Okun's law and labor productivity in Brazil♠

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Resumo: este trabalho analisa evolução do emprego e desemprego no Brasil, com foco nos anos recentes (após 2010). Estimamos a elasticidade do PIB em relação ao emprego (variante do coeficiente de Okun) utilizando diversas bases de dados e metodologias. Os resultados indicam que o coeficiente encontrado no Brasil é próximo dos obtidos por outros autores analisando outros países. A utilização de dados desagregados para o PIB não altera os resultados de forma significante. O coeficiente de Okun diminuiu levemente nos últimos anos no Brasil, principalmente a partir de 2011. As horas trabalhadas apresentam pouca volatilidade no Brasil e o ajuste no emprego ao longo do ciclo econômico ocorre principalmente pelo ajuste no número de trabalhadores. A criação elevada de emprego nos últimos anos e o baixo crescimento do PIB representam uma redução da produtividade do trabalho. Esta redução é mais aguda quando se considera a evolução das horas trabalhadas.

Abstract: this paper analyses the evolution of employment and unemployment in Brazil, particularly in the recent years (after 2010) using the Okun's laws and some variations of it. Our results indicate that the Okun coefficient in Brazil is similar to other countries. Using disaggregated data does not lead to an improvement in the model compared to using aggregated data. The Okun's coefficient diminished slightly in the last years, particularly after 2011. Average workweek hours presents low cyclicality in Brazil and the labor market adjustment over the business cycle based mostly on the adjustment of the number of employed workers. The high number of jobs created over the last years together with weak GDP growth lead decreasing labor productivity growth. This deceleration in labor productivity growth is clearer when the average workweek per worker is introduced in the analysis.

JEL Classification: J0; J2; J3; J64

Palavras-chaves: desemprego; regra de Okun, produtividade

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1 Introduction

GDP growth between 2011 and 2014 was lower than 2% per year on average. Despite this dismal growth rate, unemployment reached record low levels. This fact is associated with two related puzzles in Brazilian labor markets: a) why has unemployment been so much lower despite this low GDP growth and b) why employment growth did not fall despite this low GDP growth.

The first part of the puzzle is related to the sharp fall in participation rates in Brazil over the last years and also related to lower population growth. This topic received a lot of attention in the press and will not be discussed in detail here. We will briefly discuss the reduction in participation rates in the next section. Santos (2013) discusses this part of the puzzle in more details.

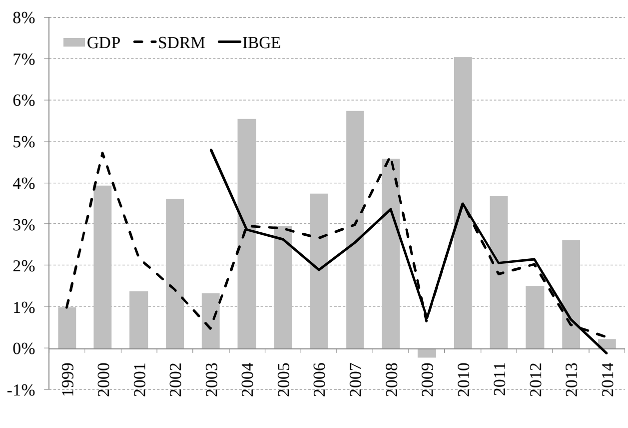
The second part of the puzzle refers to the connection between employment growth and GDP growth. Lower participation rates explain most of the recent reduction in unemployment rate. However, unusually high employment growth relative to GDP growth has been mentioned as an explanation for lower unemployment rate in Brazil recently.

Several explanations arose for this apparent distortion in the "GDP-Employment" relation. The most prominent explanation was the greater importance of the service sector in the economy. Services are more labor intensive than industry or agriculture. As GDP grew mostly because of the growth in the services sector, employment creation was stronger than predicted by the aggregate GDP. Looking at GDP disaggregated by sectors would undo this apparent puzzle in Brazilian labor statistics.

