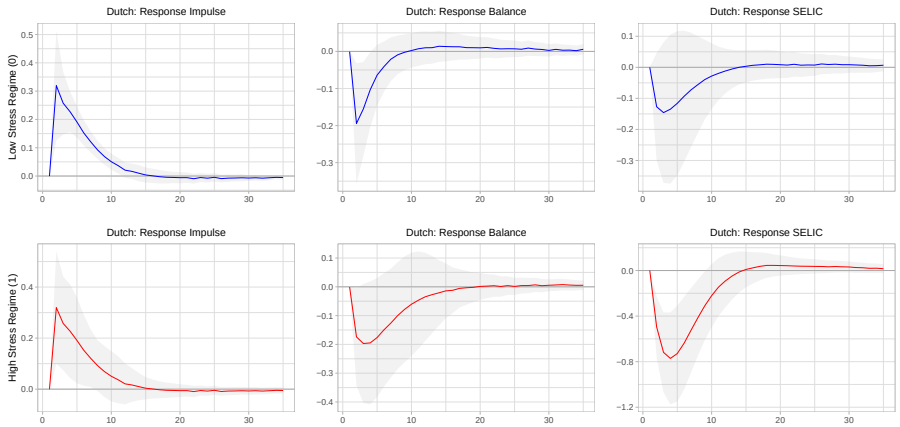


Note: This figure shows the generalized impulse response functions (GIRF) of the TVAR IMF (2006). Confidence bands (95%) obtained from the empirical distribution of simulated GIRFs assuming normality. These results suggest the impulse fiscal response was procyclical in both regimes, while the fiscal rule and monetary responses were countercyclical.

On the other hand, the fiscal rule was only significant in the economic contraction cycle, which shows the expansionary response in crises. Similarly, monetary policy had similar path. That is, it was expansionary in economic contraction cycles. Overall, this method suggests asymmetries in the direction of fiscal policy, where the fiscal impulse was procyclical in both phases of the cycle, and the fiscal rule was countercyclical only in the high financial stress regime.

The Dutch method results are presented in Figure 5. The TVAR Dutch method had similar results to the TVAR IMF (2006). However, the fiscal impulse responses were faster than the previous method, according to the confidence intervals. In general, monetary policy behaved similarly to the previous method. That is, the monetary authority acted in an expansionary manner during the contraction phases of the cycle.

Figure 5: Generalized Impulse Response Functions of the TVAR Dutch.
Response of the Fiscal Balance and Interest Rate (SELIC) to One Unit Shock of Output Gap

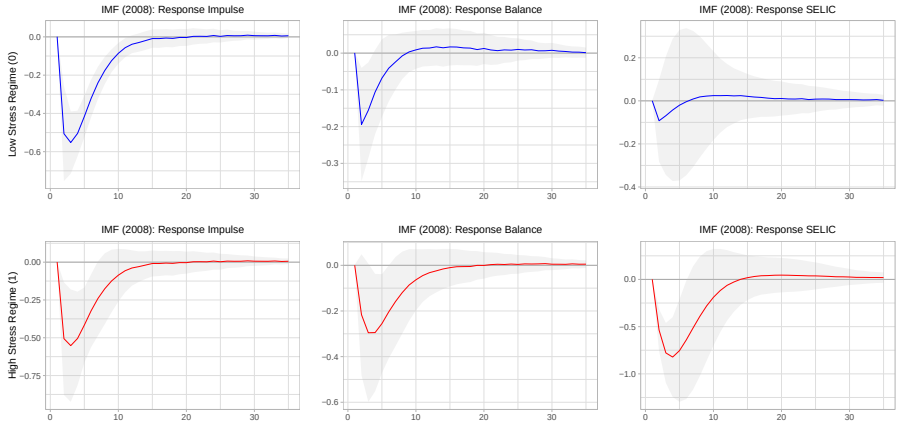


Note: This figure shows the generalized impulse response functions (GIRF) of the TVAR Dutch. Confidence bands (95%) obtained from the empirical distribution of simulated GIRFs assuming normality. These results suggest the impulse fiscal response was procyclical in both regimes, while the fiscal rule and monetary responses were countercyclical.

The main result of this method comes from the fiscal impulse that was procyclical in both regimes. In the low-stress regime, which corresponds to the growth phase of the cycle, the impulse had more significant periods. Therefore, the fiscal impulse was expansionary in the growth phase and contractionary in the crisis phase.

The IMF (2008) method are presented in Figure 6. In line with the OECD method, the fiscal policy results in the IMF(2008) method was countercyclical. In both regimes, the responses were countercyclical. In periods of growth (downturn), the fiscal authority adopted a contractionary (expansionist) policy. The difference between this method and the OECD method is that it had significant periods in the fiscal rule in the low-stress regime. Overall, the results point to a countercyclical behavior but with slight changes in speed and duration.

Figure 6: Generalized Impulse Response Functions of the TVAR IMF (2008).
Response of the Fiscal Balance and Interest Rate (SELIC) to One Unit Shock of Output Gap



Note: This figure shows the generalized impulse response functions (GIRF) of the TVAR IMF (2008). Confidence bands (95%) obtained from the empirical distribution of simulated GIRFs assuming normality. These results suggest the policies were countercyclical.

