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Growth and Volatility: An Analysis for the Brazilian Economy

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Abstract

This paper aims to analyze if there is a relationship between economic growth and the volatility of that growth in the Brazilian economy, and, if it exists, to infer if that relationship is positive or negative, since the literature shows evidence for both cases. For that purpose, the econometric strategy used is that of a Generalized Autoregressive Conditional Heteroskedasticity in Mean (GARCH-M) model, using economic growth data compiled by the Central Bank of Brazil, for the period of 1995-2018. The results corroborate the findings of the empirical literature, suggesting a negative relationship between economic growth and its volatility; that is, the hypothesis of the irreversibility of investments prevails. Therefore, the tradeoff between short-term stability and long-term growth for the Brazilian economy in the analyzed period does not seem to occur.

Keywords

Economic Growth, Volatility, GARCH-M

1. Introduction

Macroeconomic theory has long addressed the issues associated with long-term economic growth and business cycle fluctuations separately. However, there is reason to believe that growth and volatility may be positively or negatively linked (Fang and Miller [1]). It is worth noting that the direction of this relationship translates into important consequences for the conduct of macroeconomic policy. If, for example, short-term growth volatility positively affects long-term economic growth, short-term stabilization policies would be detrimental to long-term growth; that is, the government faces a trade-off between short-term stability and long-term economic growth. In a theoretical perspec-

tive, Bernanke [2] and Pindyck [3] suggest that if there are irreversible investments[1], then the increase in volatility will lead to a decrease in those investments and, consequently, to lower levels of economic growth. Mirman [4] suggests a positive relationship between growth and volatility in the presence of precautionary savings. According to the author, if there are motives for precautionary savings, greater volatility will lead to a higher rate of savings and, consequently, there will be a higher rate of investment and, therefore, greater long-term economic growth.

Traditionally, models of economic growth and economic cycles are treated as different frameworks. However, following the paper of Ramey and Ramey [5], who note that countries with higher growth volatility have lower economic growth, considerable efforts have been dedicated to analyze whether and how these factors are related. Lee [6], for example, observed a positive relationship between volatility and economic growth. Martin and Rogers [7], however, found mixed results. Developed countries showed a negative relationship between volatility and economic growth, while developing countries showed a positive relationship. On the other hand, Fatás [8] found evidence that countries with greater economic fluctuations produce lower rates of economic growth. Lin and Kim [9] also presented evidence that volatility has a negative impact on economic growth.

For the Brazilian economy, Araújo, Carpena and Cunha [10], analyzing the properties of the growth domestic product from 1850 to 2000, using a GARCH model, did not find statistically significant evidence of the impact of volatility on economic growth. On the other hand, Arbache and Sarquis [11], using data for Brazil from 1901 to 2015, perform several simulations for the Brazilian growth rate and its volatility, and suggest that high volatility has a negative impact on the country's growth. The authors argue that growth is extremely volatile in Brazil and that growth volatility has had considerable impacts on growth potential and performance over the last century, remarking that a high volatility over and beyond business cycles constrains long-term growth with particularly adverse and asymmetric cumulative effects of growth acceleration and collapse episodes on GDP.

The research problem of this work, then, is to analyze if there is a relationship between economic growth and the volatility of that growth in the Brazilian economy, and, if it exists, to infer if that relationship is positive or negative, since the literature shows evidence for both cases. Thus, the research objective is to investigate the relationship between economic growth and its volatility in the Brazilian economy using monthly data between January 1995 and August 2018, extracted from the Central Bank of Brazil through the econometric methodology Generalized Autoregressive Conditional Heteroskedasticity in Mean (GARCH-M) model.

In addition to this introduction, this paper features four more sections. The literature review is presented next, and section three follows with a discussion on

[1]An irreversible investment occurs when, once installed, capital has little or no value unless used in production.

the methodological aspects. The results are analyzed in the fourth section and, lastly, the fifth section presents the concluding remarks.

2. Literature Review

Several efforts in academic literature have been made in the attempt to identify the relationship between economic growth and growth volatility throughout the years. Ramey and Ramey [5], for example, conducted an empirical analysis that presented evidence against the standard dichotomy that separates the business cycle theory and the economic growth theory, and found that countries with greater volatility in growth rates tend to have consistently lower growth rates.