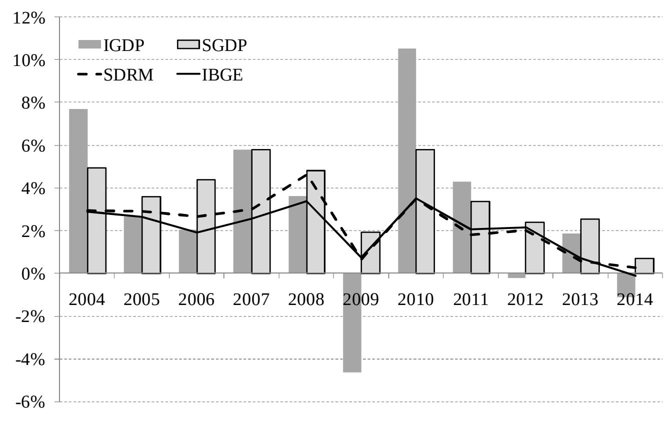
A more detailed analysis of employment and GDP data (figures 1 and 2) shows that there was no puzzle in the employment-GDP relation in the last four years. Job creation was high compared to GDP growth in 2012 but this was reversed in 2013. Figure 1a presents the evolution of GDP and employment growth in Brazil over the last years. It is clear that employment growth tracks GDP growth. However, the apparent puzzle of strong employment growth and weak GDP growth in 2012 will probably disappear in 2013 and 2014.

Fig. 1: GDP growth and employment growth

1A: GDP Growth and employment growth



1B: GDP Growth and employment growth by sector



Source: IBGE, Dieese/Seade. GDP is the quarterly GDP growth rate. SDRM and IBGE are the quarterly growth rate of employment measured by Dieese/Seade and IBGE respectively. IGDP and SGDP are the quarterly growth rate of GDP in the industrial and services sector respectively.

The smaller deceleration in employment growth in recent years has several explanations including the small volatility of employment (the deceleration is slower than in GDP), the importance of expectations, among other factors.

In this paper we estimate the Okun's coefficient for Brazil to discuss the joint evolution of GDP and employment and unemployment. We start with aggregate data and then apply time-varying techniques to investigate possible time variation in the relation between employment and GDP. We also estimate the coefficient using disaggregated GDP growth to evaluate the impact of services GDP in 2012 employment.

Our results indicate that the time-variation in the Okun's coefficient was small and disaggregated data is not a good explanation for recent employment dynamics. The explanatory power of the disaggregated model is not statistically different from the model with only aggregated data. Our results do not support the thesis relating strong employment growth with the increasing share of services in GDP: the employment-GDP elasticity in the industrial and services sectors are very close to each other.

Our results indicate that the Okun's law is a good framework to forecast job creation in Brazil. However, the strong relationship between job creation and GDP growth diminished in the last two to three years. Using GDP disaggregated between services and industrial activities does not lead to an improvement in our results. Using aggregate hours instead of only aggregate employment leads to a slightly higher employment-GDP elasticity. This is explained by the reduction in the average workweek in Brazil over the last 15 years. According to Dieese, the average workweek decreased from ~44 hours in the late 90's to ~41 hours currently.

In the final part of the paper we investigate labor productivity in Brazil over the last years using both the "old" and the current (or "new") GDP methodology. As A. Okun noted in his seminal work, a strong relation between unemployment and GDP could be associated with low labor productivity growth: a coefficient close to 1 in the Okun's law would indicate that GDP growth is being caused only by higher employment level without any increase in labor productivity. A coefficient lower than one indicates that at least part of the GDP growth is associated with higher labor productivity. We use this simple extension of Okun's analysis to study labor productivity in Brazil. Our results indicate that labor productivity growth moved from negative in the late 90's to positive in the early 2000's. However, productivity growth is decelerating since 2006 and the average productivity growth rate in the last four years is only half of the productivity growth seen in the last decade.

2 Data overview

We discuss the evolution of employment in Brazil using mainly Dieese/Seade data. Dieese/Seade data goes back to 1998 (or earlier depending on the survey) and is more useful to track possible changes in the parameters we are interested to estimate. This data is also similar to the more conventional measure of unemployment provided by IBGE. We also use data from IBGE in some estimation. Finally we use data from Caged as another source of information regarding labor market conditions in Brazil.

The main statistics for labor force and GDP are presented in figure 2. We present summary statistics and cross-correlation for all seven main variables used in this empirical research. All data refers to the 1Q02 to 2Q13 period. This is the time span for which all data are available. In all cases, the summary statistics refers to the quarterly growth rate of each variable.

