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Unemployment and output gap: Short-term empirical evidence for the Brazilian context (2012-2019)

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Abstract

Brazil currently faces unemployment rates that reach about thirteen million Brazilians. This phenomenon results, in part, from mismatched economic policies over the years, rising inflation, uncontrolled public accounts, and the instability and insecurity generated by the political crisis that began in 2014. The aim of this article is to contribute to the literature on unemployment in Brazil based on empirical evidence of Okun's law for the short-term during the period 2012-2019 comparing two scenarios: one of stability and the other with effects of political crisis. To capture the output gap and unemployment deviations, the Hamilton filter combined with regressions by ARDL models was applied. The results indicate that for the 1% reduction in the unemployment rate, the average production growth above its trend is expected to be 0.18% per month uninterruptedly during a semester. This percentage increases to 0.29% per month in the event of structural, political, institutional or reliable crisis.

Keywords: unemployment in Brazil, Okun's law, Hamilton filter, ARDL model

Introduction

Mankiw (1998) [20] states that unemployment is the macroeconomic problem that most severely affects the lives of citizens in a society. Currently Brazil faces high unemployment rates, the number of which reaches approximately thirteen million Brazilians, according to data from the Central Bank of Brazil (2019) [28]. In general, this negatively affects the economy, as high levels of unemployment lead to a decrease in household income, causing a decrease in household consumption and, depending on its intensity and duration, generates several other problems such as falling domestic production, falling state revenues, increased spending on social assistance for families without income and other social problems and, of course, these events contribute to increased future unemployment.

It is such a relevant theme in the political-economic debate that unemployment is at the center of macroeconomic discussions today (Palma and Ferreira, 2017) [25]. Its variation serves to measure labor market and economic performance and ultimately is a marker of the success or failure of economic policies implemented by governments. The poor performance of the Brazilian economy in recent years narrows this comparison. In 2015, for example, real GDP declined by -3.8% compared to the previous year and in 2016 presented a result of -3.6%. In 2017 there was growth of 1% and this same result was maintained in 2018. Faced with this falling situation and subsequent stagnation of growth, the rise in unemployment advanced dramatically. The year 2018 ended with an unemployment rate of 11.6%. Historical series and past experience show that the resumption of jobs will not be immediately verifiable, as growth over time is relatively low, and the Brazilian economy is experiencing difficulties in maintaining periods of sustainable growth (Fonseca and Araújo, 2014) [10].

Many of the reflexes experienced in the current economy are the result of events that are based on the events of rising inflation, the lack of public accounts, the instability and distrust offered by the political crisis in Brazil that began in 2014, culminating with the impeachment of President Dilma Rousseff. Thus, as commented by Lima and Marques (2019) [19], it is essential to increase output growth combined with monetary and fiscal policies to foster confidence in the business environment.

Among the theories most commonly applied to unemployment studies is Okun's law (1962) [24], which analyzes the relationship between unemployment and output growth. The central hypothesis behind the formulation of the idea that the American economist Arthur Okun developed in 1962 is that there is a significant negative relationship between output and unemployment, where an increase in output above its potential value results in lower unemployment rates observed in society.

The output gap is the difference between the current GDP and the potential GDP of the country and reveals how far the national output is from its outpution capacity. Although Mankiw (2001) [21] criticizes the use of the variable 'output gap' in estimates and Sachsida (2013) [28] warns of problems from its use as a proxy (both output and unemployment), still, many studies today use this resource in surveys and estimates. However, since potential GDP is an unobserved variable, it is recurrent in the empirical literature that explores Okun's law, especially in works related to the econometric field, the obtaining of the output gap and the deviation of unemployment from its natural rate, using statistical filters to capture these gaps. A filter promotes smoothing of the time series by removing low frequency fluctuations, which can be understood as removing the cyclic element from the series leaving only short term components.

Among the existing filtering methods the most used is the one developed by Hodrick and Prescott (1980) [18] known as HP filter. This method promotes a filtering at the end of the time series sample, and thus the values end up very different from the values of the middle of the series, which offers some criticism to its application. In addition to criticism of the method, Hamilton (2018) [15] presents a different proposal from Hodrick-Prescott. He states that applying a regression of the variable on date t performed at the four most recent values in the series from date $t + h$ offers a robust approach and eliminates the disadvantages of using the HP filter (Hamilton, 2018) [15].

