# Explaining Economic Fluctuations in Brazil with a Weekly Index

Senior Thesis Project - Honors Program in Economics

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## Abstract

This paper introduces the Brazilian Real Activity - Weekly index (BRA-W), Brazil's first weekly economic conditions index to use a dynamic factor model. This method exploits information in a broad range of economic series at the weekly, monthly, and quarterly frequencies, which cover the main sectors of the Brazilian economy. I first use this index to identify the individual contribution of different economic sectors to three recent periods of economic turmoil triggered by: the prolonged recessionary experience connected to the impeachment of Dilma Rousseff (2016), the three-week truck drivers' national strike (2018), and the COVID-19 pandemic period (2019-20). Then, I show how this index highly correlates with existing economic activity indicators. Finally, I examine the forecasting performance of the index on the Brazilian real GDP and provide an estimate for its growth in 2022Q1.

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# 1 Introduction

Traditionally, economists and policymakers evaluate levels of economic activity by using low-frequency data. The most well-established measurement used is the Gross Domestic Product (GDP), which only updates quarterly and is backward-looking. Similarly, other macroeconomic data series at the monthly and quarterly frequency share the same problem of not providing researchers with a timely way to measure changes in the state of the economy. Periods of high economic volatility, such as in the COVID-19 pandemic, exacerbate this problem, as the macroeconomic environment evolves too rapidly to allow researchers to approximate real-time conditions from low-frequency measurements. In advanced economies, these periods of fast-evolving conditions usually happen sporadically, mostly during economic recessions. However, in developing countries, periods of high economic fluctuations occur way more often, meaning that most macroeconomic analyses in those countries have the potential to benefit from the creation of alternative ways to track down economic activity in real time.

Over the last decade, Brazil has faced a particularly extended period of economic turmoil (Figure 1). After the rapid economic expansion of the early 2000s, led primarily by the boom of commodities and stimulative fiscal policies, real national output stagnated, remaining under the levels achieved in 2013[1]. Meanwhile, real GDP per capita has fallen 11.1% over the last ten years[2], and the unemployment rate has tripled[3]. Moreover, this economic contraction has now persisted through three president's administrations and has been accompanied by great political turmoil. Throughout this period, Brazil faced an impeachment trial, prominent political figures were found guilty of corruption, and a sequence of economic plans failed.

[1]Real GDP at constant national prices for Brazil. FRED. (2021, November 8). Accessed on February 15, 2022, from `https://fred.stlouisfed.org/series/RGDPNABRA666NRUG`

[2]Constant GDP per capita for Brazil. FRED. (2021, November 2). Accessed on February 15, 2022, from `https://fred.stlouisfed.org/series/NYGDPPCAPKDBRA`

[3]CEIC database, ID: 475685597 SR Code: SR157483527


**Figure 1:** The Brazilian Real GDP has remained stagnant over the last decade. In the meantime, a sequence of economic crises has weakened the national economy. OECD recession bands added in grey. Data available in the Fred database (Real GDP: NAEXKP01BRQ652S, Recession bands: BRAREC)

Although some improvements have been made in its economic legislation (particularly involving its social retirement system[4] and its labor laws[5]), these changes have not yet been enough to lead Brazil to a path of steady economic growth. There were short periods of rapid economic expansion, particularly in late 2017 and late 2019, but expectations that the stagnation period had ended were soon proven incorrect. The COVID crisis was responsible for shattering the last recovery period, as the global pandemic disrupted consolidated national production chains, requiring unprecedented adjustments from most sectors of the economy. Now, there is a fear among monetary authorities that the counteractive fiscal policies employed in 2020 may lead to inflation rates not seen since the period of hyperinflation of the 80s and 90s[6].

[4]Congresso Promulga Reforma da Previdência. G1. (2019, November 12). Accessed on February 15, 2022, from `https://g1.globo.com/politica/noticia/2019/11/12/congresso-promulga-reforma-da-previdencia-regras-comecarao-a-valer-depois-de-publicadas.ghtml`

[5]Temer Sanciona Texto da Reforma Trabalhista em Cerimônia no planalto. G1. (2017, July 13). Accessed on February 15, 2022, from `https://g1.globo.com/politica/noticia/temer-sanciona-texto-da-reforma-trabalhista-em-solenidade-no-planalto.ghtml`

[6]IPCA: Inflação Oficial Fica em 1,25% em outubro e atinge 10,67% EM 12 Meses. G1. (2021, November 10). Ac-

Given the instability of economic output in Brazil during the last decade and the likelihood that the country will continue to face macroeconomic turbulence in the near future, I argue that Brazil is in a unique position to receive the attention of researchers for the development of high-frequency economic indicators. Currently, the most widespread indices to measure economic activity have a monthly frequency (such as the LEI/CEI indices from *FGV* and the IBC-Br index from *Bacen*), while there is only one weekly index involving the Brazilian economy (a machine learning model from the OECD that uses data on Google searches). Therefore, the introduction of other weekly economic activity indexes for Brazil, based on more traditional economic data like industrial production and unemployment rate, has the potential to improve the work of researchers, businesses, and policymakers who rely on precise measurements of economic output but are constrained by periods of high fluctuation.

This paper aims to take a step in this direction by introducing the Brazilian Real Activity - Weekly (BRA-W) index. I calculate this indicator using a dynamic factor model, which takes data series that measure different aspects of the real economy and identifies co-movements among them. To better track continuous movements in economic conditions, I follow Arouba et al. (2009) and create a dataset including series at different frequencies, namely weekly, monthly and quarterly. I carefully select each data series to include the most critical sectors of the Brazilian economy, given the available data. I then design the sector division following concepts of heterogeneity and representativity established in Baumeister et al. (2021) and Lewis et al. (2020), as I divide the series into six sectors: Real Activity, Market Prices of Financials and Commodities, Household, Industry, Labor Market, and Expectations.

Overall, this paper is very connected to recent developments in the literature on weekly economic indices. The COVID pandemic pushed researchers to focus their attention on developing

cessed on February 15, 2022, from `https://g1.globo.com/economia/noticia/2021/11/10/ipca-inflacao-oficial-fica-em-125percent-em-outubro.ghtml`

tools that could assist in the high-frequency measurement of real economic activity to inform policymakers, business communities, and other researchers heavily affected by disruptions from the pandemic. Introduced by Lewis et al. (2020), the Weekly Economic Index (WEI) provided the first step in the current high-frequency indexing innovation, presenting a weekly index for the economy of the United States. It used a dynamic factor model with eight weekly series divided into three categories: Consumer-focused, Labor Market, and Industrial. Soon after, the publication of Baumeister et al. (2021) introduced high-frequency economic condition indicators for the 50 U.S. states. This paper not only expanded on the WEI by increasing the number of regions analyzed, but it also used a more significant number of indicators (25), which involved data series with different periods of update. Since then, many publications have followed this trend, and there are now weekly indices available for Germany (Eraslan and Gotz (2021)), Italy (Monache and Emiliozzi (2021)), and Turkey (Celgin and Gunay (2020)).

The paper continues as follows. Section 2 discusses a more in-depth literature review, focusing on the most important high-frequency economic indicators currently in use in Brazil. Section 3 describes the data set. I first explain the process behind selecting which series to incorporate in the model and then discuss its sector division. Section 4 introduces the dynamic factor model and explains the theoretical concepts behind calculating the index from its inputs. Finally, Section 5 presents the model's results and analyzes the BRA-W index using three methods. Section 5.1 investigates three recent events in Brazilian economic history that have the potential to be better explained with a weekly index. I study the impeachment movement of President Dilma Rousseff, a large truck-driver's strike in 2018, and the COVID crisis in Brazil. In those periods, I identify possible events that correlate with large movements in this paper's index. Section 5.2 compares the BRA-W index to two existing economic activity indices from prominent institutions and shows a significant correlation among them. Section 5.3 applies the forecasting analysis in Lewis et al.

(2020) and determines the predictability power of the index on the Brazilian GDP. Finally, Section 6 concludes the paper and suggests directions for future research.

## 2 Existing Economic Activity Indices in Brazil

To understand the motivation behind the introduction of the BRA-W index and what it brings to the table, it is essential to first look at existing indices of economic conditions in Brazil.

The most traditional indicators that measure movements of economic output in Brazil have a monthly frequency. The most important one is the Index of Economic Activity (*IBC-BR*, in Portuguese), released by the Brazilian Central Bank (*Bacen*, in Portuguese). Unfortunately, information regarding the construction of this index is limited to the series used as its inputs[7], as Bacen did not publish a paper detailing the index. From a 2018 report[8] discussing the differences in the methodology between the calculation of GDP and the IBC-BR series, it is possible to determine that it mainly estimates output by analyzing growth estimates for the agricultural, industrial, and service sectors and considering the evolution of total production supply, net imports, and taxes approved by the government. Even though information on this index is scarce, its wide use in studies from the Brazilian Central Bank makes it valuable as a source for comparison. I compare it to the BRA-W index in Section 5.2, and I show that this paper's index displays an impressive correlation with the IBC-Br.

The next two important indices come in pairs - the *Leading Economic Indicator* and *Coincident Economic Indicator*, released by *Fundação Getúlio Vargas (FGV)* in partnership with *The Conference Board (TCB)* organization. Fortunately, information on these two indices is more widely

[7]Time Series Management System - bcb.gov.br. (n.d.). Accessed on February 15, 2022, https://www3.bcb.gov.br/sgspub/consultarmetadados/, Serie=24363, under the Metadata section.

[8]Indicador de Condições Financeiras - bcb.gov.br. (n.d.). Accessed on February 15, 2022, `https://www.bcb.gov.br/conteudo/relatorioinflacao/EstudosEspeciais/Metodologia_ibc-br_pib_estudos_especiais.pdf`

available. First appearing in Campelo Jr et al. (2013), both indices are part of a more extensive study of the TCB, which composes similar monthly frequency indices for other eleven emerging markets. Both indices are based on a turning point analysis supplemented by a Markov Switching model to avoid problems with their low number of observations[9]. In addition, the authors only include data dating back to 1996 to avoid the hyperinflation period of the Brazilian Economy[10]. I follow the same strategy to avoid contaminating the BRA-W index with excessive fluctuations.