Cross-correlation is high in all cases. The mean growth rate is positive in all cases and volatility is higher in GDP, particularly industry GDP (IGDP). Means and medians are close to zero for all demeaned variables as expected.

We will base most of our estimations on growth rates and STM cycles. Growth rates is the most straightforward method to look at these variables and STM cycle produces the most correlated series. We will use Dieese/Seade data most of the time since we have a longer span for this data and this will important considering we are most interested in capturing possible changes in the relation between GDP and employment.

Table 1: Summary statistics of variables

A. Summary statistics

	GDP	IGDP	SGDP	AGDP	SDRM	IBGE	HOURS
Mean	0.9%	0.8%	0.9%	0.9%	0.5%	0.6%	-0.1%
Median	1.1%	1.0%	0.9%	1.2%	0.5%	0.5%	-0.2%
Std Dev	0.9%	1.8%	0.6%	2.8%	0.6%	0.6%	1.0%
Autocorr.	0.53	0.46	0.56	0.03	0.25	0.13	-0.49

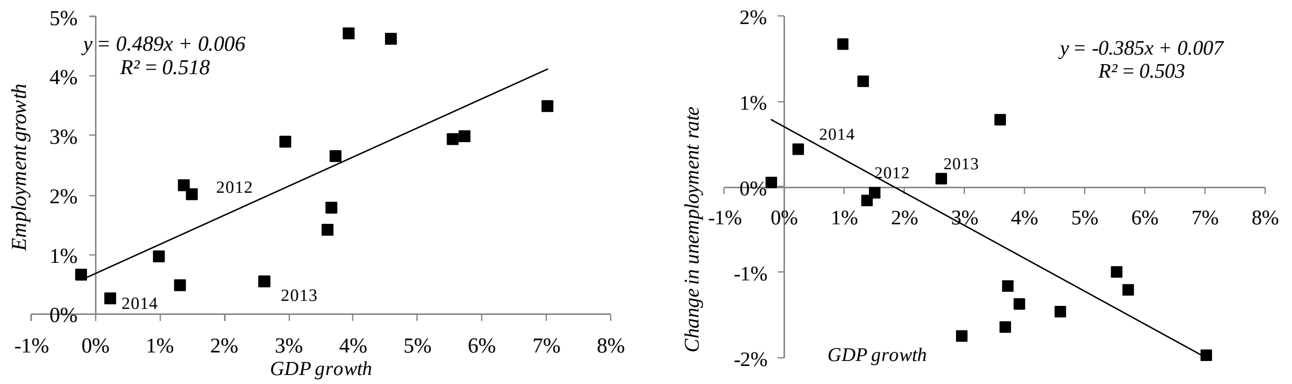
B. Cross correlations

	GDP	IGDP	SGDP	AGDP	SDRM	IBGE	HOURS
GDP	1.00						
IGDP	0.91	1.00					
SGDP	0.91	0.76	1.00				
AGDP	0.32	0.26	0.17	1.00			
SDRM	0.57	0.52	0.58	0.06	1.00		
IBGE	0.41	0.42	0.30	0.15	0.39	1.00	
HOURS	0.25	0.37	0.18	0.08	0.09	0.14	1.00

Source: author calculation.

Figure 2: Employment and unemployment vs GDP growth

Change in unemployment rate x GDP growth *Employment growth x GDP growth*



Source: IBGE, Dieese/Seade

Employment growth was strong between 2004 and 2011 when it averaged more than 2%. It was weaker earlier (1999 to 2003) and also weaker in the last two years (2012 and 2013). Other important aspects of employment growth not captured in figure 1 and table 1 are the difference in employment trends among different workers groups and sector of the economy.

Employment growth was stronger among services than in industries. This is illustrated in fig. 2. As we mentioned before, the higher share of jobs being generated in the services activities is often associated with the higher growth of GDP from services and also associated with higher Okun's coefficient and lower productivity. Another important aspect of job creation is the last years were the increase in job creation in construction activity.