The aim of this paper is therefore to contribute to the unemployment literature by testing the validity of Okun's law from empirical evidence for Brazil from 2012 to 2019, a troubled period of the Brazilian economy with marked political crisis, low growth and high levels of unemployment. For this, the econometric filtering strategy of the series is used based on the Hamilton method with statistical regression by the autoregressive distributed lags (ARDL) method.

This material, in addition to this introduction, presents in the following section the empirical literature on the relation of output and unemployment. Following are presented the data and methods of the study, followed by the analysis and discussion of the results. The study ends with the conclusions and references used.

2. Empirical evidence of the relationship between output and unemployment

Okun's law (1962) [24] has been widely empirically tested and validated in several economic studies. The original research with data for the United States from 1948 to 1960, suggests that a fall of 2 to 3 percent of GDP is associated with rising unemployment. Pinho and de Pinho (2015) [27] investigating the relationship between output and unemployment in the Portuguese economy validated the theory. However, they found different results by region in the country, which led to suggestions for defining different public policies for each location given their particularities. Guisinger, *et al*. (2018) [14] in addition to finding differences between. American states, reveal that labor indicators as well as labor market flexibility have a significant effect on Okun's relationship.

Just as different results of Okun coefficients are found between cities in the same country, it is reasonable to think that between countries, therefore, there will also be different results between the unemployment and output relationship. This is due to differences in the level of job protection, minimum wage laws, labor union power, and ultimately the demographics of each nation (Guisinger, *et al*. 2018) [14].

The results found by Micallef (2017) [24] for Malta's economy, for example, revealed instability in unemployment and output ratios. While Harris and Silverstone (2001) [17] obtained significant Okun coefficients for OECD countries from an econometric error correction model from 1978 to 1999.

For the Brazilian case, Gouveia and Feistel (2015) [12] estimated Okun's law and found results indicating that for industry the relationship between output and unemployment rate is less sensitive and that, when taking into account market seasonality, the models indicated better results. Lima and Marques [19] using ARDL models combined exports, direct investments in the country, exchange and inflation to the model and found long-term relationships between the variables. Their results indicate that, with an 11-month lag, the 1% increase in output causes a reduction in unemployment rates from 5% to 7%.

In the last years before the political crisis in Brazil, which can be said to have started in 2015, high job creation, even with the low result of the GDP represents a reduction in labor outputivity. This idea is corroborated by dos Santos (2015) [8] who in his work built a variant of Okun's law with data from 1998 to 2013 based on the estimation of GDP elasticity in relation to employment. It concluded that the results of the coefficients found for Brazil are approximate to those obtained by other studies in other countries. In this case, the adjustment in employment throughout the economic cycle in Brazil occurs mainly by the adjustment in the number of workers. In general, several papers agree on the validity of the Okun's law for Brazil (Dezordi, 2010; dos Santos, 2015; Gouveia and Feistel, 2015; Gois and Jorge, 2017; Palma and Ferreira, 2017; Margarido, 2018; Lima and Marques, 2019) [7, 8, 12, 11, 25, 22, 19] and this paper converges for your test using the latest data from the Brazilian economy in which the crisis and instability in the country can have impacts on growth, reflecting on the jobs generation.

3. Okun's theoretical and empirical model

Mathematically, what the Okun's Law postulates can be represented, through Eq. (1) which expresses how growth in the output determines changes in the unemployment rate.

$$u_t - u_{t-1} = -\beta_1(y - \hat{y}) + \varepsilon \quad (1)$$

Where $u_t - u_{t-1}$ represents the deviation of unemployment from its natural rate; parameter $-\beta_1$ measures the sensitivity of unemployment to GDP deviations; y is the observed output and $\hat{y}$ represents the potential output; ε expresses an error term. This model can be simplified in Eq. (2):

$$\Delta u_t = -\beta_1(\Delta y_t) + \varepsilon \quad (2)$$

Gordon (1984) [6] estimating a long-term version of the Okun coefficient proposes a distributed lag approach, as shown in Eq. (3).

$$\Delta u_t = \beta_0 + \sum_{i=1}^{k} \beta_1 \Delta u_{t-1} + \sum_{i=0}^{k} \beta_2 \Delta y_{t-1} + \varepsilon_t \quad (3)$$

where Δu_t represents the first difference; β_0 is the term of the constant; β_1 and, β_2 are the long term parameters. In order to find short-term evidence, it is possible to insert such parameters according to the model of Eq. (4), suggests:

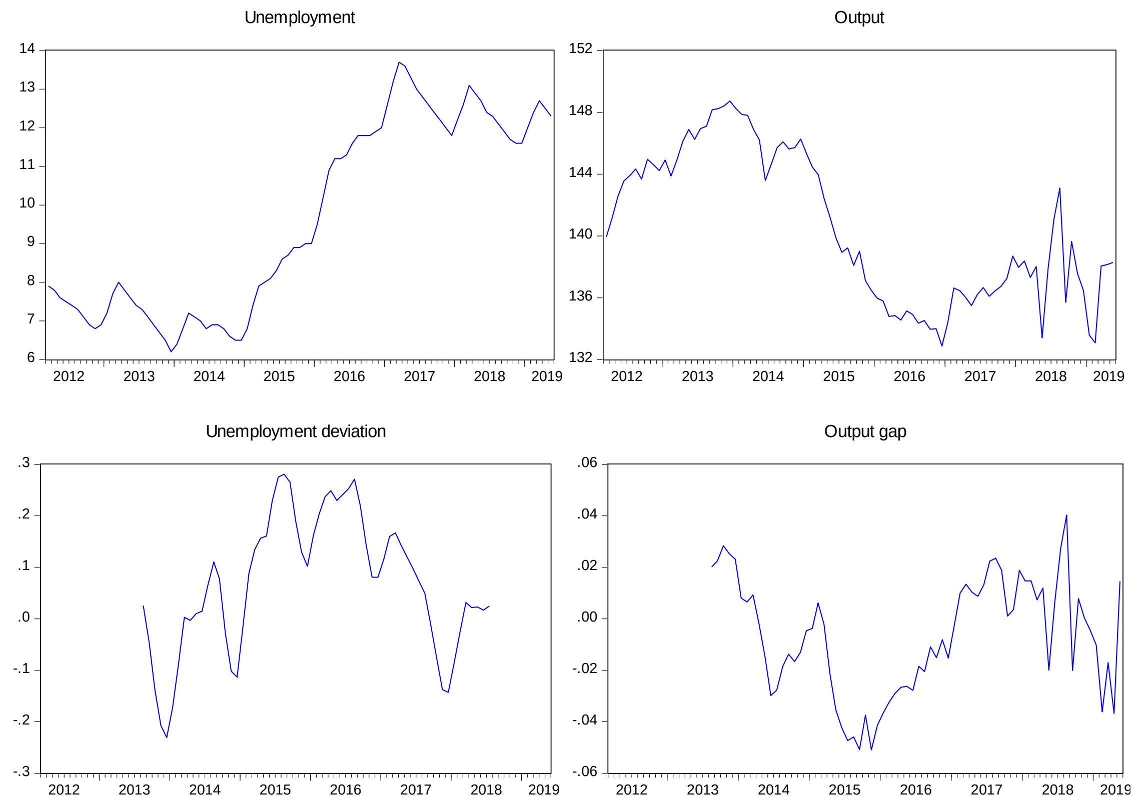
$$\Delta u_t = \beta_0 + \sum_{i=1}^{k} \beta_j \Delta u_{t-j} + \sum_{t=0}^{k} \delta_j \Delta y_{t-j} + \varphi u_{t-1} + \varphi y_{t-1} + \varepsilon_t \quad (4)$$

In this case β_j and, δ_j are the long term parameters and φ represents the short term parameters. Thus, we can apply in this study the notation described in two specific models, one that expresses the distributed lags (as in Eq. 4) and another that incorporates the political crises through which Brazil crossed with the insertion of a dummy variable (D_1) to the model. It was also decided to use the logarithmic functional specification in the variables because this action promotes the smoothing of variance of the series, which generates an advantage by reducing heteroscedasticity problems. Thus, we obtain the research model described in Eq. (5):

$$log\Delta u_t = \beta_0 + \sum_{i=1}^{k}\beta_j log\Delta u_{t-j} + \sum_{t=0}^{k}\delta_j log\Delta y_{t-j} + \varphi log\Delta u_{t-1} + \varphi log\Delta y_{t-1} + D_1 + \varepsilon_t \quad (5)$$

4. Data and method

The applied unemployment rate was obtained from IBGE data available on the Central Bank of Brazil website through time series number 24369. It expresses the national aggregate unemployment rate. For GDP, the seasonally adjusted Central Bank Economic Activity Index (IBC-Br) was used as a proxy for national GDP. The option for its use is due to the fact that the index seeks to incorporate the trajectory of variables considered for the performance of all sectors of the economy (BCB, 2010) [1]. As previously mentioned, the deviation of unemployment and output gap were obtained by applying the Hamilton filter. The behaviors of the variables without the filtering method and with the application of filters can be observed in Figure 1. Thus, two econometric models applied to the ARDL method are developed.