Dawson and Stephenson [12], on the other hand, investigated this relationship using data from 48 US states, and found no statistically significant relationship between volatility and growth, a result that is contrary to that observed in papers that analyze countries. The authors speculate the reasons for this surprising result, and point out that a possible source of volatility is the fact that the federal government's monetary and fiscal policies have the same repercussions across all the states.

Analyzing European regions and OECD countries, Martin and Rogers [7] evaluated the impact of learning-by-doing on the relationship between volatility and growth. For developed countries, the evidence points to a negative relationship between growth and volatility. However, this relationship is not observed for non-industrialized countries.

Fatás [8] explored this issue from a theoretical and, also, empirical approach. Using a simple endogenous growth model, the author suggests that growth volatility has a permanent effect on economic activity. During recessions, economic growth slows down. In the recovery period, the growth rate recovers, but remains at a lower level than observed before the recession period. Therefore, countries with higher volatility have lower long-term growth rates.

Kose, Prasad and Terrones [13] have documented stylized facts about the evolution of the relationship between growth and volatility, arguing that while there has generally been a negative relationship between volatility and growth during this period, the nature of this relationship has been changing over time and across different country groups, occurring major shifts in this relationship after trade and financial liberalizations. The results point to substantial differences in the growth-volatility ratio of developing countries before and after greater integration into the global economy. Evidence suggests that countries more open to trade flows would face less severe trade-offs between growth and volatility. On the other hand, greater financial integration seems to strengthen the negative relationship between growth and volatility.

Fang and Miller [1] examined the effect of the Great Moderation on the growth-volatility relationship for the US economy in the period of 1947-2006, with GARCH-M and ARCH-M models. The authors did not find a statistically

significant relationship between economic growth and volatility.

Lee [6] analyzed this relationship with monthly data between 1965 and 2007 for G7 countries and using GARCH-M models for panel data. The results indicate that volatility positively affects economic growth, and that the latter does not appear to affect volatility.

Lin and Kim [9] use a model of simultaneous equations employed in a panel of 158 countries in the period between 1960 and 2010. The evidence obtained indicates that growth volatility has a negative effect on economic growth and that it tends to positively influence volatility.

In terms of Brazil, analyzing the country's business cycles from 1850 to 2000, Araújo, Carpena and Cunha [10] find evidence that the behavior of Brazilian growth volatility from 1850 to 2000 was quite different from its counterparts in the US and other developed economies. The authors did not observe a statistically significant relationship between growth and volatility.

Arbache and Sarquis [11], in a more recent paper, also conducted an analysis of the volatility of growth and its impact on the performance of the Brazilian economy. The authors suggest that the excessive volatility of Brazil's economy has a strong impact on the country's growth. Their research concludes that the main challenge in Brazil is not to achieve high growth rates, but to grow in a more stable and sustained manner.

3. Methodology

3.1. Data Description and Analysis

This paper uses monthly data, from January 1995 to August 2018, of the GDP series extracted from the Central Bank of Brazil. Firstly, the data were duly deflated using the General Price Index—Internal Availability (ÍndiceGeral de Preços-DisponibilidadeInterna—IGP-DI), which is calculated by the Fundação-Getúlio Vargas and made available by the Central Bank of Brazil[2]. Then, we then calculated the GDP real growth rate, which is the variable of interest used in this work.

In order to support the econometric analysis performed here, a preliminary analysis was made of the impact of volatility on long-term growth. The graph below presents a comparison of the growth rates and volatilities of growth for the Brazilian economy in the aforementioned period. It is worth noting that in this preliminary analysis, the standard deviation is used as an indicator of volatility.

One can observe that periods with high volatility presented negative economic growth. Among the periods that seem more relevant, we can highlight January 1999, which features a shift in the Brazilian exchange policy, where the Brazilian Central Bank adopted a floating exchange rate, and triggered an economic crisis and, consequently, a negative growth rate. Another relevant period is January 2001, a year in which the combination of an energy crisis, high interest rates and

[2]http://www.bcb.gov.br.

a strong economic slowdown around the world slowed economic activity.