Labor force growth decreased from more than 3% in the late 90`s to around 1% over the last two to three years. This has important implication for unemployment rate: assuming the elasticity of employment to GDP is 1/3 (this is a good approximation as we will show in the next section), GDP growth necessary to keep unemployment constant decreased from 9% in the late 90`s to 3% currently. Santos (2013) make the same observation using a different analysis: according to Santos (2013), if labor force growth after 2004 kept the same pace observed from 1999 to 2003, unemployment rate would probably not decreased. It means a good portion of the reduction in unemployment rate over the last 8 to 9 years is related to the slowdown in labor force growth.

The slowdown in labor force growth has at least two explanations: a) lower growth of working age population and b) stabilization in participation rates. The working age population evolutes according to fertility rate 14 to 18 year earlier, mortality rate for elderly people, among other factors. In this aspect, the reduction in fertility rate since the early 90`s is the most important factor. Participation rates increased worldwide in the 80`s and 90`s due to increased female participation rates. This effected faded in 2000`s as female participation rates reached a plateau. Another important change in participation rates in Brazil was the increase in participation rates of workers aged 50 or older and the reduction of youth participation rates. For the next years, the participation rate will probably decrease as the fraction of older workers in the labor force increases. It is important to mention that at some point in the next years, retirement rules will probably change, increasing the aggregate participation rate.

These changes in the growth pattern of labor force has a clear impact on the estimated coefficient from the Okun`s law. Okun (1962) noted this possibility in his work. Due to this impact of labor force on unemployment we will rely mostly on a modified version of the Okun`s law using employment growth instead of unemployment rate changes in our estimations.

3 Okun’s law

3.1 Introduction

The Okun`s law relates unemployment to GDP. In its original work, Okun (1962) proposed several simple models to estimate the relation between unemployment and GDP. The models included the estimation using growth rates and also deviations from trends. In most of his estimations, he reached coefficients between -0.3 and -0.4: an increase in GDP of 1% is associated with a reduction in unemployment between 0.3 to 0.4 percentage points. Several authors estimated this relation using the same methods or variations of the methods proposed by Okun (1962). These include IMF (2009) among others. Santos (2013) estimated a different version based on employment growth rates instead of unemployment using brazilian data. The main argument for using employment instead of unemployment in growth equation is related to possible time variations in labor force growth. Labor force growth is probably unrelated to the business cycle but affect unemployment rate and consequently can distort the estimated impact of GDP growth on unemployment rates.

In this section we update the coefficients estimated by Santos (2013) and discuss two possible variations on the Okun's coefficient: a) time-varying parameters and b) sector-specific parameters.

The Okun`s law can be written as:

$$u_t - u_{t-1} = a + b\tilde{y}_t + \varepsilon_t \quad (1)$$

where u_t is the unemployment rate and $\tilde{y}_t$ is the growth rate of GDP (or deviation of GDP from a trend).

We estimate this equation using 1 lag of both unemployment rate and GDP growth using quarterly data. The estimated equation can be written as:

$$\Delta u_t = a + \phi \Delta u_{t-1} + b_1 \tilde{y}_t + b_1 \tilde{y}_{t-1} + \varepsilon_t \quad (1')$$

The estimation result is:

$$\Delta u_t = \underset{(0.0004)}{0.0008} + \underset{(0.09)}{0.39}\,\Delta u_{t-1} - \underset{(0.03)}{0.05}\,\tilde{y}_t - \underset{(0.03)}{0.17}\,\tilde{y}_{t-1} + \varepsilon_t \quad (1'')$$

$$\sigma_\varepsilon = 0.003, \quad R^2 = 0.59, \quad DW = 2.27, \quad \Omega = -0.36$$

The long-term impact[2] by (1") is Ω = -0.36, similar to what Ball, Leigh and Loungani (2013) find for US and other countries using a similar methodology. Okun (1962) find a similar value for US.

As discussed previously, the unemployment rate can be affect by changes in the growth rate of population causing distortions on the coefficients of (1). For this reason we will rely mostly on a different version of (1) by replacing the unemployment rate by the employment:

$$\tilde{e}_t = \alpha + \beta \tilde{y}_t + \varepsilon_t \quad (2)$$

where $\tilde{e}_t$ is the growth rate of employment (or deviation of employment from a trend).