The Coincident Economic Index tries to measure the economy's current situation. Therefore, it uses series that track past and present movements in aggregate output in Brazil. Meanwhile, the Leading Economic Index tries to predict the future situation of the economy, mainly using expectation series. Campelo Jr et al. (2013) demonstrate that both indices have a high predictive power of the turning points of business cycles, which motivated the decision to use most of their inputs in my model. In total, 11 of the 28 series used in this paper are similar to the ones used either by the LEI or CEI indices. Unfortunately, the complete LEI and CEI series are only available in a restricted database, limiting both indices as comparison sources.

Another monthly indicator of economic activity for Brazil is proposed by Matheson (2011), which relies on the same type of dynamic factor model that I implement in the BRA-W creation. This report from the *International Monetary Fund (IMF)* creates indices for 32 advanced and developing economies, using a different set of indices and starting dates for each of them. To track economic activity in Brazil, it uses an impressive number of 148 indicators. However, the study only provides a general analysis of its results for the 32 countries in the model, preventing a direct comparison with the index developed in this paper, which exclusively focuses on the Brazilian economy.

[9] At the time of publication, the input indicators used in both models only had about 200 observations, as they are reported monthly.

[10] Even though *Plano Real*, the monetary program responsible for drastically reducing inflation rate levels in Brazil called, dates back to 1994, inflation rate levels remained over two digits per year until the end of 1995

More recently, Woloszko (2020) has introduced the only weekly economic activity index for Brazil that I am aware of, called *OECD Weekly Tracker: Brazil*. This paper uses a machine-learning algorithm to analyze a panel of Google Trends data related to the Brazilian economy, starting in March 2018. Based on the search volume of specific queries on the Google website, this type of data fluctuates significantly more than the traditional economic series used in the BRA-W index and in the previous indicators. This difference can allow the OECD Weekly Tracker to identify large movements in economic conditions first, but with higher volatility in the long run. Section 5.2 details this and other differences between the OECD Weekly Tracker: Brazil and the BRA-W index, discussing the trade-off between using each approach to estimate economic conditions in Brazil.

# 3 Data

This section outlines the dataset underlying the BRA-W index and details how the input series are divided into representative categories of the Brazilian economy.

Selecting the inputs to the BRA-W index involves carefully analyzing possible alternatives[11]. Overall, there are three main factors to choose the indicators used in the model. First, all economic variables must provide information about large sectors of the national economy to supply relevant information about aggregate economic activity. The second factor is the series' frequency. The aim is to include the largest number of high-frequency series possible that cover critical economic sectors in Brazil, which is challenging given the relatively limited availability of weekly and daily series. The final database includes seven economic variables at the weekly frequency, which is similar to the number used in recent studies (see Lewis et al. (2020), Baumeister et al. (2021)). Finally, the

[11]The databases I use contain hundreds of thousands of series. While the CEIC database includes the impressive number of 753,381 series covering macroeconomics data on Brazil, searches in the FRED database return 1178 results for the Brazilian economy.

last factor is the indicator's initial date of report. In order to create a meaningful index for the whole period analyzed, it is desirable to have information for an economic variable available at the earliest starting date. However, as explained in Section 2, given the inflation turmoil of the first half of the 1990s, I cap the beginning of the period covered by the index at 1997.

After applying the above criteria, I select a subset of the remaining series encompassing a broad overview of the national economy. Table 1 summarizes this data set containing twenty-eight series[12] and describes the sector categorization of each variable and all transformations applied to it. The transformations mainly remove the variables' long-run trends, creating stationary series that are appropriate for a dynamic factor model analysis. Whenever necessary, I also deflate and seasonally adjust the variables.

The six data categories in the model are *Real Activity*, *Market Prices of Financials and Commodities*, *Households*, *Industry*, *Labor Market*, and *Expectations*.

The first category, *Real Activity*, contains series that track general economic activity in the country. As explained in the introduction, Real GDP is the traditional measurement of real activity in a country. Still, given its low frequency, it is important to supplement its information using series released at a higher frequency. Among the other series, mobility data deserves special recognition, as it is widely used among the recent weekly indices published around the world. Overall, improvements in a country's economic conditions are tied together with an increase in mobility, particularly during the turbulent COVID-19 period. Additionally, the data set includes traditional indicators related to foreign trade, measuring the foreign trade balance in US dollars, and the Quantum Index (from the Foundation for Foreign Trade Studies Center - FUNCEX). These indicators hold information on the amount of capital flowing into and out of the country, which may stimulate a stagnant economy or anticipate the deterioration of economic activity in a booming

[12]Table 2 details their sources

economy. Another important series measures energy generation, aggregating the total amount of GWh produced monthly in the National Interconnected System, which constitutes the majority of Brazil's electricity sector. The link between increasing electricity use and economic growth is fairly established in the literature (for example, see Mele (2019)), thus, non-seasonal fluctuations in energy production are an excellent proxy for changes in real activity. Finally, the dataset also compiles data on firms' revenue in the tourism sector, which tends to increase in a booming economy as more resources become available for leisure.

The *Market Prices of Financials and Commodities* category includes most of the model's indicators at the weekly frequency, and it contains important market price information on financial assets that define the Brazilian economy. The Bovespa Index (IBovespa) is a traditional benchmark index for the major stocks traded on the B3 stock exchange, and it covers the performance of stocks representing over 80% of the total number of stocks and financial volume traded in the Brazilian capital market. Another financial indicator of particular importance to Brazil is the exchange rate between its national currency (the *Brazilian Real*) and the US dollar, whose fluctuations reflect the financial flow of capital into the country. The 3-month government bond yield incorporates important information on the costs of borrowing in Brazil, affecting the behavior of investors and driving economic activity. On the commodities side, the model incorporates information on the prices of two crucial products: ethanol and soybeans. Brazil is responsible for 26.1% of total ethanol produced globally[13] and the product's price largely affects production chains throughout the country. To represent the large Brazilian agricultural sector, I include information on soybean prices, the most important crop produced in the country, currently comprising 34.8% of the sector's production value (2019). The fluctuations in the crop's price provide information not only on economic

[13]Renewable Fuels Association (October 2018). "Global Ethanol Production (2007-2020)". `https://afdc.energy.gov/data/10331` Alternative Fuels Data Center, U.S. Department of Energy. Accessed on February 16, 2022.

segments directly involved in the crop's production like farmers and machinery producers, but it indirectly influences other important markets in the national economy, such as animal husbandry and the transportation sector.

Under the label *Households* are series that provide information on the behavior of consumers in the economy. Average Real Earnings provide income data and is composed of the average family revenue from wages, gross operating surplus, capital gains, and benefits from various sources (employment insurance, government assistance programs, social security, etc.) minus recurrent expenses such as personal income and property taxes and contributions to social security. Changes in investment behavior from households also heavily influence economic conditions in the country, so the database includes information on the total amount of money available in savings accounts and the available credit provided by domestic banks to households and non-profit institutions serving households. Household expenditure is another essential factor in economic activity. So, I included an index covering the monthly growth of household purchases within the retail market and information on the deflated price of residential property. This data is calculated by an index measuring the evolution of the cost of all types of new and existing dwellings in metropolitan areas.

The series included in the *Industry* category track developments in the industrial sector in Brazil, which corresponds to a sizable portion of the Brazilian GDP[14]. This category contains two indices focused on measuring the general outlook of the industrial sector in Brazil. The Industrial Capacity Utilization Index measures monthly industrial activity as a percentage of utilization of production factors available through surveys with employers from the 19 sub-sectors of the manufacturing industry. The Industrial Production Index itself is assessed by a monthly representative survey covering over 900 products from 8500 establishments which incorporate 65% of the value added from mining and manufacturing activities in the country. This category also includes three

[14]Participação da Indústria no Pib Cresce na Pandemia. Instituto Aço Brasil. (n.d.). Accessed on February 17, 2022, from `https://acobrasil.org.br/site/noticia/participacao-da-industria-no-pib-cresce-na-pandemia/`

series covering specific industrial sectors among the most important ones for the national economy. The automotive sector is represented by a series covering the monthly number of cars produced in Brazil, which are either exported or sold domestically. The metallurgy sector, which produces over 32.8MM tons of steel each year, appears in the index through the monthly volume of steel production. Finally, the petrochemical industrial sector, led by the state company Petrobras, is represented in the total monthly revenue from the sale of petroleum products.

The *Labor Market* category includes two standard variables capturing the activity in the labor market: unemployment claims and the unemployment rate. While the unemployment rate measures the overall ratio between the size of unemployment and the labor force, the unemployment claims series complements this data by providing the number of workers that filed for unemployment insurance in a month. This category also includes an index based on the average hours worked in the manufacturing sector, computed by the National Confederation of Industry based on seasonally adjusted monthly data.

Finally, *Expectations* includes surveys that indicate expected economic conditions of specific macroeconomic factors. The OECD compiles tendency indices, which provide qualitative information on the assessment of enterprises and households on their expectations for the "direction of change" that a particular sector will have in the immediate future. The employment survey asks firms about the number of persons they expect to employ in the next quarter compared to the current one. Likewise, the manufacturing surveys gather information on the growth of production and export levels manufacturing firms expect to have. The World Uncertainty Index (Ahir, Bloom, and Furceri 2022) is computed by counting the appearance of variants of the word "uncertain" in the Economist Intelligence Unit reports for Brazil, providing researchers some information on the level of confidence market players have in their expectations.

The classifications above involve some level of subjectivity, and it is possible to relate each series to more than one category. Evidently, the dollar exchange rate and the price of ethanol often affect households' economic decisions. At the same time, total energy production and hours worked in the manufacturing sector significantly reflect variations in the industrial sector's output. Therefore, when interpreting the decomposition of the index into its categories, as in section 5.1, it is necessary to keep in mind the inherent entanglement of those different sectors in the real economy.