Source: Author's computation based on survey data.

Fig 1: Unemployment deviation and output gap

The regression by the ARDL approach is justified by the fact that the unemployment rate does not change immediately with output variations, and it is natural that its response occurs with time lapses, which is identified as lags, as explained by Gujarati and Porter (2012) [13].

This same observation and strategy was made by Harper and Jim (2019) [16] when testing the validity of the Okun's law for Brazil, however, the present article differs in several aspects: i) Hamilton filter is used and not HP or any other method to capture the deviation of unemployment from its natural rate and output gap; ii) IBC-Br, the series used as a proxy for Brazilian GDP, is more adjusted to the country's growth situation; iii) the period is more recent and considers the moment of institutional crisis facing the country; and iv) the automatic 12-month lag identification criterion is used. This option is due to the slow rate of adjustment to equilibrium unemployment in the face of a output shock, according to Lima and Marques (2019) [19].

Thus, the method will seek to offset the variables based on the established Schwarz criterion, in order to obtain the amount of lags that statistically best fits the proposed model. Data are monthly and range from March 2012 to June 2019, thus 87 observations in total.

5. Results and Discussion

5.1 Unit root test

Results should be the major findings of your experiment. You have to compare the results with previous studies done in same. Studies involving time series must meet the basic condition of stationarity, that is, the development of series must necessarily have random behavior over a constant average. If this condition is not met, the models can provide spurious analyzes (Gujarati and Porter, 2012) [13].

Associated with this point, the primary condition for using ARDL models is the assurance that the series used are all stationary at Level (series I (0)), all at first difference (series I (1)) or mutually cointegrated (series I (0) and I (1) at the same time), and it is impossible to use this approach if the series are stationary in the second difference (series I (2)). To verify this condition, the Dickey-Fuller (1981) [9] - ADF and Phillips-Perron (1989) [26] - PP tests were performed, and the hypothesis of unit root acceptance at 10% significance was adopted. The test results are reported in Table 1, and indicate that the series used in this research are a set of variables I (0) and I (1). No evidence of variables I (2) was found and, therefore, the ARDL approach can be continued.

Table 1: Unit root test

Variables	ADF			PP			Order
	Test	Lags	p-value	Test	Band.	p-value	
logΔu	1st Dif.	7	0.0002	1st Dif.	17	0.0045	I(1)
logΔy	Level	0	0.0355	Level	4	0.0116	I(0)

Source: Author's computation based on survey data.

5.2 Model stability test

To verify the stability of the regression parameters, the Recursive Residue Cumulative Sum (CUSUM) test proposed by Brown, Durbin and Evans (1975) [4] was performed. Verification allows observing the constancy of the parameters in the models at the recursive residue level in terms of average. The purpose is to monitor the process variability over the analyzed period, since the null hypothesis of the test is the stability of the coefficients, calculated at 5% of significance. For both models it was possible attest to the stability of the parameters in the research time interval, as shown in Figure 2 in the Appendix.

5.3 Estimation of models coefficient

Based on the models discussed in this study, the model estimates follow the ARDL construction with distributed lags of type (*a*, *b*), where "*a*" is understood as the amount of lags the dependent variable suffers in the model and "*b*" the amount of lag of the explanatory variable. Schwarz's criterion was used for the automatic white-matrix lag determinations to correct possible correlation effects of the error terms on the constructed regressions. The maximum number of lags obtained for each parameter in each model was 9 months for unemployment and 0 lags for the output.

As shown in Table 2, the tested models presented expected and acceptable values, in sign and magnitude, corroborating Okun's theory. Model 1 indicates that a 1% increase in output above its potential value causes a 0.92% reduction in the aggregate unemployment rate in the country. The adjusted R^2 value of 0.9667 suggests that fluctuations in the output gap explain approximately 96% of the unemployment level in the country.

From the Durbin-Watson test, no evidence of autocorrelation problems was found. The Jarque-Bera normality test, which has the hypothesis of normal statistical distribution of residues, revealed normality. These two tests were also satisfactory for Model 2.