We include one lag of employment and one lag of GDP to the equation to incorporate further dynamics into the model:

$$\tilde{e}_t = \alpha + \phi \tilde{e}_{t-1} + \beta_1 \tilde{y}_t + \beta_2 \tilde{y}_{t-1} + \varepsilon_t \quad (2')$$

Results are presented in Table 2. We estimate (2') using data from both IBGE (1Q02 to 3Q13) and Dieese/Seade (2Q98 to 3Q13). We present the results found with quarterly growth rates and using the cycle component from the *Structural Time Series* model. The results are presented in table 2.

The estimation results indicate that the GDP growth is significant in the employment equation as expected and most coefficients are significant at the 5% level. The long-term impact is higher when we use Dieese data. The model adequacy as measured by the adjusted R^2 is also higher when Dieese employment data is employed. The coefficients are close to those presented in Santos (2013).

The long-run coefficient (Ω) is significant at the 5% level in all specifications. The explanatory power of the model is not big when we use "growth rates" for both dependent and explanatory variables. However, this model generates residuals that are close to white noise. Using the cyclical component of employment as the

[2] *In dynamic model of the form $y_t = A(L)y_{t-1} + B(L)x_t$, the long-term impact is given by $\Omega = (1 - A(L)) / B(L)$.*
In (2'): $\Omega = (1-\phi) / (\beta_1 + \beta_2)$

dependent variable and the cyclical component of GDP as the explanatory variable increases the fit of the model as measured by the R^2. However, in this case residuals are autocorrelated. Independent of the transformation used, the estimated long-run impact of GDP on employment is ~0.4x when Dieese/Seade data is used and ~0.3x when IBGE data is used in the estimations. In the next sub-section we discuss two different aspects of this relation: a) is there any difference in the employment-GDP relation for different sectors?, b) how this employment-GDP relation changed over time?

Table 2: Employment elasticity to GDP

Employment variable:	SDRM	IBGE	SDRM	IBGE
Transformation:	Growth	Growth	Cycle	Cycle
	Coef.	Coef.	Coef.	Coef.
α	0,0022 **	0,0042 ***	-0,0001	0,0001
	(0,0009)	(0,0013)	(0,0003)	(0,0003)
ϕ	0,0549	0,0712	0,7057 ***	0,6089 ***
	(0,1125)	(0,1246)	(0,0778)	(0,1044)
β_1	0,1861 ***	0,0344	0,1365 ***	0,0772 ***
	(0,0535)	(0,0652)	(0,0258)	(0,0307)
β_2	0,2093 ***	0,2506 ***	-0,0029	0,0411 **
	(0,0568)	(0,0664)	(0,0318)	(0,0349)
Ω	**0,4184** ***	**0,3068** **	**0,4540** ***	**0,3025** ***
	(0,0788)	(0,0887)	(0,0355)	(0,0433)
σ_ε	0,0048	0,0054	0,0017	0,0019
R^2 adj.	0,3380	0,1345	0,8412	0,6842
DW	2,1020	2,1540	1,3462	0,81

Standard errors in parenthesis; robust standard errors computed using Andrew's method
, **, *: significant at 10%, 5% and 1% respectively*

3.2 Time-varying parameters

Changing composition of GDP among sectors, technological progress and other factors may have caused changes in the Okun's coefficient. Some authors like Ball et al (2013) and Gali et al (2011) include a dummy variable for recent periods to address this possibility. We use instead a time-varying coefficient approach.

We estimate the model using two quarters average GDP growth. Estimating two parameters like in (2) is problematic because it would be difficult to make inference about changes in the elasticity of employment to GDP.

$$\tilde{e}_t = \alpha + \phi \tilde{e}_{t-1} + \beta_t (\tilde{y}_t + \tilde{y}_{t-1}) / 2 + \varepsilon_t \qquad (3)$$

We also estimate the traditional Okun's relation using time-varying parameters:

$$u_t = a + \phi u_{t-1} + \chi_t(\tilde{e}_t + \tilde{e}_{t-1})/2 + \varepsilon_t \qquad (3')$$

To estimate β_t and χ_t, we modeled (3) and (3') as state-equations and assumed a random-walk transition equation for both β_t and χ_t. The resulting model can be estimated using the Kalman filter technique.