# 4 The Dynamic Factor Model

To calculate the BRA-W index from the data described in Section 3, I apply a dynamic factor model. This method was developed by Sargent and Sims (1977) and Geweke (1977), and it has been widely used for the construction of economic activity indices (see Stock and Watson (2016)).

In general, a dynamic factor model poses that it is possible to identify a latent factor, $f_t$ that drives the co-movement of all series in a dataset. Given a N x K matrix $\mathbf{Y}$ containing all the input indicators used in the model, where N is the number of weeks in the analysis and K is the number of variables in the dataset, each week $t$ is associated with the vector $y_t$, which contains the observation for each series during that week. $y_t$ is modeled to be equal to the sum of a common component, $\lambda f_t$, and an idiosyncratic component $u_t$. Thus,

$$y_{it} = \lambda_i f_t + u_{it} \tag{1}$$

where $\lambda$, the dynamic factor loadings, contains the weight with which the individual series load

on the common factor $f_t$, while $u_t$ captures idiosyncratic movements of each series which are the result of factors like measurement error(Matheson 2011).

Equation (1) describes the basic structure of the dynamic factor model. Nonetheless, using variables at different frequencies brings an additional layer of complexity to this study. As the base frequency of the model is weekly, the dynamic factor model assumes that the factor $f_t$ affects all input series once per week. However, the BRA-W dataset contains series that are available only at either monthly or quarterly frequency, so the matrix $\mathbf{Y}$ contains "missing" entries for those series. Additionally, there are other sources contributing to the incompleteness of $\mathbf{Y}$, such as series that only cover part of the analyzed period or the rare instances where one data source does not release an observation for its series as expected. Thus, to estimate the latent factor and the other parameters of the model, the estimation framework must be modified to proceed with the analysis.

To accommodate a mixed-frequency dataset, I modify the regular dynamic factor model to allow variables at different frequencies to have different characterizing equations. While series at the weekly frequency are still governed by equation 1, monthly and quarterly variables are estimated using these two equations, respectively, where c(m) represents the number of weeks in a month and d(q) the number of weeks in a quarter[15]:

$$y_{i,t} = \lambda_i[c(m_t)]^{-1}(f_t + f_{t-1} + ... + f_{t-c(m_t)+1}) + [c(m_t)]^{-1}(u_{i,t} + u_{i,t-1} + ... + u_{i,t-c(m_t)+1}) \quad (2)$$

$$y_{i,t} = \lambda_i[d(q_t)]^{-1}(f_t + f_{t-1} + ... + f_{t-d(q_t)+1}) + [d(q_t)]^{-1}(u_{it} + u_{i,t-1} + ... + u_{i,t-d(q_t)+1}) \quad (3)$$

To then estimate the unobserved parameters, this paper uses a statistical inference algorithm called Gibbs sampling. This framework generates a Markov Chain of samples using the Monte Carlo

[15]These equations come from Section 2.1 of Baumeister et al (2021), which derivations come from the approximation that $Y_{m_t} = Z_t + Z_{t-1} + ... + Z_{t-c(m_t)+1} \approx c(m_t)(Z_t Z_{t-1} ... Z_{t-c(m_t)+1})^{1/c(m_t)}$

method[16], making it possible to estimate the missing entries in the dataset. I postulate that all economic variables in the model fluctuate weekly, but some series are only observed monthly or quarterly. A Kalman filter algorithm is embedded in each iteration of the Gibbs sampling process, which not only filters out unwanted noise coming from the large number of dimensions in the model, but it also provides an accurate measurement of the unknown variables by calculating their joint probability distribution in each period.

The last necessary building block characterizing the model is the structure of the unobserved components. Both the latent factor, $f_t$, and the idiosyncratic component, $u_{it}$ are defined using a Gaussian auto-regressive process AR(4)[17], which depend on the autoregressive coefficients $\phi$ and $\psi$, estimated in the sampling process. Mathematically, $f_t$ and $u_{it}$ are defined as

$$f_t = \phi_1 f_{t-1} + \phi_2 f_{t-2} + \phi_3 f_{t-3} + \phi_4 f_{t-4} + \epsilon_t \qquad \epsilon_t \sim N(0, w) \tag{4}$$

$$u_{i,t} = \psi_{i,1} u_{i,t-1} + \psi_{i,2} u_{i,t-2} + \psi_{i,3} u_{i,t-3} + \psi_{i,4} u_{i,t-4} + \epsilon_{i,t} \qquad \epsilon_{i,t} \sim N(0, \sigma_i) \tag{5}$$

This dynamic factor model is based on Baumeister et al. (2021), which also models its indices from indicators updated at the weekly, monthly, and quarterly frequencies. The use of lower frequency variables in a dynamic factor framework estimating an index at higher frequencies was also implemented before in Mariano and Murasawa (2003) and Aruoba et al. (2009). This approach allows for the inclusion of economic information that is not available at higher frequencies. Other recent papers that develop weekly economic conditions indices, such as Lewis et al. (2020) and Celgin and Gunay (2020), have opted to use only series at the weekly frequency. However, it is essential to augment the BRA-W index with low-frequency variables because most economic

[16]Which in this study uses 3,000 iterations, discarding the first 1,000 for convergence

[17]The use of the AR(4) process was empirically verified to agree with year-over-year growth rates in Baumeister et al. (2021)

factors available at the highest frequencies in Brazil have recent starting dates. Therefore, including monthly and quarterly data in the model avoids creating an index that does not provide meaningful information in the first years of the estimation sample. Moreover, there are many important economic variables in Brazil that are only available at the monthly frequency, whereas other more advanced economies have access to these indicators at higher frequencies. The WEI, for example, includes weekly data on unemployment claims and steel production for the US economy. These series are simply unavailable for Brazil at that frequency. Using a mixed-frequency dynamic factor model allows for the inclusion of similar series available for Brazil, but which are reported only at the monthly frequency.

A more detailed description of the model and the estimation algorithms is available in Appendix A of Baumeister et al. (2021).

After estimating the model, the last step to create the BRA-W index is to scale the factor to the real GDP annual growth rate to achieve an easy-to-interpret index. For any given week, the value of the index informs the annual rate of growth for the Brazilian economy at that week. A report of 2% in the BRA-W index, for example, means that if economic conditions were unchanged for a whole quarter, the Brazilian economy should grow 2% relative to the same quarter in the previous year.

In many ways, this methodology diverges from the other dynamic factor model applied to the Brazilian economy in Matheson (2011). Since the purpose of this IMF study is to use a universal methodology capable of modeling 32 economies concurrently, it has to rely upon some simplifications. For example, although its dataset includes data with different frequencies, all high-frequency series are averaged out to produce monthly variables prior to running the model. Additionally, the IMF paper also chooses to include a vast number of indicators in its model

(it includes 148 series only for Brazil, while Sweden tops the list with 290 series). The large contrast between the number of variables used in the BRA-W index and the IMF index illustrates a larger debate in the economic literature about the use of "Big Data" or "Small Data" dynamic factor models for measuring real activity (see Aruoba 2009 and Diebold 2003). Both decisions include noticeable trade-offs, and a large number of indicators can allow the model to average out idiosyncratic fluctuations in the index estimation. Nonetheless, as the IMF study is inevitably less cautious when selecting which series to include in their study, it also has to construct a 7-month moving average process to smooth some indicators' short-run volatility.

# 5 Analysis of the Results

In this section, I analyze the BRA-W index and discuss how this high-frequency indicator provides noticeable benefits for investigating economic conditions in Brazil. I divide this analysis into three parts: an in-depth look into specific turbulent economic periods by observing the BRA-W level and its decomposition into different sectors; a comparison between the BRA-W index and traditional economic indices for Brazil; and a forecasting exercise investigating the relationship between the BRA-W index and real GDP.

## 5.1 A Historical Analysis of the Index and its Main Drivers

Figure 2 shows the demeaned BRA-W index from February 02$^{\text{nd}}$, 1997, to March 12$^{\text{th}}$, 2022. I have normalized the index such that the value of zero indicates national long-run growth. The overall evolution of the index aligns with well-known periods of rapid economic expansion and contraction over the last two decades. For most recession periods, identified with the gray shaded areas corresponding to recession dates from the OECD Recession Indicator, the index observes a

drop in its levels compared to the months prior. The periods in which the index hit its lowest values correspond to the 2008-09 crisis (-7.21%), the 2014-16 Brazilian recession (-7.39%), and the COVID-19 2020 recession (-15.78%). Meanwhile, during well-known periods of economic expansion, the index presents high values. Some examples are during President Lula da Silva's second term (+5.05%), President Rousseff's first term (+7.22%), and during the COVID-19 2021 recovery period (+12.36%).

