INVESTIGATING THE OKUN'S LAW IN BRAZIL AND THREE OF ITS METROPOLITAN AREAS

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Abstract

The Okun's Law has been frequently addressing in macroeconomic studies around the world, mostly at the national level, but few studies estimate such relationship at the regional level. This work, using 2002q1-2014q3 quarterly data, estimated the Okun's coefficients for Brazil and for the metropolitan areas of Belo Horizonte, Porto Alegre, and São Paulo, using the differences version, the gap, and two specifications of the dynamic version of the Law, and the cyclical components were obtained by the HP filter, the linear trend, quadratic trend, and through Beveridge-Nelson decomposition. Results show that Okun's Law is valid in Brazil as a whole and in one of the three metropolitan regions studied and there are regional differences in the responsiveness of labor markets to output fluctuations and deviations from their long-term levels.

Keywords: Okun's Law; Time series; Metropolitan Areas of Brazil.

1 INTRODUCTION

Between the first quarter of 2002 and the third quarter of 2014, considering seasonally adjusted quarterly data, Brazil recorded an annualized growth of 3.58% of its GDP in real terms. As foreseen, unemployment fell during this period, from 12.87% to 4.89%. At the end of that period, the average growth slowed, but unemployment continued to fall to a level that prompted the discussion about full employment in the Brazilian labor market. This was seen as an enigma by policy-makers and economists, who had expected the unemployment rate to rise during the economic downturn, just as provides the economic literature through Okun's Law, which identifies an inverse relationship between the unemployment rate and the real output growth. The opposite was widely discussed in the recent literature, since the post-Great Recession period 2008-2009 was marked in various economies and particularly in the US, by "jobless recoveries", calling into question the validity of Okun's Law.

Since its original contribution in 1962, Okun's Law is used by policy-makers and forecasters, however it has been addressed mostly at the national level; there are few studies that analyze the relationship at the regional level. The scarce international literature that addresses the Okun's Law at the regional level shows that the existence of significant differences of Okun's coefficients into the same country is important for the implementation of efficient and effective economic policies.

Thus, based on data of the Brazilian economy and three of its metropolitan areas, this paper contributes to this literature, aiming to investigate whether the Okun's Law can highlight the responsiveness of the Brazilian labor market to fluctuations in output for the selected period (2002q1-2014q3), as well if there are regional differences in the relationship between those variables.

The empirical strategy consists in estimating the differences version, the gap, and two specifications of the dynamic version of the Law, and to obtain the cyclical components were used the HP filter, the linear trend, quadratic a trend, and through Beveridge-Nelson decomposition.

In order to achieve this end, the work comprises, in Section 2, a theoretical review on the Okun's Law. Section 3 brings a brief summary of the main international studies that estimated the Okun's Law at the national, international and the regional level. Section 4 presents the empirical methodology while section 5 presents and analyses the results. Finally, Section 6 gathers the main conclusions and some suggestions for future research.

2 THEORETICAL REVIEW

The relationship between the unemployment rate and output growth can be explained from a demand point of view, that is, changes in aggregate demand cause companies to adapt their production targets, which affects the demand for labor and consequently the unemployment rate. This means that a decrease in gross domestic product (GDP) reduces the demand for labor and, ceteris paribus, increases unemployment.

Therefore, it is very interesting to estimate the rate of growth needed to reduce unemployment (SÖGNER; STIASSNY, 2002). This relationship can also be seen on the supply side of the economy, so that the product increases in recovery phases, resulting from the hiring of unemployed workers. On the other hand, the product falls during recessions stemming from the elimination of jobs (LAL et al., 2010).

In his seminal article, Okun (1962) was the first to notice a steady negative relationship between unemployment and real output (MITCHELL; PEARCE, 2009). Departing from this mostly empirical relationship[1], the name of Okun

1 According to Harris and Silverstone (2001), Okun's Law is an important macroeconomic concept not only from an empirical point of view, but also theoretical. Empirically, this law is present as a "golden rule" for forecasting and policy-making. Theoretically, it is the link between the aggregate supply curve and the Phillips curve.

was later associated with what is known today as Okun's Law (KNOTEK, 2007). In this sense, what is behind the Okun's Law is the fact that changes in aggregate demand cause changes in production, which, in turn, lead companies to hire or fire workers. So when unemployment is high, it can be reduced through expansionary demand policies (BALL; LEIGH; LOUNGANI, 2012).

Okun (1962) noted two empirical relations: quarterly changes in the unemployment rate related to the quarterly growth of real output, and deviations in the unemployment rate related to potential output gaps (CHAMBERLIN, 2011). Using quarterly data from the US economy since the second quarter of 1947 to the fourth quarter of 1960 suggested that a variation of 1 percentage point in the unemployment rate would be associated with a change in the opposite direction of approximately 3% of the real product[2].

Nowadays, many authors postulate that a deviation of 1% of potential GDP in the US economy is associated with an opposite variation in the unemployment rate in the magnitude of half a percentage point (KNOTEK, 2007). Exactly the same magnitude indicated by the famous Mankiw (2010); Dornbush, Fischer and Startz (2009) and Romer (2012) textbooks and quite similar to that reported by Blanchard (2011). This ratio of two to one is called *constant of proportionality* by Daly and Hobijn (2010) and is the basis for most of the macroeconomic forecasting models.

The Okun's coefficient varies substantially from country to country. Idiosyncratic characteristics of national labor markets explain in part this variation. Estimates done by the authors with annual data from 1980 to 2011 show that the coefficient in Japan is -0.15; in the United States, -0.45; and is -0.85 in Spain. These different coefficients reflect particular characteristics of national labor markets, for example, the lifetime employment tradition in Japan and the prevalence of temporary employment contracts in Spain (BALL; LEIGH; LOUNGANI, 2012). In the United States, the coefficient is related to partial social and legal restrictions, which facilitates the adjustment of employment

2 This specification is in line with the theory of production, where production depends on the amount of work (LEE, 2000). In most current studies, this argument is reversed, so that it's asked how much economic growth is necessary to reduce or stabilize the unemployment rate. Thus, the Okun's coefficients are estimated for different countries, regions and periods (OBERST; OELGEMÖLLER, 2013). Okun's Law is then seen as the elasticity of the unemployment rate in relation to output growth (CAZES; VERICK; AL HUSSAMI, 2012). Although a causality test – such as the Granger Test (GRANGER, 1969) – can point to the causal relationship between these two variables, the present work follows only one direction in order to maintain comparability with other studies mentioned here and due to the large number of data series, opting for defining the product or the output gap as a dependent variable. It is worth noting that the results of both directions, according to Lee (2000), are qualitatively similar.

by firms (BLANCHARD, 2011). According to the International Monetary Fund (IMF), higher values for the coefficient of Okun, in a module, indicate larger increases in unemployment when the product decline.

Although this increased responsiveness of the labor market may intensify unemployment in a recession, it can also increase the employment elasticity in prosperity times. Moreover, the responsiveness of unemployment to changes in the product has increased over time in several advanced economies, mainly because of lower employment protection and dissemination of temporary employment contracts (IMF, 2010).

However, different Okun's coefficients between countries cannot be explained only by differences in the labor market regulation, since not always flexible markets present higher coefficient[3] (CAZES; VERICK, 2011). There are other factors influencing the Okun's coefficient, such as the work force participation rate, skill levels of workers and labor productivity (MARIE-ESTELLE; FACCHINI, 2013). According to Ball, Jalles and Loungani (2014) the magnitude of the coefficient also depends on the costs related to the adjustment of employment, which can be either technological costs or costs arising from the employment protection laws; and the number of workers entering and leaving the labor force. Because these factors are different between countries so tend also to be the coefficients.

The Okun's Law is marked by simplicity because it involves only two macroeconomic variables (KNOTEK, 2007); is also considered a reference point for policy-makers seeking to measure the cost of rising unemployment (LEE, 2000); important for forecasting and policy-making (HARRIS; SILVERSTONE, 2001), including to determine the optimal or desirable growth rate (SILVAPULLE; MOOSA; SILVAPULLE, 2004).