The beginning of 2003 is also worth mentioning, a period of great economic instability as a result of then President Lula being elected, therefore there was a rise in uncertainty in terms of economic policy. Lula came from the Brazilian Workers Party, which had historically been critical of the orthodox macroeconomic policy which had been practiced in Brazil by the previous government in the eight years prior. The beginning of 2009 was also marked by low economic growth, a period in which Brazil began to suffer the impacts of the 2008 global crisis in a late manner. In 2013 and 2014 the country went through considerable political and economic instability, which culminated in an impeachment process in 2016, where one can observe high volatility and economic recession, which has lingering results in the Brazilian economy (**Figure 1**).

3.2. Econometric Strategy

The analysis of the relationship between volatility and economic growth for the Brazilian economy will occur through the application of the *Generalized* Autoregressive *Conditional Heteroskedasticity model in the mean,* or GARCH-M.

The GARCH model, presented by Bollerslev [14], is an extension of the ARCH model featured in Engel [15]. This model considers that the conditional variance of the error is also related to past conditional variances, so that the error term follows the following process:

$$\varepsilon_t = v_t \sqrt{h_t} \tag{1}$$

where, v_t are random variables which are identical and independently distributed with mean zero and variance one, that is, $v_t \sim (0,1)$ and h_t represents the conditional variance. Thus:

$$h_t = \alpha_0 + \sum_{i=1}^{s} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{r} \beta_i h_{t-i} \tag{2}$$

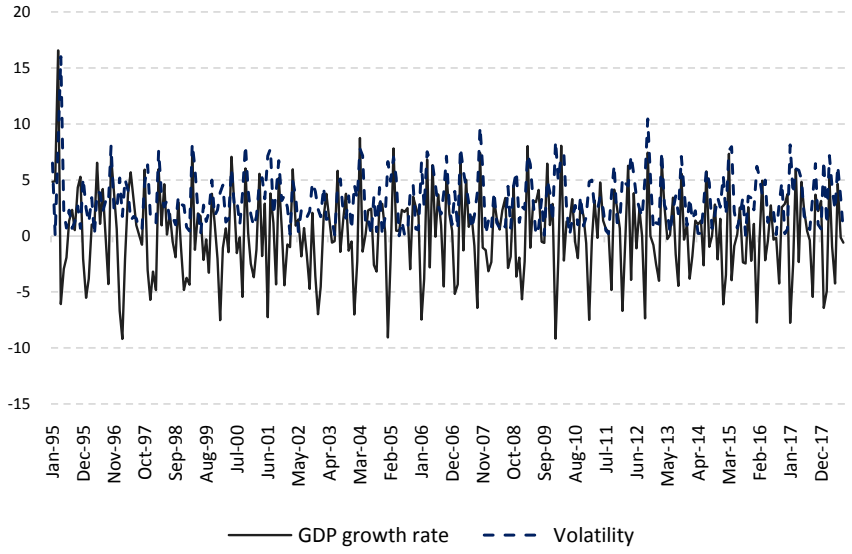

Figure 1. Growth and growth volatility.

Equation (2) is known as the Generalized Autoregressive Conditional Heteroscedasticity model of order (r,s), *i.e.*, GARCH(r,s). For some problems, however, a greater refinement of the GARCH model is required. The rate of return of a financial series, for example, depends on the volatility of the process; that is, its conditional variance. To meet this requirement, a new model was developed, called GARCH in the mean (or GARCH-M). A generic GARCH-M (*r*, *s*) model is, then, given by:

$$\begin{aligned} \varepsilon_t &= v_t\sqrt{h_t} \\ \mu_t &= \beta + \delta h_t \\ h_t &= \alpha_0 + \sum_{i=1}^{s}\alpha_i\varepsilon_{t-i}^2 + \sum_{i=1}^{r}\varphi_i h_{t-i} \end{aligned} \tag{3}$$

where μ_t denotes the average return, β and δ are the constants, with δ indicating the risk premium parameter. This model is often used in financial applications where the expected return on an asset is related to its risk. The estimated coefficient on the expected risk is a measure of the risk/return trade-off. In this paper, the trade-off between short-term stability and long-term economic growth is analyzed. Therefore, the use of the GARCH-M model is an adequate strategy. In this context, the model will be used along the lines of Engle, Lilien and Robins [16], which can be described as follows:

$$Y_t = X_t'\theta + \lambda h_t + \varepsilon_t \tag{4}$$

$$h_t = w + \sum_{i=1}^{r}\varphi_i h_{t-i} + \sum_{i=1}^{s}\alpha_i\varepsilon_{t-i}^2 + Z_t'\pi \tag{5}$$

In which Y_t is the growth rate of the economy, X_t is the vector of exogenous variables in the mean equation, and Z_t is a vector of exogenous regressors of the conditional variance equation.