The estimation result of (3) and (3') are presented in figures 6A and 6B: the elasticity of employment to GDP decreased moderately after 2008. It is not clear what could have caused the change in this parameter during this period. One possible explanation is that firms fired less workers than usual during the crisis and consequently hired less during the "boom" years that followed. Another possible explanation would be changes in the methodology used to construct the series but we are not aware of any change in data.

Fig.6A: Time-varying β

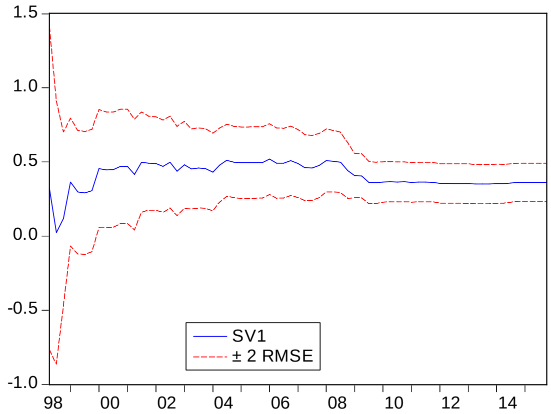
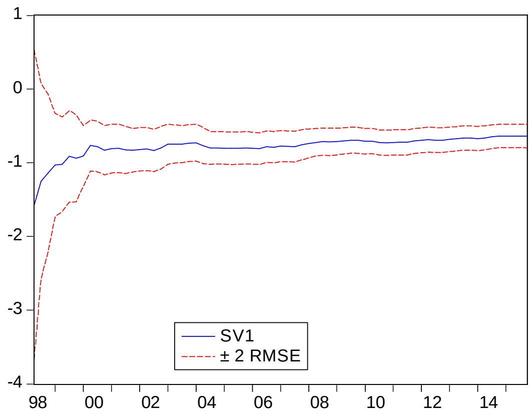


Fig.6A: Time-varying χ



Both charts present the filtered state and filtered state plus +/- two standard deviations.

3.3 Disaggregated parameters

A possible explanation for a time-varying parameter at the Okun's law is the reduction in the share of industry in GDP and the increase of services. Services are more labor intensive and its increasing importance on GDP could have caused an increase in the Okun's coefficient over time. In Brazil, the acceleration in employment growth in 2012 despite a severe slowdown in GDP growth was explained using this different impact of industry and services activities on employment.

$$\tilde{e}_t = \alpha + \phi\tilde{e}_{t-1} + \gamma_1\tilde{y}_{I,t} + \gamma_2\tilde{y}_{I,t-1} + \kappa_1\tilde{y}_{S,t} + \kappa_2\tilde{y}_{S,t-1} + \mu_1\tilde{y}_{A,t} + \mu_2\tilde{y}_{A,t-1} + \varepsilon_t \qquad (4)$$

Where I denotes the GDP from Industry, S denotes the GDP from Services and A denotes the GDP from Agriculture.

The estimation results are presented in equation (4'). We present only the static long-run solution to save space.

$$\tilde{e}_t = \underset{(0.001)}{0.002} + \underset{(0.065)}{0.125}\,\tilde{y}_I + \underset{(0.181)}{0.320}\,\tilde{y}_S - \underset{(0.027)}{0.012}\,\tilde{y}_A \qquad (4')$$

$$\sigma_\varepsilon = 0.0056, \quad R^2 = 0.31$$

Comparing the results from (4') and the first column in Table 2 we can draw some conclusions: a) model fit is worse using disaggregate data, b) the estimated employment-GDP elasticity are close in the estimations. The disaggregate model leads to higher residuals and lower R^2, indicating that disaggregated information about GDP does not help to solve the apparent puzzle relating weak GDP growth in the last four years and strong employment growth. Summing the employment-GDP elasticity of industry and services we reach a coefficient of 0.44, not much different from the 0.42 presented in Table 2 (first column; Dieese/Seade data from 1998 to 2014, same sample period used in (4')). The services sector in GDP is about 3x the size of the industrial sector: the services sector represents about 70% of GDP meanwhile the industrial sector represents about 22%. Using RAIS employment data, close to 20% of the workforce is employed in the industrial sector. All in all, there is some evidence that there is no sensible difference in the employment-GDP elasticity between the industrial and service sector.