It is still an important tool for predicting changes in the unemployment rate (KNOTEK, 2007); part of the core macroeconomic practices, resulting in a truly robust empirical regularity and impressive reliability, in which "we should all believe" (BLINDER, 1997). The Law indicates one of the most enduring relationships in macroeconomics which has important implications for macroeconomic policy, mainly in determining the ideal and desirable output growth rate (MOAZZAMI; DADGOSTAR, 2009).

Furthermore, to link aggregate supply curve and the Phillips curve (HARRIS; SILVERSTONE, 2001) – by taking for hypothesis the fact that, according to

3 Lower, according to the same authors when considering the differences version that takes into account a negative value of β.

Stiglitz (1997), changes in the inflation rate are largely due to the labor market pressures, which can be analyzed by the unemployment rate – many economists, according to Wen and Chen (2012), present the Okun's Law as an useful tool for monetary policy because it offers opportunity for a formulation of expansive aggregate output policies, further reducing unemployment. Therefore, it is necessary that this relationship could be statistically significant and that the natural rate of unemployment could be properly evaluated, too.

Despite its popularity, stability and usefulness of Okun's Law are matters of disputes (WEN; CHEN, 2012). Harris and Silverstone (2001) recognize the theoretical and empirical usefulness of Okun's Law, but consider that most specifications assume a symmetrical relationship, implying that the expansions and contractions of the real product have the same effect on unemployment, which may not be the case.

It is likely that the unemployment rate decrease in boom times more than increase during recessions, given institutional characteristics of the labor market[4]. As well as asymmetry, Silvapulle, Moosa and Silvapulle (2004) and Mayes and Viren (2002) are examples of authors who demonstrated non-linearity in the relationship between the product and unemployment. Moreover, according to Chamberlin (2011), as a statistical relationship, the law may be subject to structural breaks[5] or regime changes. Besides, even though the Okun's Law is taken as a rule of thumb to predict how changes in the product affect the labor market, according to Beaton (2010), it should be used with caution due to its instability over the business cycle.

Actually, Okun's Law is a statistical relationship and not exactly a structural feature of the economy. In this sense, as any statistical relationship, it may be subject to revision in the context of an economy in constant change (KNOTEK, 2007). However, Ball, Leigh and Loungani (2012) understand the Okun's Law as a strong and stable relationship in most countries, and that did not undergo

4 According to Silvapulle, Moosa and Silvapulle (2004), restricting the ability of employers to fire workers makes unemployment respond less intensively to product changes during the contraction phase than in the expansion. On the other hand, employers tend to be more pessimistic during recessions than optimistic in the expansion, moving faster for bad news than with good news. For these authors, the second argument is more relevant to the US, while the first it may be more appropriate for Europe. Anyway, Cazes, Verick and Al Hussami (2012) argue that at the macroeconomic level, employment protection legislation can serve as a "stabilizer" to soften the adjustment of the labor market to adverse macroeconomic shocks. Important to mention that there are other institutional factors influencing the labor market, such as unemployment insurance and trade unions.

5 In the context of the US economy, a recent critique of Okun's Law is that it "breaks down" during recoveries, particularly in the case of the last three recoveries, which were called jobless recoveries (OWYANG; VERMANN, 2013).

substantial changes during the Great Recession of 2008-2009. They also claim that, in general, its use is consistent to verify that changes in unemployment are related to output fluctuations.

The Okun's Law was developed with the assumption that more work results in greater production (CHAMBERLIN, 2011). However, Okun realized that changes only in the unemployment rate are not able to totally explain the variations found in the real product and there are other factors related to these variables[6] (ADANU, 2005) – such as the stock of capital, level of capacity utilization, productivity, average hours of work, participation rates, size of the workforce – but he considered that this measure could serve as an important summary of the amount of work that is employed in the economy, providing a proxy for the amount of idle resources (CHAMBERLIN, 2011).

Thus, the response of the labor market to product variations across countries is presented as an interesting issue (CHAMBERLIN, 2011). Moreover, besides the importance of estimating Okun's law at the national level, estimates of Okun's Law at regional level make available to policy-makers a strategy to solve regional problems of unemployment (APERGIS; REZITIS, 2003).

As regional disparities in unemployment rates are large and persistent in most countries, it implies that unemployment policies cannot be seen only from a national perspective (MARIE-ESTELLE; FACCHINI, 2013). Thus, the knowledge arising from this relationship for each region is important for the implementation of efficient and effective economic policies (VILLAVERDE; MAZA, 2009). Freeman (2000) complements that regional estimates provide further evidence of the magnitude of the coefficient besides ensuring the estimation of more efficient parameters.

3 OKUN'S LAW AT REGIONAL LEVEL

Since the original contribution of Okun, this law has often been addressed in the national and international level; there are few studies that analyze the

6 Some studies address the Okun's Law through a production function that relates the product changes to several variables (CHAMBERLIN, 2011). Prachowny (1993) estimates the law based on a Cobb-Douglas aggregate production function consisting of working hours, productivity and the participation rate. Gordon (2010), also using a production function, found that the last three recessions in the United States (1990-1991, 2001 and 2007-2009) were followed by jobless recoveries, combining a great productivity growth together with the fall in employment.

relationship at regional level (MARIE-ESTELLE; FACCHINI, 2013). In recent years, however, since Freeman (2000), some studies aimed to overcome this gap (VILLAVERDE; MAZA, 2009), analyzing the issue at the regional level. The literature can be summarized as follows.

Freeman (2000) estimated the Okun's Law to eight american regions, using annual data from 1977 to 1997, as well as at national level for the quarters from 1959 to 1998. He used the band-pass filter of Baxter-King, the quadratic trend filter and the gap version of Okun's Law, which considers the output gap as the dependent variable and the unemployment gap as an independent. Estimates point to a coefficient close to -2 for both national and regional data. He concluded that there seems to be regional differences in the unemployment response to reductions in production capacity, with respect to deviations of the equilibrium levels.

Apergis and Rezitis (2003) estimated Okun's coefficients for certain regions of Greece based on annual data from 1960 to 1997. The Hodrick-Prescott (HP) and Baxter-King (BK) filters were used as well as the gap version of Okun's Law. The results show no interregional differences, except for two of the eight regions analyzed. Considering the HP filter, the average Okun's coefficient at homogeneous regions was -1.4, while the other two regions reached coefficients of -2.9 and -3.6.

Christopoulos (2004) estimated the Okun's coefficient for thirteen Greek regions, using 1971-1993 annual data, and cointegration with panel data, and provided evidence that the relationship that considers the log of the product as explained variable and time and the log of unemployment as explanatory, can be confirmed in six regions. The coefficients ranged from -0.3 to -1.7. In addition, he verified the existence of a long-term relationship between unemployment and output growth in the Greek regions.

Adanu (2005) estimated Okun's coefficients for ten provinces of Canada, using annual data from 1981 to 2001, HP filter, quadratic trend, and dynamic version of Okun's Law, which considers the output gap as the dependent variable and the unemployment gap as an independent. He concluded that the absolute coefficients values are higher in the relatively largest and most industrialized provinces. Considering HP filter, the coefficients cover the range of -0.4 to -2.1 between the provinces.

Villaverde and Maza (2007) analyzed the Okun's Law for Spain and seventeen of its regions, with 1980-2004 period annual data. Employing two different trend techniques (HP filter and quadratic trend) and the gap model of Okun's Law, the results showed Okun's coefficients very different, such as with the HP filter, ranged between -0.3 and -1.6, in addition to an inverse the relationship between unemployment and the product for most Spanish regions and the whole country.

Later, in quite similar work, Villaverde and Maza (2009) added the Baxter-King filter analysis and concluded that using this filter, the Okun's Law is confirmed in eleven regions, whereas using the HP filter and the quadratic trend filter it is confirmed in fifteen of the seventeen regions. Similarly, the authors conclude that regional differences in Okun's coefficients are remarkable and statistically significant. With the BK filter, the coefficients varied from -0.4 to -1.1.