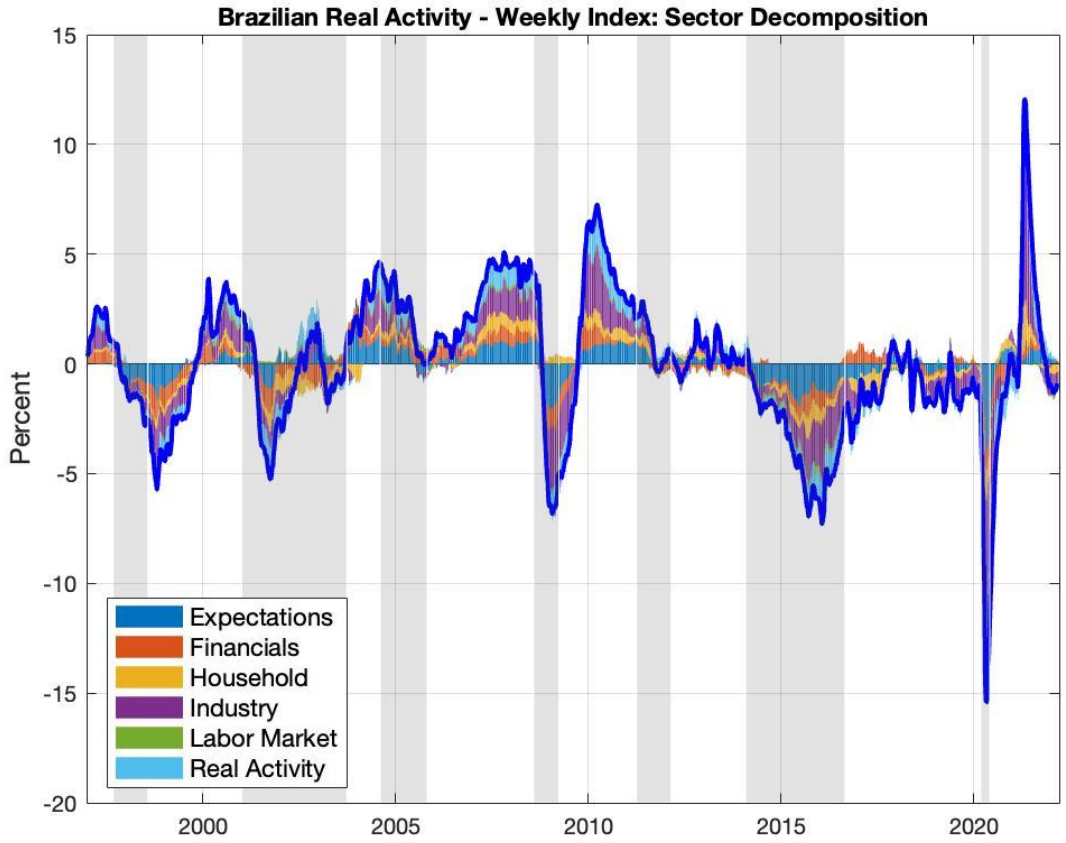


**Figure 2:** The Brazilian Real Activity - Weekly index, starting in 1997-02-08. The values here are demeaned: the value of zero indicates national long-run growth. The graph presents the decomposition of the BRA-W index into the six broad sector categories described in Section 3. Data from BRA-W update on Mar 26$^{th}$, 2022. Recession bands from OECD (FRED: BRAREC)

One significant benefit of a dynamic factor model framework is the possibility of decomposing

the index into each sector's contributions. This approach allows for a more comprehensive analysis of specific economic events, as one can identify the main underlying forces driving changes in economic conditions during those periods. Figure 2 plots this decomposition, and the contributions of each sector in each week are stacked together to fit the area under the BRA-W index curve.

Over the entire sample period, the most prominent driver of economic activity was the industrial sector, which was responsible for 30.40% of the absolute impact on the fluctuations of the BRA-W index. This number is calculated by adding the total absolute area representing one sector in Figure 2 and dividing it by the sum of the absolute area of all sectors[18]. This fraction was larger when the BRA-W index drifted away from long-run growth by more than 2%, reaching 33.4%. The Real Activity and Expectations categories are the next most influential, corresponding to 21.25% and 19.30% of the index absolute levels over the entire period, respectively. Conversely, the Labor Market had the lowest overall contribution to the BRA-W index, with 3.45%. However, this relatively low overall impact does not diminish the importance of this sector on the index, as there are specific periods when this category dominates the others, such as in May 2018, when it covered 22.43% of the total BRA-W level. Finally, while the Market Prices of Financials and Commodities had a substantial overall impact of 13.16% on the index, it is when economic activity is close to the long-run growth where it stands out, being the leading force with 26.70% participation.

To further explore how the BRA-W index can assist economists in studying the Brazilian economy, I analyze three turbulent periods in recent history. These periods differ in terms of length, nature, and magnitude, but they all significantly shaped the trajectory of aggregate economic activity in Brazil over the last decade. Therefore, they provide excellent opportunities to test the index in diverse environments.

[18]Here, "absolute" area means that if the area representing one sector in a specific time interval is under the x-axis, it contributes positively to the sum.

### 5.1.1 Impeachment of Dilma Rousseff (Dec 2015 - Aug 2016)

The Impeachment of Dilma Rousseff was a long and intense event that started when the House of Representatives accepted an impeachment petition on December 2$^{nd}$, 2015, and only concluded with her final trial in the Senate on August 31$^{st}$, 2016. During these nine months, complex political news shook the national economy every week, particularly involving the investigations of *Operation Car Wash*. This political movement is interconnected to the 2014-2016 Brazilian crisis, which was related to the deterioration of the federal government budget over the previous years. This prolonged recession deteriorated President's Rousseff popularity[19], and many market players saw her Impeachment as the solution to the economic instability of the time.

Politics and economics walk abreast. In the same way that shifts in economic activity can affect a government's popularity, movements in the political scenario can positively affect economic output. Figure 3 shows the decomposition of the BRA-W index from September 2015 to December 2016, and it is possible to recognize two main phases of movements in economic activity over the impeachment period based on the magnitude of fluctuations in economic activity. These two phases correspond almost precisely to before and after President Rousseff's impeachment.

The first phase, ranging from December 2015 to April 2016, is marked by large economic fluctuations. A critical movement happened between the beginning of the impeachment process and the last week of January when economic conditions fluctuated by -1.4%. The Real Activity category explains over 60% of this shift in the BRA-W decomposition. This period coincides with when the credit rating agency *Fitch Ratings Inc.*, motivated by political uncertainty, reduced its evaluation of the country from BBB- to BB+, a non-investment grade[20]. This action may have

[19]Governo Dilma tem aprovação de 9 e reprovação de 70. Globo. Accessed on March 26$^{th}$, 2020. https://g1.globo.com/politica/noticia/2015/12/governo-dilma-tem-aprovacao-de-9-e-reprovacao-de-70-diz-ibope.html

[20]Firch rebaixa Brasil e país perde grau de Investimento. Agencia Brasil. Accessed on March 26$^{th}$, 2022. https://agenciabrasil.ebc.com.br/economia/noticia/2015-12/fitch-rebaixa-brasil-e-pais-perde-grau-de-investimento

had an immediate effect on the levels of foreign trade in Brazil, as the Quantum Index decreased by 27.2% from December 2015 to January 2016.

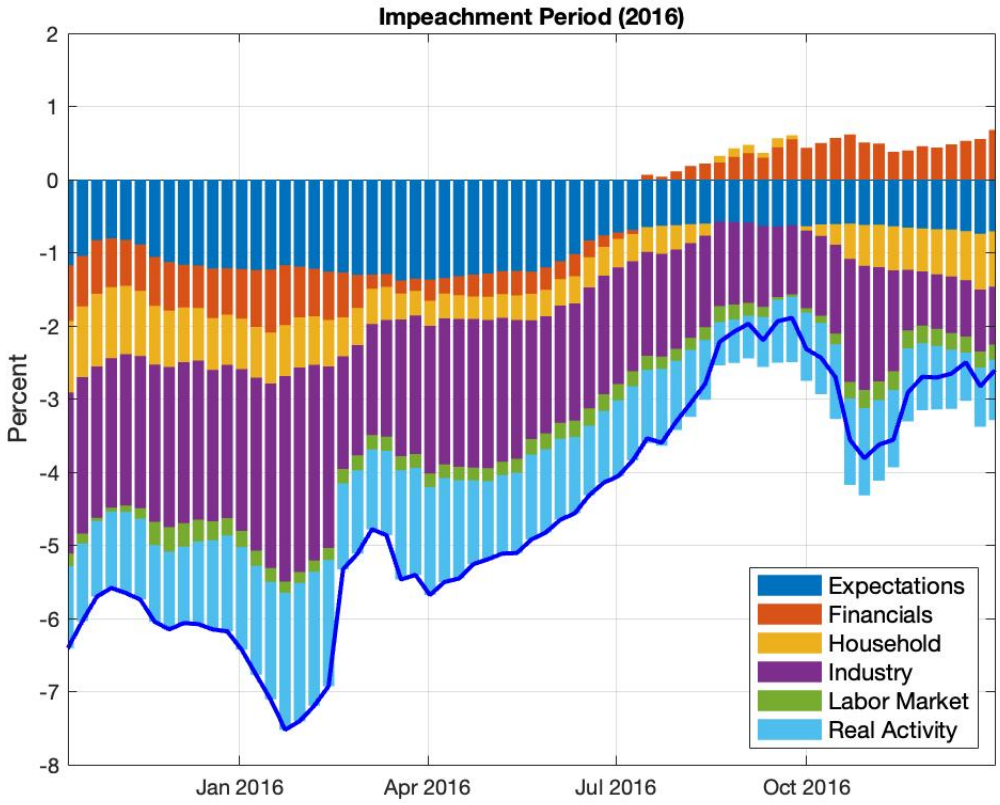


**Figure 3:** Data from BRA-W update on Mar 26$^{\text{th}}$, 2022

President Rousseff was then impeached on April 17$^{\text{th}}$, 2016. In Brazil, when the House of Representatives impeaches a president, they have their powers suspended, and the vice president, at the time Michael Temer, becomes acting president. This peculiarity of the Brazilian constitution makes it unlikely for a president to be acquitted by the Senate once impeached, as they lose most of their political influence and cannot use the federal budget to prevent their conviction. Therefore, when President Temer took office, he had the political stability necessary to appoint the conservative economist Henrique Meirelles as his economy ministry, which started to propose economic reforms lined up with the austerity that investment firms wanted. Coincidence or not, this event aligns

with the week the BRA-W index identifies as the start of a long period of steady recovery.