4. Analysis and Discussion of the Results

The most well-adjusted model is the GARCH-M (2, 2) which includes the growth level lagged in one period (Y_{t-1}), in the variance equation. The results are summarized in **Table 1**.

Thus, considering the research problem of analyzing the relationship between economic growth in Brazil and its volatility, the results point to a negative and statistically significant relationship; that is, a more stable economic environment can lead to greater economic growth. According to Bernanke [2] and Pindyck [3], this evidence seems to suggest the validity of the irreversibility of investment hypothesis, where higher volatility produces a reduction of investment, which, ceteris paribus, decreases economic growth. Arbache and Sarquis [11] also observe similar effects for Brazil.

When analyzing the volatility equation, it can be observed that economic growth has a negative and statistically significant impact on volatility. Evidence along these lines may indicate a rapid process of convergence in economic activity to its steady state.

Table 1. Results GARCH-M.

Mean Equation		Conditional Variance Equation	
Variable	Coefficient	Variable	Coefficient
Const.	0.68* (0.01)	Const.	0.57* (0.00)
GARCH	−0.08** (0.05)	ε_{t-1}^2	0.05* (0.00)
Y_{t-1}	−0.15* (0.00)	ε_{t-2}^2	−0.16* (0.00)
Y_{t-2}	−0.10** (0.02)	h_{t-1}	0.68* (0.00)
Y_{t-3}	−0.10* (0.01)	h_{t-2}	0.33* (0.00)
Y_{t-4}	−0.21* (0.00)	Y_{t-1}	−0.34* (0.00)
Y_{t-5}	0.04 (0.39)		
Y_{t-6}	−0.24* (0.00)		
Y_{t-7}	−0.07*** (0.09)		
Y_{t-8}	−0.06 (0.13)		
Y_{t-9}	−0.08*** (0.07)		
Y_{t-10}	−0.27* (0.00)		
Y_{t-11}	0.01 (0.65)		
Y_{t-12}	0.54* (0.00)		

1) P-value in parenthesis. 2) *Significant at the 1% level, **Significant at the 5% level and ***Significant at the 1% level 10%.

In order to overcome possible autocorrelation problems, up to 12 economic growth lags were included in the mean equation. To verify the lack of correlation in the residues, we used the autocorrelation (ACF) and partial autocorrelation functions (PACF), described in Figure 2.

It can be observed that, for a level of significance of 5%, both functions are statistically null in all lags. Thus, we do not reject the hypothesis that both functions are zero until lag 24, and therefore we conclude that the residues are not correlated. Also, to verify that the residues are devoid of any ARCH effect, the ACF and PACF of the squared residue series were calculated. The results are shown in Figure 3. It was found that both functions are statistically null and therefore have no additional ARCH effect.