Marie-Estelle and Facchini (2013) based on annual data from 1990 to 2008, using the HP filter, panel data and the gap version, estimated the Okun's Law for each of the 22 administrative regions of France. The results show regional differences in the coefficients and confirmed the law in fourteen regions, invalidating it in the others. The valid coefficients were included in the range of -0.9 to -1.8.

To sum up, in general, most of these studies show substantial regional differences in the values of the Okun's coefficients. However, is important to mention that the magnitude of these coefficients cannot be compared with the present study because we use the current product as an independent variable and unemployment as a dependent for both differences and gap versions.

4 EMPIRICAL STRATEGY

To estimate the Okun's coefficient, it assumes that there are some long-term levels of output, employment and unemployment. The term "potential output" will be adopted for the long-term product, and "natural rate" for the long-term unemployment (BALL; LEIGH; LOUNGANI, 2012). The formal definition of potential output may be originally credited to Arthur Okun in 1962 (MURRAY, 2014), who believed that potential output was the result of full employment, which is the level of employment that would not cause inflationary pressures, or the NAIRU[7] level (OWYANG; SEKHPOSYAN, 2012). According to Ball, Leigh and Loungani (2012), potential output is determined

7 In his original work, Okun (1962) considered a NAIRU of 4%.

by the productive capacity of the economy and expands over time, in line with technological changes and the accumulation of factors of production.

The natural unemployment rate and the level of long-term employment are determined by the size of the workforce and existing frictions in the labor market. Okun postulates that changes in aggregate demand make the product floating around its potential. These movements encourage companies to hire or fire workers, changing the level of employment and consequently the unemployment rate. In this sense, this relationship can be expressed as:

$$E_t - E_t^* = \gamma\left(Y_t - Y_t^*\right) + \eta_t \ , \qquad \gamma > 0 \qquad (1)$$

$$U_t - U_t^* = \delta\left(E_t - E_t^*\right) + \mu_t \ , \qquad \delta < 0 \qquad (2)$$

Where E_t is the log of employment, Y_t is the log of the product, U_t is the unemployment rate, γ is the elasticity coefficient of product in relation to work, δ is the coefficient of the effect of employment in the unemployment rate, and * indicates a long term level. η_t and μ_t capture the disturbances and, respectively, factors that affect the relationship between the variables of his equations. In this context, one can derive the Okun's Law substituting (1) into (2):

$$U_t - U_t^* = \beta\left(Y_t - Y_t^*\right) + \varepsilon_t \ , \qquad \beta < 0 \qquad (3)$$

Where $\beta = \gamma\delta$ and $\varepsilon_t = \mu_t + \eta_t$. Thus, the β coefficient of Okun's Law depends on the coefficients of the two relationships that support the law. The error term ε_t captures factors which alter the relationship between unemployment and the product, such as changes in productivity or even in the workforce participation.

In his original article, Okun presented two approaches to estimate the law. One of them, known as gap or "levels" version, is used to estimate equation (3). In this approach, the main obstacle is to measure the natural rate of unemployment U^* and potential output Y^* (BALL; LEIGH; LOUNGANI, 2012) because these values are unobservable and must be estimated (DRITSAKI; DRITSAKIS, 2009). The most widely used method to deal with this issue is to soften the product and unemployment series with the Hodrick-Prescott filter (BALL; LEIGH; LOUNGANI, 2012).

There is no simple and easy way to find potential GDP and the natural unemployment rate that ensures the accuracy of estimates. In general, techniques are estimated by time series methods or through the construction of a production function (FREEMAN, 2000).

Among the forms found in the literature, we mention techniques for univariate time series (removal of deterministic or quadratic trends, trend-cycle decomposition, first differences), more sophisticated techniques such as Hodrick-Prescott filter, band-pass filters of Baxter-King (ADANU, 2005) and Christiano-Fitzgerald (CF) (CHRISTIANO; FITZGERALD, 2003); Beveridge-Nelson decomposition and multivariate techniques (MURRAY, 2014), of which we can highlight the Hodrick-Prescott filter with multivariate production function (HPFP) (BARBOSA FILHO, 2009).

Modern macroeconomics offers several alternatives for separating trends and cycles in economic time series (FREEMAN, 2000). Different methods allow us to look at the series with a different perspective. Thus, some authors use more than one method. The purpose of using two removal trends methods, according to ADANU (2005), is to observe the sensitivity of the Okun's coefficient to the select method. Lee (2000) used three different filters and concluded that the estimates of Okun's Law are sensitive to the choice of filtering method. The Brazil Central Bank (2005) uses four methods to keep up with the Brazilian potential output: linear trend, HP filter, Cobb-Douglas and the filter HPFP. According to Freeman (2000), the choice of the trend removal method may explain the failure to reject the non-stationarity of the variables used in a regression. The present work, in addition to the HP filter, uses the linear trend (TL), quadratic trend (QT), and decomposition Beveridge-Nelson (BN).

To Cusinato, Minella and Porto Jr. (2010), a simple and old method for obtaining the cyclic component of the series is the linear trend, which can be expressed by:

$$y_t = \alpha + \beta_t + \varepsilon_t, \qquad t = 1, \ldots, T \tag{4}$$

α is a constant; β the estimated parameter; t a trend term; ε the error of the regression; and T the sample size. The assumption of this model, according to

Souza Junior (2009), is that the series can be decomposed into a trend component $(\alpha + \beta_t)$ and a cyclic component (ε_t). Referring to the application of the linear trend to GDP log series, the author states that this method, by assuming that potential growth (β) is constant, does not recognize the existence of supply shocks. Nevertheless, in general, these series are not stationary. Thus, the cyclical component may comprise part of what it should be the trend component.

The extension of the linear trend which consists adding the quadratic term is called quadratic trend (CUSINATO; MINELLA; PORTO JR., 2010), and can be defined as follows:

$$y_t = \alpha + \beta_1 t + \beta_2 t^2 + \varepsilon_t, \qquad t = 1,\ldots,T \tag{5}$$

Hodrick and Prescott (1997) proposed a trend removal technique which separates a time series (y_t) in trend (g_t) and cyclic components (c_t), considering that $y_t = g_t + c_t$. Note that there is still the seasonal component, but Hodrick and Prescott developed the method suggesting that data have been previously seasonally adjusted. For the authors, the trend component may contain a deterministic trend or a stochastic trend. The smoothing parameter determines the periods of stochastic cycles that drive the stationary cyclical component. Formally, the equation for estimating the HP filter may be defined by:

$$\frac{Min}{\{g_t\}_{t=-1}^{T}} \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} \left[(g_t - g_{t-1}) - (g_{t-1} - g_{t-2}) \right]^2 \right\} \tag{6}$$

In this sense, the sum of squared deviations is minimized, and the penalty given by the parameter λ. The smoothness of the trend depends, then, on λ. In this regard, the trend becomes softer when $\lambda \to \infty$, so that, as noted by Ball and Mankiw (2002), if there is no penalty, the filter would produce the original series; while a high λ yields a linear trend.

According to Murray (2014), the HP filter requires explicit judgment on the choice of smoothing parameter. However, Hodrick and Prescott (1997) recommend a λ = 1600 for quarterly data series, which, according to Souza Junior (2009) is the default value used for quarterly data in the literature of real economic cycles.

On the other hand, an HP filter shortcoming is the so-called border effect (BARBOSA FILHO, 2009) or problem of the end point, which affects not only the HP filter, but other "two-sided filters" given the data unavailability of the end of the sample.

At the end of the sample, the negative output gap tends to the bias potential output down, while the positive gap tends to bias upward (MURRAY, 2014). In the case of GDP, for example, Barbosa Filho (2009) asserts that when GDP grows faster than in the recent past, potential GDP tends to be revised upwards. In the opposite case downward revision occurs when GDP grows slower than in the recent past. Thus, revisions of estimates of potential output in the present occur while knowing future values of GDP. Souza Junior (2009) adds that if the data of the end of the sample do not reflect the long-term trend, the resulting figure may be underestimated or overestimated.