Over the next four months, the BRA-W index increased by 3.17% at a regular pace. The index remained below its long-term levels during this period, but it is possible to identify improvements in all categories. One perceptive movement happened around June 2016, when the Expectation category decreased its negative impact on the BRA-W index by 42.3%. This shift may be related to projections for the labor market, which estimated that with the stabilization of the political and fiscal scenario, it would be possible to recover over the following years the 2.07 million jobs lost during the 2014-2016 crisis[21]. Furthermore, at the end of the Impeachment trial, in August 2016, the Market Prices of Financial and Commodities category had the first positive contribution to the demeaned BRA-W index of any sector since September 2014. This movement is related to the 11.32% reduction in the Dollar-Real exchange rate from June to August 2016, which shows an appreciation of the Brazilian currency that many analysts attribute to President Temer's fiscal adjustment[22].

### 5.1.2 A Nationwide Truck Drivers' Strike (May 2018 - June 2018)

Another interesting episode was the 2018 truck driver's crisis which, in contrast to the impeachment period, was a rather short-lived event. On May 21$^{st}$ 2021, the Brazilian Association of Truckers (*ABCAM*, in Portuguese), which represented over 600,000 self-employed truck drivers, started a nationwide strike that paralyzed numerous roads across the country. These drivers criticized recent spikes in fuel prices and demanded tax cuts on diesel. They also requested that the federal government exert its influence over the state company *Petrobras* to change its policy of

[21]Brasil so deve recuperar estoque de empregos perdidos a partir de 2021. Globo. Accessed on March 26$^{th}$, 2022. https://g1.globo.com/economia/concursos-e-emprego/noticia/2016/08/brasil-so-deve-recuperar-estoque-de-empregos-perdidos-partir-de-2021.html

[22]Dolar fecha em queda após aprovação do Impeachment. Globo. Accessed on March 26$^{th}$. https://g1.globo.com/economia/mercados/noticia/2016/08/dolar-fecha-em-queda-apos-aprovacao-do-impeachment.html

international market-based pricing. Over the following days, major cities suffered from shortages of fuel and medicine, large food chains were disrupted, and many supermarkets across Brazil had to limit the number of products that each buyer could purchase. Additionally, 11 airports were shut down throughout the country, including the international airports of Brasília and Recife, and the nation's capital had problems with water supply. The protests officially ended on May 30$^{\text{th}}$, after a deal was struck between the government of President Temer and ABCAM to cut down diesel prices by R$ 0.46 per liter, which also included a reduction on the PIS/Cofins federal tax. However, protests remained active for a few more days around the largest port in Brazil, *Porto de Santos*, and it was not only after June 3$^{\text{rd}}$ that the last few highways were unblocked (Melo 2018).

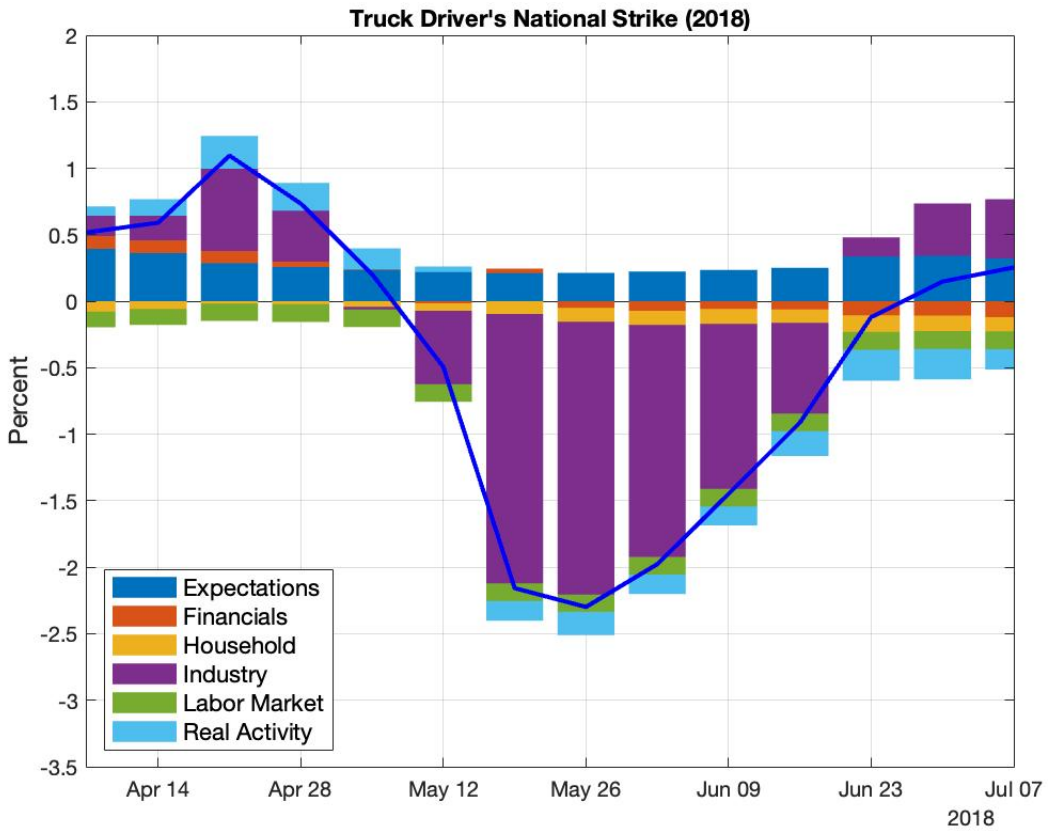


**Figure 4:** Data from BRA-W update on Mar 26$^{\text{th}}$, 2022

Figure 4 shows a significant downturn in the BRA-W index during the weeks ending on

May 19th, May 26th and June 2nd. Although the event's official starting date was on May 21st, the BRA-W already shows a large reduction in economic activity a week earlier, on the days between May 13th and May 19th. Such an observation is in accordance with the ABCAM's threat, on May 16th and May 18th, of a nationwide strike if the federal government did not take action against the rising prices of fuel. It is possible that these demands created enough instability to negatively influence economic activity in the week prior to the roads' blockade. Nevertheless, the lowest level of real economic activity happened between May 20th and May 26th, between the beginning of the strike and the agreement between ABCAM and the national government. As expected, economic conditions slightly improved during the last week of the strike (ending on June 2nd), as protesters were dispersed after the agreement's announcement, but it would not be until June 23rd that economic activity would return to its pre-strike levels.

The Industry sector contributes to explain 71.23% of the overall drop in the demeaned BRA-W index during the strike. This contribution coincides with an 11.00% decrease in the Industry Production Index, and it is related to the shortages of fuel and raw materials that affected the entire production chain. For example, all automakers in the country halted their production on May 25th because of a shortage of parts at the assembling line[23], and over 47 sugar and ethanol plants reduced or stopped their activities due to production distribution issues [24]. Contrastingly, the Financial sector contributed little to the index's level (2.51%), despite the fact that Ibovespa fell by over 9% during the strike.

[23]Produção de veículos vai parar. Globo. Accessed on March 16, 20220, from https://autoesporte.globo.com/videos/noticia/2018/05/producao-de-veiculos-vai-parar-nesta-sexta-por-causa-da-greve-dos-caminhoneiros-dizem-montadoras.ghtml,

[24]Usinas de cana são prejudicadas. Globo. Accessed on March 16, 20220, from https://g1.globo.com/economia/noticia/usinas-de-cana-sao-prejudicadas-por-greve-de-caminhoneiros-diz-associacao.ghtml

### 5.1.3 The COVID-19 Crisis

Compared to the other two analyzed periods, the COVID-19 pandemic stands out as the only international event. It also contains the two most extreme movements of the BRA-W index, reaching the values of -15.78% and 12.36% on the weeks of May 2$^{nd}$, 2020 and May 8$^{th}$, 2021, respectively. From 2020 to 2021, more than 600k people died from COVID-19, and GDP suffered its largest annual reduction since 1990. As the pandemic is still an ongoing event and several factors define its complexity, I have divided my analysis into three parts: the interval of lowest economic activity in 2020, the period covered by the special federal basic income program (from April to December 2020), and the beginning of the fast economic recovery in 2021.

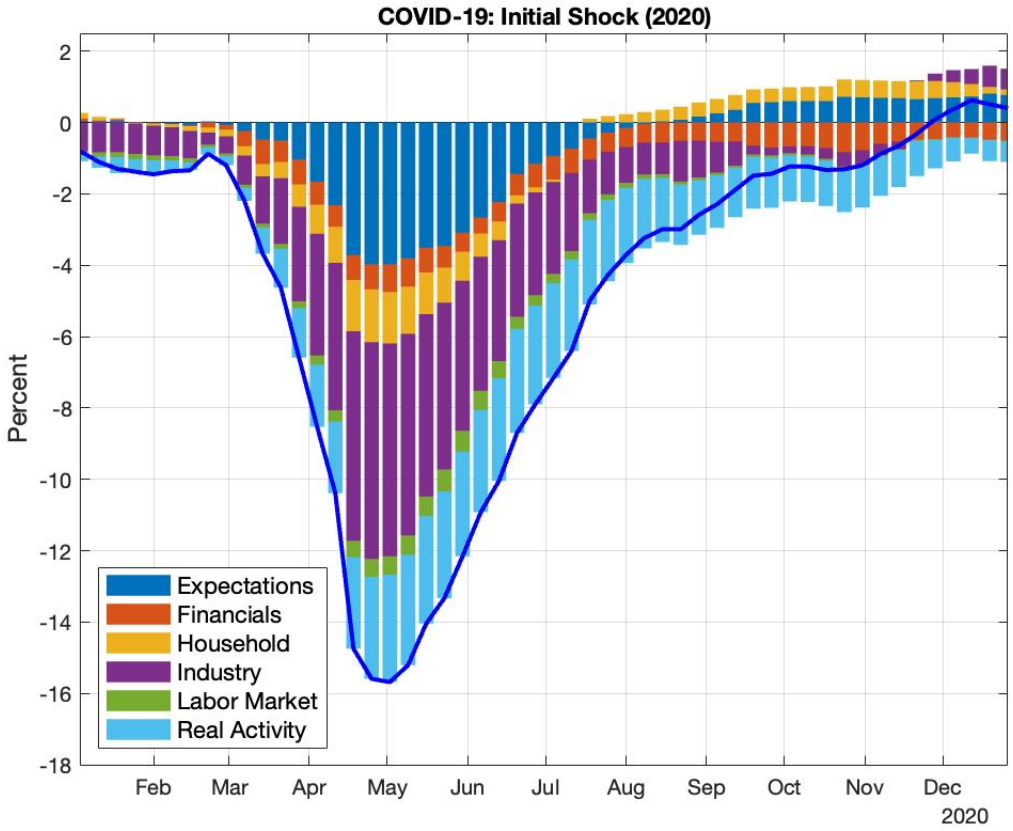


**Figure 5:** Data from BRA-W update on Mar 26$^{th}$, 2022

During the period of lowest economic activity (between the weeks ending in April 04$^{th}$ and June 13$^{th}$ 2020), when the BRA-W index displays values lower than -8% compared to the long-run growth rate, the Industry (37.13%) and Expectations (24.45%) sectors were the most significant drivers of economic activity. On the industry side, this correlates to the major hit in total production during the second quarter of 2020, when the sector laid off close to 500 thousand workers. Meanwhile, the Expectations category has a noticeable deviation from its long-term impact over the period (26.70%), which encapsulates how insecure market players were about future economic activity.