Equation (4) disaggregates GDP by sector but do not disaggregate employment. There are two reason for this: a) the sectors used in measuring GDP do not exactly match those available for employment, b) disaggregate employment is not available in the Dieese/Seade data. Despite these difficulties, to dig deeper in this employment-GDP relation we estimate a simple model with both employment and GDP disaggregated by sector (services and industry) using employment data provided by IBGE according to this equation:

$$\tilde{e}_{i,t} = \alpha + \phi\tilde{e}_{i,t-1} + \gamma_1\tilde{y}_{i,t} + \gamma_2\tilde{y}_{i,t-1} + \varepsilon_t \qquad (5)$$

where $\tilde{e}_{i,t}$ stands for employment growth in services or industry and $\tilde{y}_{i,t}$ is the GDP growth in services or industry. We estimate this equation using data from 3Q02 to 4Q13. The estimation results for the industry sector is presented in equation (5I) and the estimation results for the service sector is presented in equation (5S).

The long-run impact of industry GDP on employment at the industry sector is 0.2, similar to what we estimated using more aggregated data. The individual coefficients are not significant in several cases.

$$\tilde{e}_{I,t} = 0.002 - 0.177\tilde{e}_{I,t-1} + 0.037\tilde{y}_{I,t} + 0.209\tilde{y}_{I,t-1} + \varepsilon_t \qquad (5I)$$
$$\sigma_\varepsilon = 0.014, \quad R^2 = 0.10, \quad DW = 2.06, \quad \Omega = 0.21$$

The long-run impact of services GDP on employment in the services sector is also close to 0.2. The main difference between (5I) and (5S) is that the constant coefficient on (5S) is significant at the 5% level and the constant on (5I) is not significant even at the 10%.

$$\tilde{e}_{S,t} = 0.006 - 0.164\tilde{e}_{S,t-1} - 0.032\tilde{y}_{S,t} + 0.231\tilde{y}_{S,t-1} + \varepsilon_t \qquad (5S)$$
$$\sigma_\varepsilon = 0.006, \quad R^2 = 0.07, \quad DW = 2.09, \quad \Omega = 0.17$$

The general conclusion from this section is that disaggregating employment or GDP does not improve our understanding of the employment-GDP relation over the business cycle. The difference in employment-GDP elasticity for different sector is not big and the model fit using disaggregate data is worse. In the next sector we analyze the relevance of productivity to the evolution of employment in Brazil.

4 Output per workers versus output per hour

In the previous sections we looked at the output-employment relation disregarding any possible cyclical variation in hours effectively worked. There is an ample literature on the cyclical nature of aggregated hours of work in US. However, this variable is not commonly mentioned in Brazilian research papers. The main reason may be the more rigid labor regulation in Brazil and tradition of monthly (instead of hourly) based salaries in Brazil. The regular workweek in Brazil has 40 hours (8 hours during the 5 business days) and in some cases it has 44 hours due to a half-day working period on Saturdays. In figure 7 we show the average workweek in Brazil using Dieese data. The average workweek decreased from about 43.5 hours in the late 90's to about 41.5 hours currently. This can be related to a smaller share of companies working half-day on Saturdays or to the increase in the number of part-time workers. A downward trend in hours per week is also present in IBGE's Monthly Employment Survey and other data sources such as PNAD (*Pesquisa Nacional por Amostra de Domicílio*)[3].

Figure 7B shows the evolution of workers and average hours per week during the 2008 financial crisis and during the recent (late 2014 to early 2015) slowdown in GDP growth. It can be seen that the average number of hours per worker decreased in both cases. To make a better assessment of the response of hours to GDP growth we will re-estimate the employment-GDP relation. Due to the reduction in average workweek over the last years we estimate the employment-GDP relation using aggregated hours instead of employment. We also estimate this relation separately for first and second half of our sample to look for indications of changing parameters.