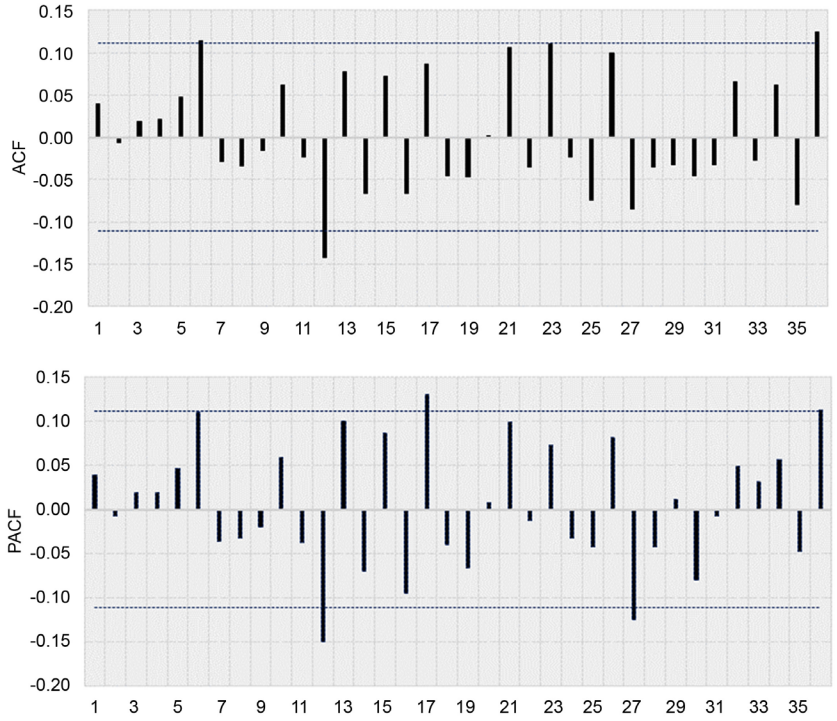

Figure 2. Residuals correlogram.

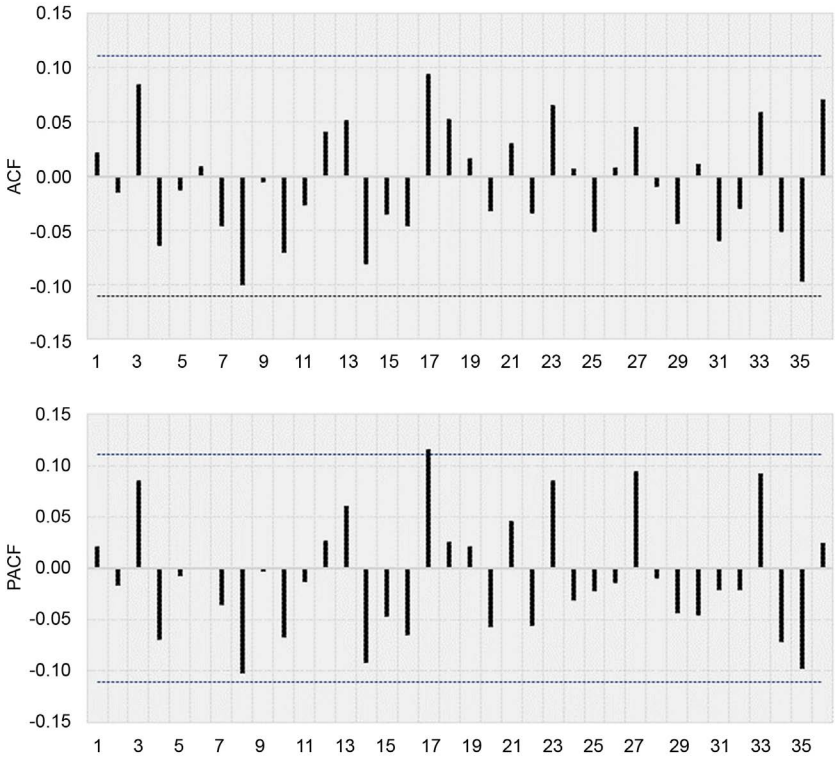

Figure 3. Squared residuals correlogram.

5. Concluding Remarks

This paper analyzed the relationship between economic growth and its short-term

volatility for the Brazilian economy using monthly data between January 1995 and August 2018 and a GARCH-M model.

The results point out a negative relationship between volatility and economic growth. In an environment of political instability, for example, economic growth would be negatively impacted. This evidence has an important implication for macroeconomic policy. In this scenario, it would be interesting for the government to follow clear rules in its economic policies, avoiding abrupt and discretionary measures, in order to produce economic stability and less uncertainty. Thus, the trade-off between short-term stability and long-term growth for the Brazilian economy in the analyzed period does not appear to occur.

Lastly, when analyzing the impact of economic growth on volatility, a negative result is also observed, which can be explained by the acceleration of the speed of convergence. In this scenario, the economy would move faster towards a new steady state, reducing its short-term volatility.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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