In the last week of April 2020, one week before the lowest historical value of the BRA-W index (Figure 5), the federal government launched the *Auxílio Emergencial*, a R$322 billion project that guaranteed a minimum income for households during the pandemic. This wide-reaching intervention program lasted until December 2020, and it paid R$600/month per person, an amount three times higher than the regular basic income program from the federal government, *Programa Bolsa Família*, which was paying an average paycheck of R$ 190.75 in February 2020. Furthermore, up to two persons in the same family could request the benefit, which, if summed together, represented 43.75% of the average family income. It is difficult to isolate the impact of this single program on economic conditions in the country, mainly because the Auxílio Emergencial started around the time the global economy reversed its downwards trend. Nonetheless, the Household category was the first to start to positively influence the demeaned BRA-W index, reversing its impact in the second week of July 2020. Also, from February to October 2020, it had a total participation rate 39.07% lower than its long-run average, meaning that other sectors were more responsible than usual in driving down economic activity. Those facts corroborate the argument that the Auxílio Emergencial successfully provided a social cushion to protect households from the worst effects of the recession.

At the end of 2020, around early November, a second wave of the disease hit the country,

which turned out to be the deadliest so far, hitting a peak of 1,817 deaths per day at the beginning of 2021Q2. Nonetheless, in the last month of 2021Q1, economic activity in Brazil took off (Figure 6). From that point until the last week of April 2021, Households and Industry had relatively similar participation in the BRA-W index. It is plausible that the Auxílio Emergencial allowed families to be better positioned to drive the recovery of economic activity. However, later on, in 2021Q2, the Industry sector dominated more than 60% of the demeaned BRA-W index, solely elevating the indicator by 7.75% points in the first weeks of May. This result is connected to the substation improvement in this production division over the quarter, with the machines and equipment industry and textile industry expanding over 64.9% and 97.6%, respectively, compared to the same quarter in the previous year.

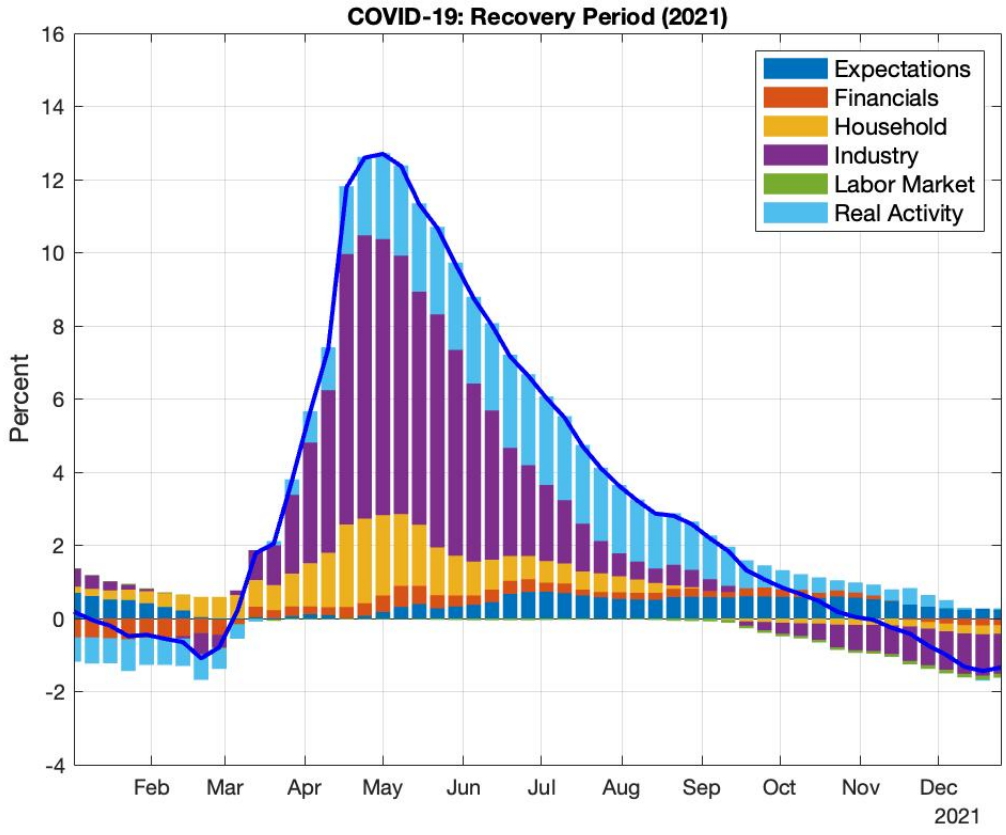


**Figure 6:** Data from BRA-W update on Mar 26th, 2022

## 5.2 A Comparison with Existing Indicators

The second part of this analysis compares the BRA-W index with other economic activity indices for Brazil and examines how well this new weekly indicator fits among them. From the indices discussed in Section 2, I have chosen to look at Bacen's IBC-Br and the OECD Weekly Tracker for comparisons with the BRA-W index. These choices are natural. While the IBC-Br is the most popular monthly index for the Brazilian economy, the OECD's index is the only other index for the country at the weekly frequency.

A large co-movement exists between the BRA-W index and the demeaned IBC-Br YoY growth rate across the last 18 years. The correlation coefficient between Bacen's indicator and the monthly average of the BRA-W values is 0.91. Figure 7 plots their relationship with 4-quarter real GDP growth for comparison. On the top, I have graphed them over the entire sample period, and the graph shows that their strong correlation is present in all periods. A more detailed observation also reveals a considerable harmony in how both series fluctuate at short intervals, which lower-frequency measurements (such as GDP) cannot reproduce. To better illustrate this idea, I have also graphed both variables during the periods discussed in Section 5.1 (Figure 7). During the Impeachment, it is possible to identify in the IBC-Br series the two main phases of economic activity discussed in section 5.1.1. During the truck driver's strike, the IBC-Br indicator also showed a large trough in economic activity during May 2018, while in April and June, the economy performed significantly better. Finally, fluctuations in economic activity during the COVID-19 pandemic are also closely aligned, as the two indices trace peaks and troughs with similar shapes. As I calculated this paper's index independently of the IBC-Br, the fact that the BRA-W index can reproduce the general trends found in it is remarkable.

Nonetheless, a closer look at Figure 7 reveals the advantages of a weekly indicator over a

monthly one. First, as Bacen has to compress the fluctuations in economic activity of an entire month in one observation, it produces a very discrete series, where each observation tends to deviate a lot from the previous one. On the other hand, the weekly frequency of the BRA-W index provides a more comprehensive picture of each event, as the indicator can capture a smooth acceleration of economic activity from one week to the next. This advantage is particularly evident when analyzing short-lasting events. For example, during the truck driver's strike, while the IBC-Br summarizes the whole period in a single data point, the BRA-W index shows a gradual worsening of economic conditions at the beginning of May 2018, which only started to improve at the beginning of the following month.

The connection between the BRA-W index and the OECD Weekly Tracker is also impressive, with a correlation coefficient of 0.90. Figure 8 shows this relationship, and it is noticeable how both indices have traced a similar path over the last four years. While both series indicate levels of economic growth around the national long-run average between March 2018 and February 2020, the OECD weekly tracker presented more significant fluctuations across the period, having an autocorrelation coefficient at lag 1 of 0.29. As Lewis et al. (2020) summarized, "in normal times, real activity moves sluggishly," so it is reasonable to assume that economic activity in Brazil did not fluctuate so intensely during a time of relative stability. This assumption is more aligned with the smooth picture traced by the BRA-W index over the period, which has an autocorrelation coefficient of 0.88. Another noticeable difference is in the two most significant deviations from long-run growth in the graph, corresponding to the periods analyzed in Section 5.1.3. Both indices reached similar extrema on those two occasions, but the OECD indicator achieved these levels a few months faster than the BRA-W index. As data from Google searches are less inertial than traditional economic series, an analysis based on them will be able to identify large booms and bursts first, but at the cost of more volatility.