Model 1 also presents, from the cointegration equation, the speed of adjustment of the unemployment level. The negative and significant result of -0.1083 indicates that the model converges significantly to long-term relations between output and unemployment, and reveals that if a shock occurs in output, the unemployment rate adjusts by 10% each month. returning to the existing equilibrium unemployment situation prior to the shock. A slow result that shows that the effect on the labor market takes approximately 10 months to adjust after the shock.

Table 2: Estimation of models – Dependent variable: *logΔu*

Variables	Model 1	Model 2
	ARDL (9,0)	ARDL (9,0)
	0.0015	-0.0073
Coefficient	(0.0048)	(0.0055)
	[0.3149]	[-1.3250]
	-0.9200***	-0.5727*
logΔy	(0.2068)	(0.2933)
	[4.4472]	[-1.9525]
	-	0.0191**
Dummy	-	(0.0089)
	-	[2.1451]
R² Adjusted	0.9667	0.9687
Jarque-Bera	0.4047	0.2820
Durbin-Watson	1.9795	2.0158
Lags	12	12
Information Criteria	Schwarz	Schwarz
Eq. Coint.	-0.1089***	-0.0843**

Notes: Coefficients in bold; *** significant at 1%. ** significant at 5%. * significant at 10%. ( ) Denotes Standard Deviation. [ ] Denotes t-statistic values.

Source: Author's computation based on survey data.

When Model 2 is analyzed, which incorporates the effects of the national economic and political crisis, the results are less intense. The Okun coefficient, for example, points to variations of approximately 0.75% in the country's aggregate unemployment rate for every 1% increase above its potential output. The adjusted R^2 value also indicates an explanatory power of 96% of the independent variable over the dependent variable.

In the case of output shocks, given the uncertainties of a crisis and political instability, the rate of adjustment for unemployment in the Brazilian labor market is slower. The results point to the return in about 12 months. There is evidence that uncertainties increasing from the national crisis associated with low growth and unemployment contribute to rising unemployment rates. The dummy that incorporates crises is directly related to unemployment and presented a statistically significant coefficient of approximately 0.02. This indicates that the instability generated by crises in the country directly contributes to unemployment by 0.02%.

Another interesting and observable analysis is the possibility of verifying how much it would be necessary to grow each time period to cope with unemployment rates. If the government, amidst the difficulties of the crises of the period, wants to implement policies to reduce the unemployment rate by 1 percentage point, for example from 11% to 10% in 6 months, the unemployment rate should fall on average. 0.17 points each month. Substituting the values in Eq. (2) is therefore:

$$\Delta u_t = -\beta_1(\Delta y_t) + \varepsilon$$

$$(\Delta y) = \frac{0.17}{0.5727} = 0.2968$$

That is, the economy is expected to grow by 0.2968% above its long-term trend monthly for six consecutive months, which represents a half-year expansion of approximately 1.79% above trend: $(1.002968)^6 = 1.0179$

In the case of a normal scenario (without crises) the monthly growth should be 0.18% above its trend for six consecutive months. An accumulated 1.11% expansion in the semester. At this point, Gouveia and Feistel (2015) [12] note that the unemployment rate is not only impacted by the output, but also by other factors, such as variations in the number of jobs offered, new entrants to the job market. labor outputivity, as well as other macroeconomic factors that may become determinant of fluctuations in unemployment levels, as suggested by Lima and Marques (2019) [19]. Hence, various econometric models and attempts to theoretically model and explain the functioning of the dynamics of unemployment derive from variables that compose it.

6. Conclusions

This work empirically evidenced Okun's law for Brazil with monthly data from 2012 to 2019 from the use of two autoregressive models of distributed lag ARDL. One of the models based on the use of the Hamilton filter for the construction of the output gap and unemployment deviation, the other with the insertion of a crisis dummy.

The results for both models were satisfactory, with statistically significant Okun coefficients and expected signal. It was revealed that the 1% increase over potential output causes a 0.92% reduction in the aggregate unemployment rate in the country, and that in crisis scenarios the increase in output loses strength in boosting job creation, given the uncertainties. In effect of a crisis the predicted reduction is 0.52% for every 1 percentage point increase above potential output. The political and economic crisis that struck Brazil contributed by itself with a 0.02% increase in the unemployment rate. The return, therefore, to equilibrium unemployment levels in this scenario occurs at a slow speed and is established 1 year after the shock event in the output.

The results show that for the unemployment policies applied that intend to reduce the index must take into account actions that promote the average growth of the product in 0.18% monthly consecutively during a semester. This percentage increases to 0.29% growth per month also uninterrupted for six months in the event of a structural crisis, whether political, institutional or reliable.

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