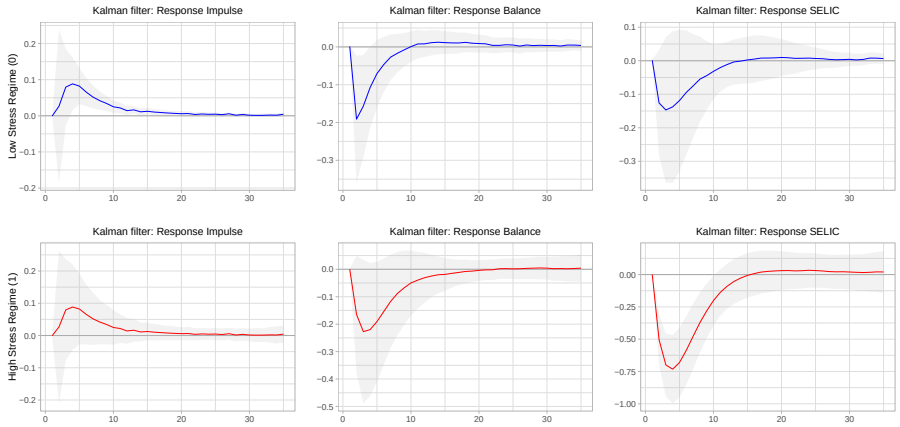
The Kalman filter method are presented and in Figure 7. Finally, the fiscal impulse showed a significant result in the low-stress regime and the SELIC response to a gap shock in the high-stress regime in the Kalman filter method. In this model, the results show that there were procyclical responses to the fiscal impulse. Concerning the rule, a significant result emerged in the low-stress regime. Therefore, the fiscal authority acted in a countercyclical manner in the growth phase of the cycle. In Table 4, we summarized all the impulse-response results: Low Stress Regime (0) means low financial stress and High Stress Regime (1) means high financial stress, both are related to economic growth and crisis, respectively.

In general, the results suggest the fiscal impulse was mostly procyclical in the low-stress regime, while the fiscal rule was countercyclical. In other words, these results suggest that in the growth phases, fiscal policy was expansionary in impulse but contractionary as a rule. Still, in this regime, monetary policy did not show significant results.

In the high-stress regime, the monetary authority was countercyclical in all models. The fiscal impulse was procyclical in two of the five models, while the fiscal rule was countercyclical in two of the five models. In this regime, the models showed more non-significant results. However, the procyclical result was greater than the countercyclical concerning the impulse. Therefore, fiscal policy was contractionary in impulse and expansionary as a rule in crisis phases. Monetary policy, in turn, acted in an expansionary manner. It is noteworthy that each model responds with different reaction speeds and durations.

The main contributions of the results are twofold. First, we present five methods to disaggregate fiscal policy in rule and impulse, making available comparisons among results and building a scoreboard based on statistical significance. Second, the confidence interval of the generalized impulse response function gives support to delivery robustness that is absent in Wichmann & Portugal (2013), whose results also suggest asymmetries in fiscal policy.

Figure 7: Generalized Impulse Response Functions of the TVAR Kalman.
Response of the Fiscal Balance and Interest Rate (SELIC) to One Unit Shock of Output Gap



Note: This figure shows the generalized impulse response functions (GIRF) of the TVAR Kalman. Confidence bands (95%) obtained from the empirical distribution of simulated GIRFs assuming normality. These results suggest the impulse fiscal response was procyclical in both regimes, while the fiscal rule and monetary responses were countercyclical.

Table 4: Summary of Generalized Impulse Response Results

Method	Regime					
	Low Stress (0)			High Stress (1)		
	Impulse	Rule	SELIC	Impulse	Rule	SELIC
OECD	Counter	-	-	-	-	Counter
IMF (2006)	Pro	-	-	Pro	Counter	Counter
Dutch	Pro	Counter	-	Pro	-	Counter
IMF (2008)	Counter	Counter	-	Counter	Counter	Counter
Kalman	Pro	Counter	-	-	-	Counter
Procyclical	3	0	0	2	0	0
Countercyclical	2	3	0	1	2	0
No Significance	0	2	5	2	3	5

Note: This table reports a summary of Generalized Impulse Response results of all models with fiscal impulse. Low Stress Regime (0) means low financial stress and High Stress Regime (1) means high financial stress, both are related to economic growth and crisis, respectively.

6. Concluding Remarks

In this research, we contribute to the literature on non-linear responses of fiscal and monetary policies by studying the role of financial conditions as a possible propagator of asymmetries in the responses of monetary and fiscal policies, the business cycle and financial sector. Our research aims to analyze the monetary and fiscal responses in periods of financial stress using the Financial Stress Index (FSI) as a threshold variable to identify two states of nature: low stress regime (economic growth) and high stress regime (economic downturn).

Using Brazilian data, the empirical results come from the benchmark *threshold*-VAR (TVAR) model and five TVAR models that include the fiscal impulse methods - OECD, IMF (2006), Dutch, IMF (2008), and Kalman filter. Consistent with the related empirical literature, our results show supporting evidence for nonlinearities. This, this research recognizes the existence of asymmetries in the transmission between the financial sector, monetary and fiscal policies, and the real economy. In addition, the findings suggest that the effects of monetary and fiscal shocks on output are stronger when the financial system is sound. Our results are from 2000 February through November 2020, which includes data of the ongoing economic disruption caused by COVID-19, marked by unprecedented and sharp fiscal interventions designed to attenuate the economic downturn.

The main results suggest that in the growth phases, fiscal policy was expansionary in impulse but contractionary as a rule. In the downturn cycle, the monetary authority was countercyclical in all models. The fiscal impulse was procyclical in two of the five models, while the fiscal rule was countercyclical in two of the five models. In this regime, the models showed more non-significant results. This analysis is necessary since growth and crisis periods can lead to asymmetric responses of policymakers. Overall, the evidence suggests that the government had a procyclical record.

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