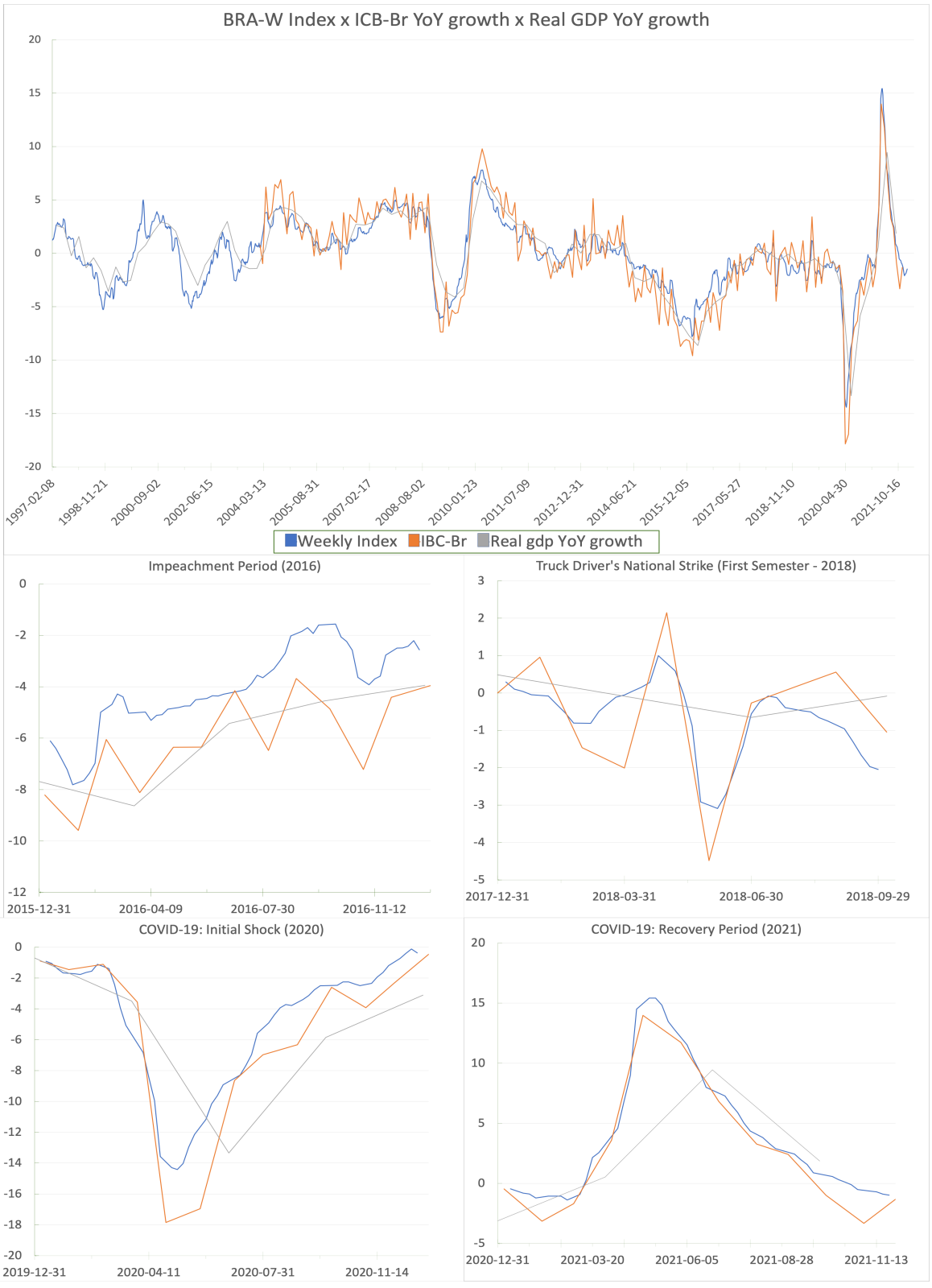


**Figure 7:** A comparison between the BRA-W index and the demeaned IBC-Br YoY growth, with Real GDP YoY growth demeaned for comparison. Based on data requested on Mar 26$^{th}$, 2022

The introduction of a new weekly index, based on a completely different set of indicators and distinct methodology, allows researchers to analyze specific economic events from different perspectives. Overall, the BRA-W and the OECD indices complement each other, and economists should implement them depending on the purpose of their study, taking into account the pros and cons of both approaches. While the two indices can validate each other whenever they provide similar measurements, the BRA-W index can also complement the Weekly Tracker on its limitations. For example, the OECD indicator only goes as far back as 2018, while the BRA-W index allows investigating events starting in 1997. Also, the index decomposition provides data for researchers and policymakers interested in identifying the driving economic forces influencing each period.

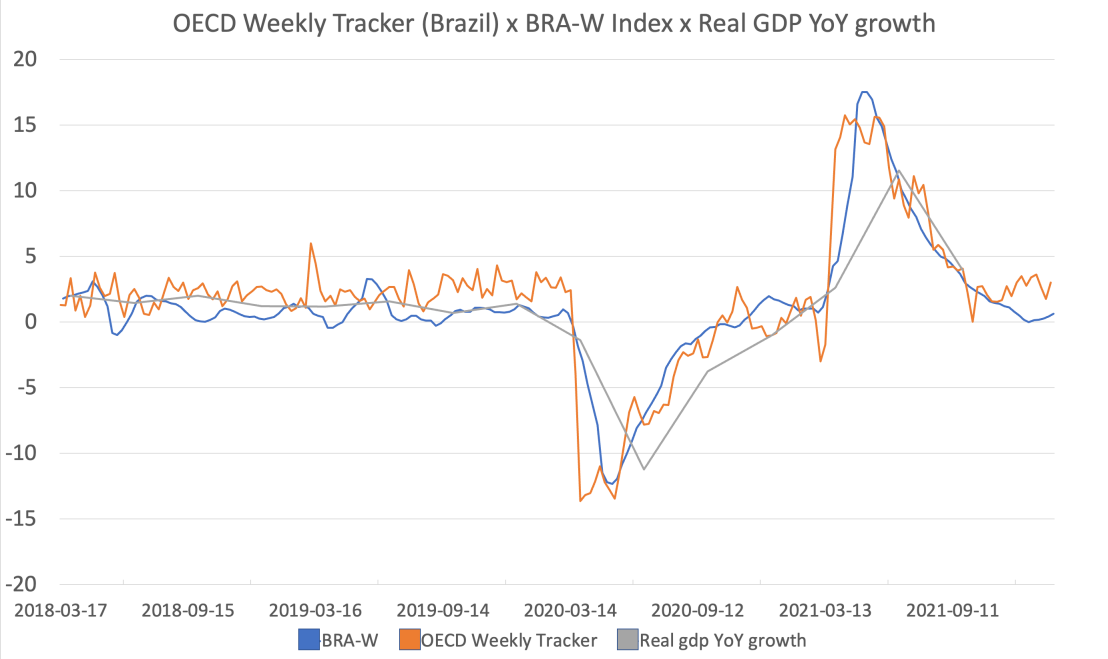


**Figure 8**

**Figure 9:** A comparison between the BRA-W index and the OECD Weekly Tracker: Brazil, with Real GDP YoY growth demeaned for comparison. Based on data requested on Mar 26$^{th}$, 2022

### 5.3 The BRA-W Index and Real GDP

While both the BRA-W index and Real GDP provide information on economic conditions, they measure different concepts. The concept of economic conditions is broader than the low-frequency measurement of Gross Domestic Product, and it reflects information that GDP does not always capture, such as economic expectations. Additionally, the focus of the BRA-W index is to capture the variations in economic conditions in Brazil from one week to the next, not to target the average movement over a quarter, which is the usual approach of traditional GDP.

Nonetheless, it is evident that economic activity heavily influences a country's quarterly GDP, so the BRA-W index should have a strong predictive relationship with this low-frequency measurement. To study their connection, I regress annual GDP growth on the BRA-W index in two ways (following Lewis et al. (2020)). First, I average out the weekly values of the BRA-W on each quarter and regress based on

$$\Delta^{4q} GDP_q = \alpha + \beta_1 \overline{BRA\text{-}W}_q^{quarter} + \sum_{l=1}^{2} \delta_l \Delta^{4q} GDP_{q-l} + \epsilon_q, \tag{6}$$

where $\Delta^{4q} GDP_q$ represents the annual real GDP growth for each quarter q. I also include two lags of $\Delta^{4q} GDP_q$ in the regression. To account for structural macroeconomic changes over the decades, I restricted the estimating sample to start in 2008Q4. The first columns of tables 3 and 4 display the regression results, and it gives an $R^2$ value of 0.926 (or 0.902 without lags).

I also simulate this relationship by considering the flow of information throughout the quarter. This time, I regress the annual growth rate on the monthly average of the BRA-W using

$$\Delta^{4q} GDP_q = \alpha + \beta_1 \overline{BRA\text{-}W}_q^{m_1} + \beta_2 \overline{BRA\text{-}W}_q^{m_2} + \beta_3 \overline{BRA\text{-}W}_q^{m_3} + \sum_{l=1}^{2} \delta_l \Delta^{4q} GDP_{q-l} + \epsilon_q, \tag{7}$$

and obtain a predictor with improved $R^2$ and standard error values (column (4)). Similar to Lewis et al. (2020), incorporating the flow of information into the regression did produce a better prediction of quarterly GDP. This approach also allows for assessing how well the BRA-W index can predict GDP growth when limiting the information available to the first months of a quarter (columns 2 and 3). While each additional month improved the predictive power on the regression with lags, data on the third month did not improve the model on the regression without lags.

Using the regression from equation (7) and the values for the BRA-W index calculated on Mar 26$^{\text{th}}$, 2022, it is possible to predict an annual growth rate of +0.60% of the Brazilian GDP for 2022Q1 (with a 90% confidence interval between -0.94% and 2.15%). The *Brazilian Institute of Geography and Statistics* (IBGE) will publish the official measurement on June 02$^{\text{nd}}$, 2022.

# 6 Discussion

In this paper, I introduced the BRA-W index, an innovative way of tracking down economic activity in Brazil. This index uses a dynamic factor framework with 28 economic indicators at the weekly, monthly, and quarterly frequencies, and it largely correlates with established economic indices from prominent institutions. I used the BRA-W index to analyze three turbulent economic events in recent Brazilian history and showed how a weekly index could provide a more comprehensive picture of the situation at the time. I also decomposed the index into the influence of six categories and was able to identify the main driving forces behind changes in economic conditions during those events. Finally, I showed that the BRA-W index is a significant predictor of the Brazilian GDP growth, as it can explain 94.4% of its variations.