To Jahan and Mahmood (2013), however, any method of estimating the potential output has its shortcomings. Ravn and Uhlig (2002) state that the HP filter, despite criticism, has performed well the tests of time and discussions. Christiano and Fitzgerald (2003) – CF filter creators – concluded that, for quarterly data, the HP filter seem to fit very well.

Beveridge and Nelson (1981) split the decomposition of non-stationary time series into permanent component (stochastic trends) and transient (cycles). The method assumes that absolute changes or in their natural logarithm is stationary with the representation of an autoregressive moving average process (ARMA) and autoregressive integrated moving average (ARIMA), ARIMA (p, 1, q). The decomposition according to Canova (1988), leads to obtaining a non-stationary component and a continuous stationary cyclic component[8].

Because the changes in the trend are unpredictable it constitutes a decomposition of the series in a random walk and a cyclical component, so that $y_t = \tau_t + c_t$ and the trend is expressed by $\tau_t = \tau_{t-1} + \xi_t$ where ξ_t is a white noise.

One advantage of the BN decomposition, according to Denis, Mc Morrow and Roger (2002), is that the equation depends only on the series stochastic generator process, namely it depends only on its past. Accordingly, the endpoint problem does not exist in this method. However, to these authors it can produce very volatile cyclical components and negatively correlated with GDP

8 For reasons of space this decomposition will not be shown here, but can be found in Araujo, Areosa and Guillén (2004).

growth. In this regard, it is noteworthy that Araujo, Areosa and Guillen (2004), using different univariate and multivariate techniques estimate the output gap for the Brazilian economy in the period from 1995q1 to 2003q4 and concluded that the predictions arising from the decomposition of Beveridge-Nelson were the most efficient.

Indeed preceding the decomposition is the estimation of the ARIMA model (FAVERO, 2001), so that problems in the ARIMA model specification are passed to this method (CANOVA, 1988). Considering this observation, the present model uses the algorithm created by Hyndman and Khandakar (2008). Table 1 shows the selected models:

Table 1

ARIMA Models Identification

Serie	Model
GDP Log, Brazil	ARIMA (1,1,0)
Unemployment, Brazil	ARIMA (1,1,1)
GDP Log, RABH	ARIMA (0,1,1)
Unemployment, RABH	ARIMA (0,1,1)
GDP Log, RAPA	ARIMA (1,1,0)
Unemployment, RAPA	ARIMA (0,1,1)
GDP Log, RASP	ARIMA (0,1,1)
Unemployment, RASP	ARIMA (0,1,1)

Source: Elaborated by the authors.

Overcame the issue of measurement of the cyclical components that make up the gap version of Okun's Law, we highlight now the other approach presented by Okun in 1962 which, according to Ball, Leigh and Loungani (2012), seeks to estimate the differences version of the law which can be expressed by:

$$\Delta U_t = \alpha + \beta \Delta Y_t + \omega_t \tag{7}$$

where Δ is the change from the previous period. Importantly, this equation arises from the levels equation if we consider that the natural rate U^* is constant and that potential output Y^* grows at a constant rate. Accordingly, equation (3) yields equation (7), in which $\alpha = -\beta\Delta Y^*$ and ΔY^* represents a constant growth rate of potential product, and $\omega_t = \Delta\varepsilon_t$.

Although it is easier to estimate the equation (7), since it does not include unobservable variables and in many countries it is not a reasonable assumption taken as a constant natural rate U^* and a potential product Y^* growing at a constant rate. Thus, it is better to estimate U_t^*; Y_t^* to avoid problems. Despite the equations (3) and (7) fit the data well, in most countries is better to use the levels equation (BALL; LOUNGANI; LEIGH, 2012).

The differences and gap versions are the most used in the literature to estimate Okun's coefficients (MARIE-ESTELLE; FACCHINI, 2013). When he or she uses the differences model, unemployment and real GDP variables are covered in first differences. In the gap model variables are scaled by their long-term trend deviations (SILVAPULLE; MOOSA; SILVAPULLE, 2004).

The model in first differences is a convenient way to reach the stationary data, while the levels model provides interesting inferences about the behavior over the business cycle. Thus, for a balanced treatment of the subject, it is a wise strategy to consider the two approaches (LEE, 2000).

Over the years, economists have expanded the research including elements not considered by Okun in its analysis (KNOTEK, 2007). The inclusion of lags of the explanatory variable, called dynamic version of Okun's Law, is a common approach in the literature, since firms need time to select and hire new workers as well as to dismiss them due to employment protection legislation (OBERST; OELGEMÖLLER, 2013) as well as time for people to enter or quit the workforce (BALL; LEIGH; LOUNGANI, 2012).

In other words, it can take time to the labor market adjust to the output variations. That is why the adjustment of the equation can improve with the inclusion of lags of the product in case of using quarterly data. According to Ball, Leigh and Loungani (2012), the model with two-period lag can be specified as follows:

$$U_t - U_t^* = \beta_0\left(Y_t - Y_t^*\right) + \beta_1\left(Y_{t-1} - Y_{t-1}^*\right) + \beta_2\left(Y_{t-2} - Y_{t-2}^*\right) + \varepsilon_t \qquad (8)$$

Although not explicitly specified to have another dynamic version, Ball, Leigh and Loungani (2012) also estimated:

$$\Delta U_t = \alpha + \beta_0 \Delta Y_t + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta Y_{t-2} + \omega_t \quad (9)$$

In this regard, the present paper estimates the differences versions, the gap, the two specifications of the dynamic version, and the cyclical components obtained by the HP filter, the linear trend, quadratic trend, and through Beveridge-Nelson decomposition.

The Augmented Dickey-Fuller test (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS), are used then for test the presence of unit root of the residuals. If there is disagreement in the first two tests, the KPSS test is used as a tool for verification of stationarity. The number of lags used was based on Akaike information criterion (AIC) and Schwarz's Bayesian information criterion (SBIC), observing the principle of parsimony.

In this regard, considering the critical values proposed by MacKinnon (1996) or by Kwiatkowski et al. (1992), as appropriate, results no reject the null hypothesis of unit roots for most of the series, as can be seen in Table A1, in the appendix.

Those series which violate the assumption of stationarity were estimated in first differences. The relationships that showed serially correlated errors, under the Durbin-Watson table, were adjusted by the method of Cochrane-Orcutt, to prevent the occurrence of spurious regression; situation that combines a high degree of adjustment with a low value for the Durbin-Watson statistic.

The choice of the metropolitan areas (MAs) of Belo Horizonte, Porto Alegre and São Paulo were based on data availability to ensure the reasonable number of time series observations[9], besides these are areas that contribute significantly to Brazilian GDP and jobs[10]. Map 1 illustrates the three metropolitan areas.

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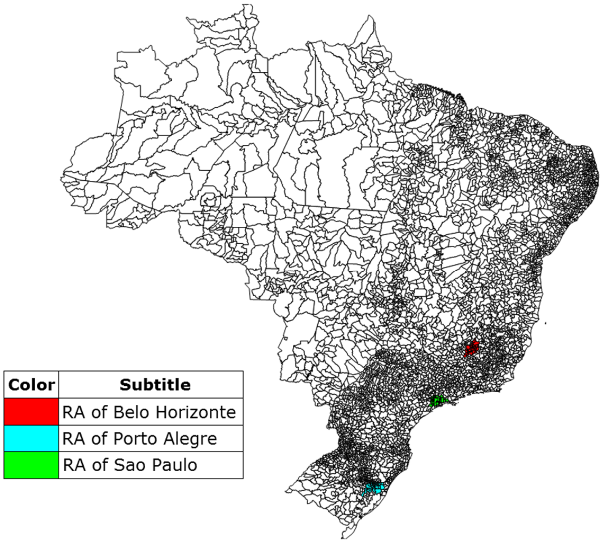
9 Okun (1962) estimated his law based on data from 1947q2 to 1960q4, corresponding to 55 observations. In the case of the present study, the period 2002q1-2014q3 comprises 51 observations. Knotek (2007) uses rolling regressions of 52 points and argues that this method ensures that the distant past (the 50s, for example) does not interfere in determining the recent relationship (1990s and 2000s, for example).

10 Despite the low expressiveness in terms of geographical area, occupying only 0.3% of the country, according to 2012 IBGE data, the metropolitan areas of Belo Horizonte, Porto Alegre and São Paulo generated, 23.7% of all GDP; 20.2% of industrial added value; and 25.6% of services value added in Brazil. 2010 Census data show that 15.2% of the population lives in one of these locations. Data from the 2013 National Household Sampling Survey (PNAD) show that these three metropolitan concentrated 15.7% of the Brazilian economically active population (PEA), 15.7% of employed persons and 15.8% of Brazilian unemployed. According to the data of 2013 Annual Register of Social Information (RAIS), these RAs account for 22.7% of formal work contracts, 17.2% of establishments and 27.6% of salaries related to formal labor linkages. Also, General Register of Employed and Unemployed (CAGED), pointed that 25.3% of formal jobs created between January 2002 and September 2014 belonged to one of this three RAs.

Map 1

Metropolitan Areas of Belo Horizonte, Porto Alegre and São Paulo



Source: IBGE.

Table 2 indicates the variables and data sources used:

Table 2

Data Series

Brazil and metropolitan areas (2002q1 to 2014q3)		
Variable	**Proxy**	**Source**
Unemployment Rate	Unemployment Rate – Brazil, RASP, RAPA and RABH	IBGE
NaturalUnemployment Rate	Estimates done by the authors using HP, TL, TQ and BN filters.	IBGE
Real GDP – Brazil	Real GDP – Brazil	IBGE
Real GDP – RASP	Real GDP –SP State	SEADE Foundation
Real GDP – RAPA	Real GDP –RS State	FEE/CIE/Department of Regional Accounts
Real GDP – RABH	Real GDP –MG State	Joao Pinheiro Foundation

(continua)

Table 2

Data Series (*conclusão*)

Brazil and metropolitan areas (2002q1 to 2014q3)		
Variable	**Proxy**	**Source**
Potencial GDP	Estimates done by the authors using HP, TL, TQ and BN filters.	IBGE; SEADE Foundation; FEE/CIE/Department of Regional Accounts; Joao Pinheiro Foundation

Source: Elaborated by the authors.

As in Owyang and Sekhposyan (2012), the original real GDP series are quarterly, while the unemployment series are monthly, requiring a compatibilization. As these authors, the present paper also opted for the quarterly average of the monthly series to calculate the quarterly unemployment rate. The GDP data are seasonally adjusted figures, while the unemployment series were seasonally adjusted by x12 method from the US Census Bureau, since, according to Beveridge and Nelson (1981), the seasonal adjustment is a step that precedes the analysis of the business cycle.

It is important to note that Okun used the Gross National Product (GNP) in his original work, but many authors make their estimates using real GDP, or even other product measures, such as non-agricultural private sector production. The Okun's coefficient, however, tends to be sensitive to the choice of data representing the product (ADANU, 2005). Regressions are performed either by ordinary least squares (OLS) or Cochrane-Orcutt method, as appropriate.

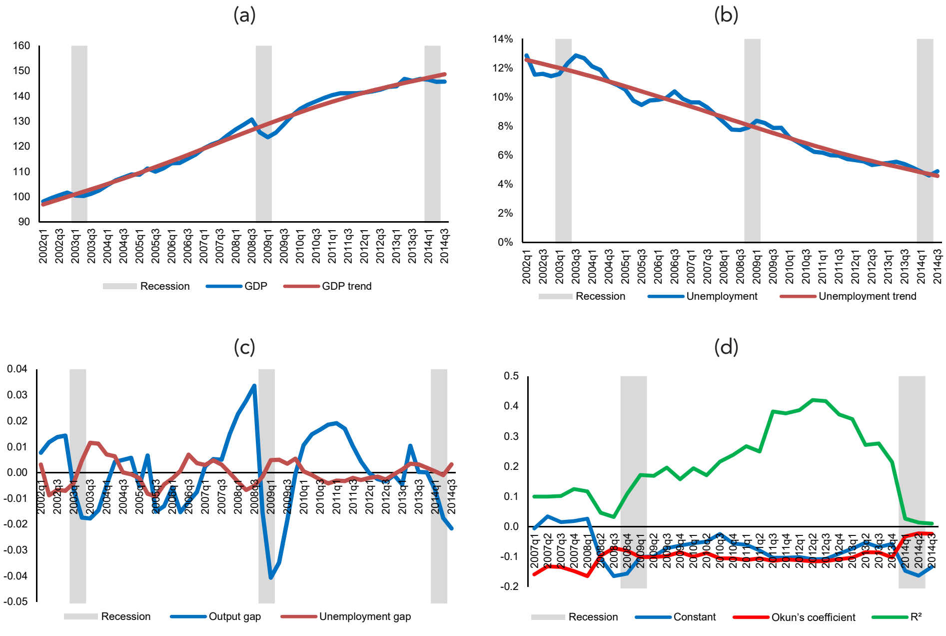
5 RESULTS

Estimates of Okun's Law for Brazil and for the metropolitan areas of Belo Horizonte, Porto Alegre and São Paulo show that the coefficients vary according to the model specification and the method used to extract the cyclical components, which, according to Lee (2000), points out the difficulty of separating what is long-term trend and what is cyclical fluctuations in economic time series, so that the inferences should be interpreted with caution.

Although Okun's Law does not show valid in some developing countries (LAL et al., 2010), the law is validated in Brazil, so that, according to the levels version taking into account the HP filter with a λ= 1.600 (most common specification in the literature), an increase of 1% of the actual GDP above potential is associated with a fall of 0.12 percentage point of unemployment gap. The differences version indicates a coefficient of 0.11. In this case, it means that, ceteris paribus, to reduce the Brazilian unemployment rate by 1 percentage point in a year, real GDP needs to grow 2.27% for 4 consecutive quarters, representing an annualized growth of 9.4%.

Figure 1

GDP, Unemployment, Gaps and Okun's coefficient – Brazil, 2002q1-2014q3



Notes: (a) GDP Index (2002 mean = 100), trend using HP filter λ = 1.600.
(b) Unemployment Rate ,trend using HP filter λ = 1.600.
(c) GDP and unemployment rate lags using HP filter λ = 1.600.
(d) *Rolling regression*, based on a 20 quarters period and on differences version of Okun's Law. The choice of 20 quarters occurred mainly due to the size of the series. Aiming to capture cyclical variations in the regression coefficients in a faster way, Chamberlin (2011) also opted for a 20 quarters period.

Source: Elaborated by the authors, based on IBGE seasonally adjusted data and on the research results.

Table 3

Okun's Law Estimates – Brazil (2002q1-2014q3)

	Levels Equation								Differences Equation	
	Linear Trend		Quadratic Trend		Hodrick-Prescott Filter		Beveridge-Nelson Decomposition			
β0	-0.109***	-0.071**	-0.120***	-0.075**	-0.117***	-0.075**	-0.086***	-0.011	-0.110***	-0.071**
	(0.041)	(0.035)	(0.039)	(0.035)	(0.041)	(0.035)	(0.022)	(0.036)	(0.041)	(0.035)
β1		-0.116***		-0.121***		-0.121***		-0.110***		-0.116***
		(0.036)		(0.037)		(0.037)		(0.037)		(0.037)
β2		-0.006		-0.015		-0.015		0.078		-0.006
		(0.035)		(0.035)		(0.036)		(0.036)		(0.036)
β0 + β1 + β2		-0.193		-0.211		-0.210		-0.042		-0.192
α									-0.072	0.013
									(0.059)	(0.058)
Obs.	50	48	51	49	51	49	49	47	50	48
R^2 adjusted	0.111	0.275	0.143	0.330	0.124	0.297	0.232	0.162	0.111	0.269
RMSE	0.003	0.003	0.003	0.003	0.003	0.003	0.001	0.001	0.342	0.279
Durbin-Watson (original)	1.560	1.490	0.650	0.522	0.657	0.571	3.134	2.814	1.605	1.486
Durbin-Watson (transformed)			1.669	1.395	1.677	1.392	1.909			1.939

Note: Standard errors in parentheses. ***, ** and * indicate statistical significance levels of 1, 5 and 10 percent, respectively. The regressions showing transformed Durbin-Watson were estimated by the Cochrane-Orcutt method.