For future studies, I suggest improving the analysis between the BRA-W index and GDP in the following ways. First, it would be interesting to examine different regression models to the one in

Section 5.3 and see if it is possible to achieve a lower standard error value. This improvement would allow predictions with narrower confidence intervals. Second, it would be interesting to compute a basic forecasting analysis on real GDP Growth where we "forecast" past GDP observations based on the latest BRA-W data and then compare our "predictions" to the official values. Finally, a step further would be to implement a forecasting exercise of real GDP under "real conditions." This analysis would involve running the model hundreds of times to calculate a unique index series for each week, starting a few years ago, using only information available at the time. This improvement would require significant computation effort, and it is currently hard to implement since many series in the dataset have recent starting dates.

I also recommend introducing additional input series into the model to evaluate how the BRA-W index behaves under modifications to its dataset. Many other indicators are available for this type of study, and other series might provide valuable data on aggregate economic activity, which the current model misses. Additionally, the calculation of the BRA-W index currently uses series that might become unavailable shortly, such as the Apple Mobility Index, which can become private whenever the pandemic ends. Therefore, it is essential to test how vital each economic variable is for the BRA-W index calculations by removing indicators and analyzing the index's performance without each of them.

Overall, this paper's main objective is to incentivize the introduction of other high-frequency indices of economic activity in Brazil, which can provide clear benefits for economic analysis compared to traditional low-frequency data. I hope this paper sheds some light on this topic and that Brazil does not fall behind in this worldwide indexing innovation.

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**Table 1. Dataset**

| Data category | Variables | Frequency | First observation | Data source | Transformation | Seasonal Adjustment |
|---|---|---|---|---|---|---|
| Real Activity | Apple Mobility Index | Weekly* | 2020-01-13 | Apple | 1 | NSA |
| | Foreign Trade - Balance | Weekly* | 2003-01-10 | CEIC | 5** | NSA |
| | Foreign Trade - Index | Monthly | 1996-01-01 | CEIC | 2* | NSA |
| | Energy Generation | Monthly | 1998-01-01 | CEIC | 2 | NSA |
| | National Revenue from Tourism | Monthly | 2011-01-01 | CEIC | 2* | SA* |
| | Real GDP | Quarterly | 1996-01-01 | CEIC | 2 | SA* |
| Market Prices of Financials and Commodities | Bovespa Index (IBovespa) | Weekly* | 1996-01-01 | CEIC | 2* | NSA |
| | Dollar Exchange Rate | Weekly* | 1996-01-01 | CEIC | 2*** | NSA |
| | Fuel Prices Ethanol | Weekly | 2011-01-01 | CEIC | 2* | NSA |
| | Soybean Prices | Weekly* | 2014-01-01 | CEIC | 2* | NSA |
| | Government Bond Yield (3 months) | Monthly | 2000-04-04 | IPEA DATA | 1 | NSA |
| Household | Savings Deposits | Weekly* | 2003-01-01 | CEIC | 4* | NSA |
| | Retail Trade Index | Monthly | 2000-01-01 | CEIC | 2* | SA* |
| | Average Real Earnings | Monthly | 2012-01-01 | CEIC | 2 | NSA |
| | Household credit | Quarterly | 1996-01-01 | FRED | 2** | NSA |
| | Real Residential Property Prices | Quarterly | 2002-01-01 | FRED | 1 | NSA |
| Industry | Industrial Production Index | Monthly | 1996-01-01 | FRED | 2 | SA* |
| | Steel Production: Volume | Monthly | 1996-01-01 | CEIC | 2 | NSA |
| | Industrial Capacity Utilization Index | Monthly | 2003-01-01 | CEIC | 1 | SA* |
| | Automobile Sales | Monthly | 1996-01-01 | CEIC | 2 | NSA |
| | Petroleum Product Sales | Monthly | 2000-01-01 | CEIC | 2 | NSA |
| Labor Market | Unemployment Rate | Monthly | 2012-01-01 | CEIC | 1 | SA |
| | Unemployment Claims | Monthly | 2000-01-01 | CEIC | 1 | SA |
| | Manufacturing Working Hours Index | Monthly | 2003-01-01 | CEIC | 1 | SA* |
| Expectations | Manufacturing Exports Tendency | Monthly | 1996-01-01 | FRED | 1 | SA* |
| | Manufacturing Production Tendency | Monthly | 1996-01-01 | FRED | 1 | SA* |
| | Future Tendency Employment | Monthly | 1996-01-01 | FRED | 1 | SA* |
| | World Uncertainty Index | Quarterly | 1996-01-01 | FRED | 3 | NSA |

NOTES:

**1 - Frequency:** Entries identified with (*) were originally published with a daily frequency. To convert it to a weekly frequency, I took the weekly average.

**2 - First Observations:** The dates refer to the first entry used to calculated the index. As explained in the Data Appendix, I decided to only use values starting from 1996-01-01.

**3 - Transformations** The codes above refer to: 1- No transformation required; 2- Year over Year growth rate; 3- Year over Year difference 4- 4-week average of Year over Year growth rate; 5- 4-week average;

(*) Series were deflated with IBGE: IPCA (CEIC - ID: 273491403 SR Code: SR5814771), a monthly CPI released by *Instituto Brasileiro de Geografia e Estatistica*. (**) Deflated with US CPI (FRED code: CPIAUCSL). (***) For these series, I had to consider both the inflation in Brazil and in the US. When deflating weekly series, I extended the monthly CPI by letting all weekly values of a month to be the monthly value divided by n for a month with n weeks.

**4 - Seasonal Adjustment:** SA - Seasonally adjusted, NSA - Not seasonally adjusted. (*) signifies that series were originally reported with seasonal adjustment. For series with monthly or quarterly frequency, I used the X13-ARIMA package.

**Table 2. Data Request Information**

| Source | Series Name | Identification |
|---|---|---|
| Apple | Apple Mobility Index | region: Brazil & transportation_type: driving |
| CEIC | Automobile Sector | ID: 205388802 SR Code: SR4266819 |
| | Average Real Earnings | ID: 376266557 SR Code: SR98321397 |
| | Bovespa Index: IBOV | ID: 40774401 SR Code: SR4685374 |
| | Dollar Exchange Rate | ID: 1326501 SR Code: SR4690985 |
| | Energy Generation | ID: 365246102 SR Code: SR6741274 |
| | Foreign Trade - Balance | ID: 245232002 SR Code: SR4641526 |
| | Foreign Trade - Index | ID: 471295677 SR Code: SR153983837 |
| | Fuel Price Ethanol | ID: 255784002 SR Code: SR4964096 |
| | Industrial Capacity Utilization Index | ID: 283504504 SR Code: SR6658430 |
| | Manufacturing Working Hours Index | ID: 356295407 SR Code: SR7300823 |
| | Nomianal Revenue from Tourism | ID: 385720717 SR Code: SR105578867 |
| | Petroleum Product Sales | ID: 229230402 SR Code: SR4326341 |
| | Real GDP | ID: 366988057 SR Code: SR88309317 |
| | Retail Trade Index | ID: 385726277 SR Code: SR105535237 |
| | Savings Deposits | ID: 455322477 SR Code: SR141339927 |
| | Soybean Price | ID: 455427917 SR Code: SR143496007 |
| | Steel Production: Volume | ID: 297371601 SR Code: SR4489914 |
| | Unemployment Claims | ID: 458692687 SR Code: SR143241917 |
| | Unemployment Rate | ID: 475685597 SR Code: SR157483527 |
| FRED | Future Tendancy Employment | BSEMFT02BRM460S |
| | Future Tendancy Manufacturing Production | BSPRFT02BRM460S |
| | Future Tendency Manufacturing Exports | BSXRLV02BRM086S |
| | Household Credit | QBRHAMUSDA |
| | Investment Goods in Manufacturing | PRMNVG01BRQ661S |
| | Real Residential Property Prices | QBRR368BIS |
| | World Uncertainty Index | WUIBRA |
| IPEA DATA | Government Bond Yield (3 months) | ANBIMA12-TJTLN312 |

**Websites:**
Apple - `https://www.apple.com/covid19/mobility`
CEIC - `https://www.ceicdata.com/en`
FRED - `https://fred.stlouisfed.org/`
IPEA DATA - `http://www.ipeadata.gov.br/Default.aspx`

**Table 3. Regression results (with lags)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| BRA-W First Month | | 0.98 | 0.43 | 0.09 |
| | | (0.07) | (0.14) | (0.21) |
| BRA-W Second Month | | | 0.54 | 0.62 |
| | | | (0.12) | (0.17) |
| BRA-W Third Month | | | | 0.24 |
| | | | | (0.14) |
| BRA-W Quarter | 1.05 | | | |
| | (0.07) | | | |
| Intercept | 1.97 | 1.80 | 1.81 | 1.52 |
| | (0.20) | (0.22) | (0.19) | (0.18) |
| Standard Error | 1.136 | 1.283 | 1.089 | 0.932 |
| Adjusted $R^2$ | 0.926 | 0.893 | 0.929 | 0.944 |

**Table 4. Regression results (no lags)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| BRA-W First Month | | 1.07 | 0.52 | 0.53 |
| | | (0.6) | (0.138) | (0.14) |
| BRA-W Second Month | | | 0.53 | 0.45 |
| | | | (0.126) | (0.19) |
| BRA-W Third Month | | | | 0.09 |
| | | | | (0.15) |
| BRA-W Quarter | 1.08 | | | |
| | (0.05) | | | |
| Intercept | 1.97 | 1.93 | 1.93 | 1.95 |
| | (0.17) | (0.19) | (0.16) | (0.17) |
| Standard Error | 1.210 | 1.353 | 1.172 | 1.179 |
| Adjusted $R^2$ | 0.902 | 0.878 | 0.908 | 0.907 |

NOTE:
This table shows the regression results following equations (6) (scenario 1) and (7) (for scenarios 2 to 4). Regression on data from 2008Q4 to 2021Q4.