Source: Elaborated by the authors based on the research results.

The coefficients found for Brazil vary from -0.09 to -0.12, depending on the version of the law and the filter chosen, as shown by Figure 1 and Table 3 above, which is below the value found by Dezordi (2011) and, with the exception of Beveridge-Nelson decomposition, very close to one of the estimated coefficients for Tombolo and Hasegawa (2014).

As we have seen, the literature considers this coefficient low, which is even lower than that found in Japan, according to estimates of Ball, Leigh and Loungani (2012), with annual data from 1980 to 2011(around -0.15), especially due to its lifetime employment tradition.

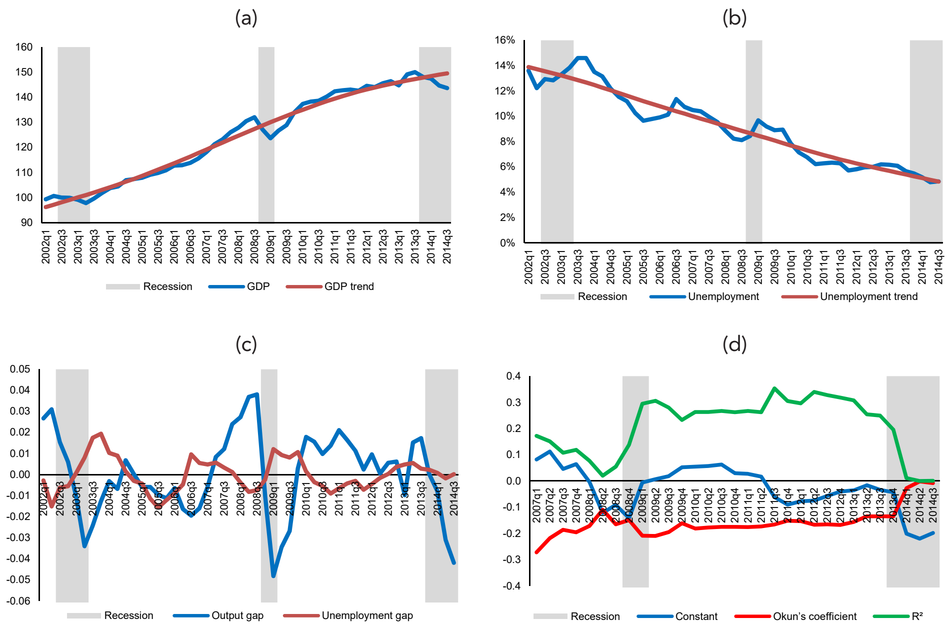
It can be seen that this method of inserting gaps to make the dynamic model works for the Brazilian economy as a whole and in the metropolitan areas of Belo Horizonte and São Paulo, too, with respect to changes in the unemployment gap to potential output gaps. The evidence also point out that the unemployment variations were related to GDP fluctuations of the previous quarter in Brazil, MABH and in MASP, capturing the idea that firms need some time to hire and dismiss workers due to economic situation changes.

The empirical results show different regional coefficients, and confirm the presence of Okun's Law in one of three metropolitan areas. São Paulo had, in absolute terms, the highest rates, ranging from -0.05 to -0.14, which means that the labor market responds proportionately more intensively to product variations compared to the other regions.

A special feature of the MASP is the fact of being an exporting region and supplier of goods to the rest of the country, which intensifies the effects of cycles on labor market. Thus, the MA of São Paulo tends to lose proportionally more jobs in a recession than other locations studied. However, in periods of economic prosperity, it also has more jobs recovery capabilities. To reduce, ceteris paribus, in a year, the unemployment rate by 1 percentage point, the real GDP of the MASP needs to grow 1.78% for four consecutive quarters, representing an annualized growth of 7.3%. Figure 2 and Table 4 present these results:

Figure 2

GDP, Unemployment, Gaps and Okun's coefficient–Metropolitan Area of São Paulo, 2002q1-2014q3



Notes: (a) GDP Index (2002 mean = 100), trend using HP filter λ = 1.600.

(b) Unemployment Rate, trend using HP filter λ = 1.600.

(c) GDP and unemployment rate lags using HP filter λ = 1.600.

(d) *Rolling regression*, based on a 20 quarters period and on differences version of Okun's Law. The choice of 20 quarters occurred mainly due to the size of the series. Aiming to capture cyclical variations in the regression coefficients in a faster way, Chamberlin (2011) also opted for a 20 quarters period.

Source: Elaborated by the authors, based on IBGE, on SEADE Foundation seasonally adjusted data and on the research results.

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Table 4

Okun's Law Estimates – Metropolitan Area of São Paulo (2002q1-2014q3)

	Levels Equation								Differences Equation	
	Linear Trend		Quadratic Trend		Hodrick-Prescott Filter		Beveridge-Nelson Decomposition			
β0	-0.140***	-0.060	-0.136***	-0.071	-0.139***	-0.096**	-0.050*	-0.023	-0.141***	-0.078
	(0.048)	(0.048)	(0.045)	(0.047)	(0.048)	(0.046)	(0.028)	(0.025)	(0.049)	(0.047)
β1		-0.187***		-0.132**		-0.099**		-0.116***		-0.136***
		(0.062)		(0.050)		(0.048)		(0.034)		(0.049)
β2		0.003		-0.003		-0.042		0.027		-0.005
		(0.057)		(0.047)		(0.047)		(0.035)		(0.048)
β0 + β1 + β2		-0.244		-0.206		-0.236		-0.112		-0.218
α									-0.069	0.000
									(0.080)	0.082)
Obs.	50	48	51	49	51	49	50	47	50	48
R^2 adjusted	0.131	0.249	0.139	0.232	0.125	0.207	0.042	0.190	0.130	0.230
RMSE	0.005	0.004	0.005	0.004	0.005	0.004	0.001	0.001	0.506	0.446
Durbin-Watson (original)	1.711	1.624	0.481	0.420	0.536	0.500	2.164	2.031	1.711	1.582
Durbin-Watson (transformed)			1.647	1.462	1.693	1.572				

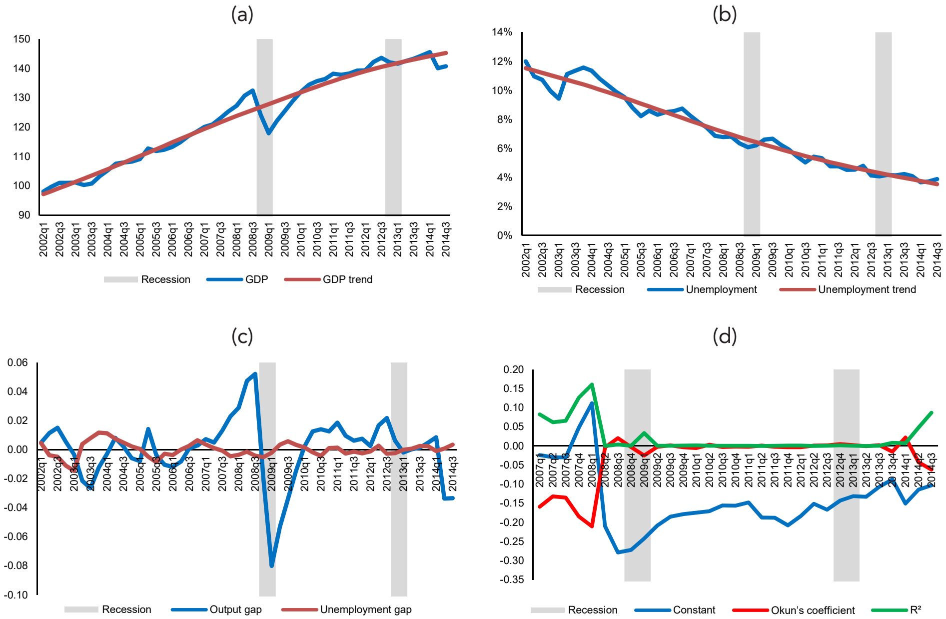
Note: Standard errors in parentheses. ***, ** and * indicate statistical significance levels of 1, 5 and 10 percent, respectively. The regressions showing transformed Durbin-Watson were estimated by the Cochrane-Orcutt method.

Source: Elaborated by the authors based on the research results.

In the metropolitan area of Belo Horizonte, the Okun's coefficients were not statistically significant in any of the estimates of the levels and differences versions. However, evidence shows that the performance of economic activity influences the subsequent quarter of the labor market in dynamic models. Specifically in this case, one can say that the law is valid, as can be seen in Figure 3 and Table 5 below.

Figure 3

GDP, Unemployment, Gaps and Okun's coefficient–Metropolitan Area of Belo Horizonte, 2002q1-2014q3



Notes: (a) GDP Index (2002 mean = 100), trend using HP filter λ = 1.600.

(b) Unemployment Rate, trend using HP filter λ = 1.600.

(c) GDP and unemployment rate lags using HP filter λ = 1.600.

(d) *Rolling regression*, based on a 20 quarters period and on differences version of Okun's Law. The choice of 20 quarters occurred mainly due to the size of the series. Aiming to capture cyclical variations in the regression coefficients in a faster way, Chamberlin (2011) also opted for a 20 quarters period.

Source: Elaborated by the authors, based on IBGE, on Joao Pinheiro Foundation seasonally adjusted data and on the research results.

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Table 5

Okun's Law Estimates – Metropolitan Area of Belo Horizonte (2002q1-2014q3)

	Levels Equation								Differences Equation	
	Linear Trend		Quadratic Trend		Hodrick-Prescott Filter		Beveridge-Nelson Decomposition			
$\beta0$	-0.032	0.002*	-0.038	-0.019	-0.055	-0.005	-0.002	-0.003	-0.032	-0.018
	(0.033)	(0.032)	(0.032)	(0.034)	(0.041)	(0.045)	0.014	(0.012)	(0.034)	(0.034)
$\beta1$		-0.149***		-0.074**		-0.100*		-0.076***		-0.074**
		(0.051)		(0.036)		(0.052)		(0.026)		(0.035)
$\beta2$		-0.056		-0.054		-0.063		-0.013		-0.050
		(0.049)		(0.036)		(0.047)		(0.027)		(0.037)
$\beta0 + \beta1 + \beta2$		-0.203		-0.147		-0.167		-0.093		-0.141
α									-0.138**	-0.035
									(0.066)	(0.069)
Obs.	50	48	51	49	51	49	50	48	50	48
R^2 ajustado	-0.002	0.191	0.007	0.181	0.016	0.203	-0.020	0.137	-0.002	0.144
RMSE	0.004	0.191	0.004	0.003	0.005	0.005	0.001	0.001	0.429	0.388
Durbin-Watson (original)	1.674	2.001	0.708	0.710	1.242	1.391	2.025	2.407	1.570	1.920
Durbin-Watson (transformado)			1.556	1.669	1.977	2.086				

Note: standard errors in parentheses. ***, ** and * indicate statistical significance levels of 1, 5 and 10 percent, respectively. The regressions showing transformed Durbin-Watson were estimated by the Cochrane-Orcutt method.

Source: Elaborated by the authors based on the research results.

On the other hand, in the MA of Porto Alegre, coefficients of all models are not statistically different from zero, which indicates that there is no evidence that unemployment is sensitive to changes in the product and that a cyclical recovery is not accompanied by a reduction in unemployment.

To Christopoulos (2004) this situation may show a strong structural unemployment component. The author points out that it is difficult to explain the reasons why Okun's Law holds true for some regions and not for others, but suggests that distinct characteristics of each local labor market could, in part, explain this situation. Figure 4 and Table 6 present the results related to the MAPA:

Figure 4

GDP, Unemployment, Gaps and Okun's coefficient–Metropolitan Area of Porto Alegre, 2002q1-2014q3

Notes: (a) GDP Index (2002 mean = 100), trend using HP filter λ = 1.600.
(b) Unemployment Rate, trend using HP filter λ = 1.600.
(c) GDP and unemployment rate lags using HP filter λ = 1.600.
(d) *Rolling regression*, based on a 20 quarters period and on differences version of Okun's Law. The choice of 20 quarters occurred mainly due to the size of the series. Aiming to capture cyclical variations in the regression coefficients in a faster way, Chamberlin (2011) also opted for a 20 quarters period.

Source: Elaborated by the authors, based on IBGE, on FEE/CIE/Department of Regional Accounts seasonally adjusted data and on the research results.

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Table 6

Okun's Law Estimates – Metropolitan Area of Porto Alegre (2002q1-2014q3)

	Levels Equation								Differences Equation	
	Linear Trend		Quadratic Trend		Hodrick-Prescott Filter		Beveridge-Nelson Decomposition			
β0	-0.026	-0.027	-0.028	-0.029	-0.023	-0.022	0.003	0.005	-0.027	-0.026
	(0.023)	(0.025)	(0.023)	(0.025)	(0.023)	(0.024)	(0.003)	(0.003)	(0.021)	(0.023)
β1		-0.010		-0.012		-0.006		-0.006		-0.004
		(0.024)		(0.025)		(0.024)		(0.005)		(0.024)
β2		-0.016		-0.017		-0.014		-0.007		-0.014
		(0.024)		(0.024)		(0.023)		(0.005)		(0.022)
β0 + β1 + β2		-0.053		-0.058		-0.042		-0.008		-0.044
α									-0.090	-0.043
									(0.070)	(0.077)
Obs.	51	49	51	49	51	49	49	47	50	48
R^2 ajustado	0.005	-0.031	0.011	-0.027	0.001	-0.042	-0.007	0.062	0.011	-0.032
RMSE	0.004	0.004	0.004	0.004	0.004	0.004	0.000	0.000	0.483	0.471
Durbin-Watson (original)	0.688	0.707	0.685	0.719	0.861	0.871	1.767	1.912	1.555	1.672
Durbin-Watson (transformado)	1.443	1.495	1.448	1.512	1.494	1.543				

Note: standard errors in parentheses. ***, ** and * indicate statistical significance levels of 1, 5 and 10 percent, respectively. The regressions showing transformed Durbin-Watson were estimated by the Cochrane-Orcutt method.

Source: Elaborated by the authors based on the research results.

On the existence of different Okun's coefficients, which are possibly related to specific regional idiosyncrasies (MARIE-ESTELLE; FACCHINI, 2013) or to regional disparities in productivity growth (VILLAVERDE; MAZA, 2009), some authors suggest a number of measures to reduce unemployment as well as regional disparities in employment. From a Keynesian point of view, Christopoulos (2004) suggests the adoption of demand management policies in order to reduce the unemployment level in regions where the law is observed; and employment subsidy or funding of local infrastructure in areas where the law is not valid.

From a neoclassical perspective, Apergis and Rezitis (2003) recommend policies that emphasize deregulation of certain economic branches, especially in the labor market, which could increase the overall productivity and reduce unemployment in all regions, especially those where the unemployment is more insensitive to changes in production; while Villaverde and Maza (2009) cite that to complement and expand the flexibility of labor, policies should be adopted to increase the interregional mobility for those areas where the law has not been validated.

In this context, Marie-Estelle and Facchini (2013) argue that the existence of different Okun's coefficients in the same country suggest the adoption of reducing unemployment policies that take into account the specificities of each region.

Considering Brazil as a whole, the expansion of government programs – such as the Program University for All (PROUNI), the Student Financing Fund (FIES), the National Program for Access to Technical Education and Employment (PRONATEC) – and the expansion of the federal education system, may be related to the behavior of Okun's Law, because study and work can be seen as a trade-off for many young people who decide to postpone their entry into the labor market in search of education and qualification, a fact that reduces the labor force and hence the unemployment rate in the short term.

6 CONCLUSION

This study estimated the Okun's coefficients for Brazil and three of its metropolitan areas using quarterly data from 2002q1 to 2014q3. The differences version, and two gap dynamic versions of the specifications were used, the cyclic components were obtained by Hodrick-Prescott with two smoothing filter parameters for the linear trend, quadratic trend, and through Beveridge-Nelson decomposition.

In summary, results show that Okun's Law occurs in Brazil and one of the three metropolitan regions studied and that there are regional differences in the responsiveness of labor markets to output fluctuations and deviations from their long-term levels. The labor market of the Metropolitan Area of São Paulo responds proportionately more intensively to the product variations compared to the other two metropolitan areas.

In the Metropolitan Area of Belo Horizonte, the Okun's coefficients were not statistically significant, except for the fact that economic activity influences the labor market in the subsequent quarter. Regarding to the Metropolitan Area of Porto Alegre, there is no evidence that Okun's Law is valid.

Regional different coefficients imply, according to the literature, the need to implement employment policies observing not only the regional disparities in the labor market, but also the response of these changes in economic activity at each location.

In the regional aspect, a further suggestion is to check why unemployment responds different to product variations, taking into account that the sector composition of these economies is a relevant aspect in this process, especially for having sectors more labor intensive than others. Another hypothesis is that due to different levels of productivity, possibly the most industrialized Brazilian regions have a larger product, but the labor market there have a reduced response to variations in production which generates distinct regional variations in the unemployment rate.

Another possible offshoot of this study is to analyze if there is asymmetry in Okun's Law in Brazil in order to identify if unemployment responds more strongly to output growth than in its downturn, which may be related to some rigidity in the Brazilian labor market, owing to institutional restrictions on firing workers.

INVESTIGANDO A LEI DE OKUN NO BRASIL E TRÊS DE SUAS ÁREAS METROPOLITANAS

Resumo

A Lei de Okun tem sido frequentemente abordada em estudos macroeconômicos em todo o mundo, principalmente em nível nacional, mas poucos estudos estimam essa relação em nível regional. Este trabalho, utilizando dados trimestrais de 2002q1 a 2014q3, tem por objetivo estimar os coeficientes de Okun para o Brasil e para as áreas metropolitanas de Belo Horizonte, Porto Alegre e São Paulo, utilizando a versão de diferenças, a versão *gap* e duas especificações da versão dinâmica da Lei. Os componentes cíclicos foram obtidos pelo filtro HP, a tendência linear, tendência quadrática e por meio da decomposição de Beveridge-Nelson. Os resultados mostram que a Lei de Okun é válida para o Brasil como um todo e para uma das três regiões metropolitanas estudadas, que há diferenças regionais na capacidade de resposta dos mercados de trabalho às flutuações de produção e desvios de seus níveis de longo prazo.

Palavras-chave: Lei de Okun; Séries de tempo; Áreas Metropolitanas do Brasil.

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APPENDIX

Table A1

Testing of the series stationarity

Variable	ADF	PP	KPSS	Result
$(Y - Y^*)$, Linear trend, Brazil	-1.942	-1.614	0.254***	Non-stationary
$(U - U^*)$, Linear trend, Brazil	-4.158***	-2.992**	0.063	Stationary
$(Y - Y^*)$, Linear trend, RABH	-2.132	-2.240	0.21**	Non-stationary
$(U - U^*)$, Linear trend, RABH	-3.217**	-3.078**	0.139*	Stationary
$(Y - Y^*)$, Linear trend, RAPA	-3.768***	-4.367***	0.134*	Stationary
$(U - U^*)$, Linear trend, RAPA	-2.766*	-2.780*	0.109	Stationary
$(Y - Y^*)$, Linear trend, RASP	-1.566	-1.309	0.239***	Non-stationary
$(U - U^*)$, Linear trend, RASP	-3.691***	-2.876**	0.050	Stationary
$(Y - Y^*)$, Quadratictrend, Brazil	-3.731***	-2.795*	0.105	Stationary
$(U - U^*)$, Quadratictrend, Brazil	-3.342**	-2.969**	0.051	Stationary
$(Y - Y^*)$, Quadratictrend, RABH	-3.605***	-3.196**	0.050	Stationary
$(U - U^*)$, Quadratictrend, RABH	-4.577***	-3.181**	0.054	Stationary
$(Y - Y^*)$, Quadratictrend, RAPA	-3.811***	-4.668***	0.073	Stationary
$(U - U^*)$, Quadratictrend, RAPA	-2.816*	-2.797*	0.109	Stationary
$(Y - Y^*)$, Quadratictrend, RASP	-3.028**	-2.621*	0.124*	Stationary
$(U - U^*)$, Quadratictrend, RASP	-4.073***	-2.938**	0.039	Stationary
$(Y - Y^*)$, HP Filterl=1.600, Brazil	-4.370***	-3.134**	0.058	Stationary
$(U - U^*)$, HP Filterl=1.600, Brazil	-3.761***	-3.228**	0.037	Stationary
$(Y - Y^*)$, HP Filterl=1.600, RABH	-3.816***	-3.339**	0.044	Stationary
$(U - U^*)$, HP Filterl=1.600, RABH	-3.740***	-4.511***	0.044	Stationary
$(Y - Y^*)$, HP Filterl=1.600, RAPA	-4.090***	-5.008***	0.048	Stationary
$(U - U^*)$, HP Filterl=1.600, RAPA	-3.350**	-3.422**	0.056	Stationary
$(Y - Y^*)$, HP Filterl=1.600, RASP	-4.304***	-3.052**	0.069	Stationary
$(U - U^*)$, HP Filterl=1.600, RASP	-4.112***	-2.979**	0.036	Stationary
$(Y - Y^*)$, BNFilter, Brazil	-5.121***	-5.121***	0.085	Stationary
$(U - U^*)$, BNFilter, Brazil	-4.750***	-11.291***	0.062	Stationary

(continua)

Table A1

Testing of the series stationarity (*conclusão*)

Variable	ADF	PP	KPSS	Result
(Y – Y*), BNFilter, RABH	-7.369***	-7.369***	0.025	Stationary
(U – U*), BNFilter, RABH	-7.491***	-7.491***	0.028	Stationary
(Y – Y*), BNFilter, RAPA	-8.824***	-8.824***	0.027	Stationary
(U – U*), BNFilter, RAPA	-6.496***	-6.496***	0.077	Stationary
(Y – Y*), BNFilter, RASP	-7.138***	-7.138***	0.086	Stationary
(U – U*), BNFilter, RASP	-7.584***	-7.584***	0.036	Stationary
ΔY_t, Brazil	-4.273***	-5.176***	0.066	Stationary
ΔU_t, Brazil	-4.857***	-5.981***	0.036	Stationary
ΔY_t, RABH	-4.391***	-5.086***	0.043	Stationary
ΔU_t, RABH	-6.218***	-6.218***	0.034	Stationary
ΔY_t, RAPA	-9.513***	-9.513***	0.020	Stationary
ΔU_t, RAPA	-5.963***	-5.963***	0.063	Stationary
ΔY_t, RASP	-4.262***	-4.794***	0.112	Stationary
ΔU_t, RASP	-3.830***	-6.042***	0.040	Stationary

Note: The null hypothesis of the ADF and PP tests is the unit root, whereas the null hypothesis of KPSS test is that there is no unit root. P-value of the ADF and PP tests based on MacKinnon (1996), and p-value of KPSS-based testing Kwiatkowski et al. (1992).
***, ** and * indicate statistical significance levels of 1, 5 and 10 percent, respectively.

Source: Research results.