Fig. 7A: Average workweek (hours) - Dieese

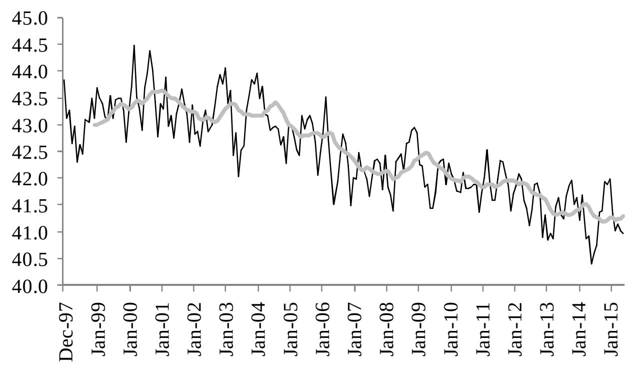
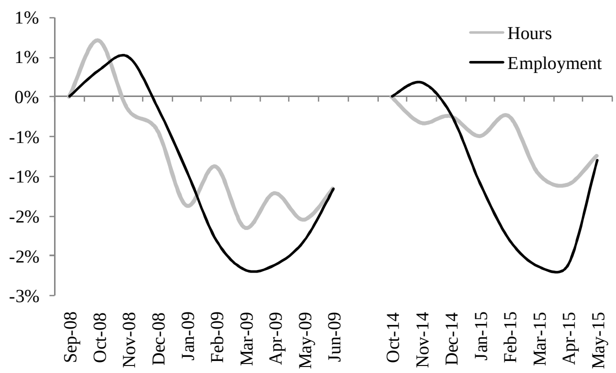


Fig. 7B: Hours and Employment in recessions



Source:Dieese/Seade. Data in figure 7B were seasonally adjusted using the X-12 procedure.

We analyze the impact of adjusting employment by the average workweek re-estimating equation 2 using aggregated hours instead of the number of hours. The aggregated hours variable was constructed using multiplying the total number of workers by the average weekly working hours. Both data were provided by Dieese/Seade. Denoting the growth rate of aggregated hours by h_t, we estimate the following equation:

$$h_t = \alpha + \phi h_{t-1} + \beta_1 \tilde{y}_t + \beta_2 \tilde{y}_{t-1} + \varepsilon_t \qquad (7)$$

[3] *Barbosa Filho and Pessoa (2013) discuss the evolution of hours in more detail.*

The estimation results are presented in equation (7'):

$$h_t = \underset{(0.002)}{0.002} - \underset{(0.114)}{0.435} h_{t-1} + \underset{(0.139)}{0.153} \tilde{y}_t + \underset{(0.139)}{0.519} \tilde{y}_{t-1} + \varepsilon_t \qquad (7')$$

$$\sigma = 0.012, \quad R^2 = 0.29, \quad DW = 2.15, \quad \Omega = 0.47$$

The estimated long term impact, Ω, is 0.47. This is only slightly higher than the 0.43 estimated using only employed workers (first column in table 2). Other relevant difference between this equation and the first column of table 2 is the lower fit of the "hours" model. This can be seen in the larger standard deviation of the error term and also in the lower R^2. In sum, using aggregate hours instead of employed workers does lead to an improvement in the explanatory power of the model.

Breaking down the sample in two parts does not lead to conclusive results. The estimated elasticity is higher in the first part of the sample but at the cost of lower model fit.

5 Labor productivity

This final section uses standard growth decomposition to discuss the evolution of labor productivity in Brazil in the last years. As we mentioned before, the Okun coefficient is closely related to labor productivity: a high coefficient indicates that a large number of workers (or hours) are required to produce more output. Consequently, labor productivity is low. On the other hand, a low coefficient may be associated with higher productivity.

We estimated the evolution of labor productivity in Brazil using the output identity described in Gordon (2010)[4]:

$$Y = \frac{Y}{H} \cdot \frac{H}{E} \cdot \frac{E}{L} \cdot \frac{L}{N} \cdot N \qquad (8)$$

where *Y/H* is the output per hour, *H/E* is the average workweek per employee, *E/L* is the employment rate and *L/F* is the participation rate.

Using lower case to denote growth rates we have:

$$y = (y-h) + (h-e) + (e-l) + (l-n) + n \qquad (9)$$

Equation (8) decomposes growth into output per hour (or labor productivity) and aggregated hours. The conventional wisdom (after Okun's seminal work) is that labor productivity accounts for 1/3 of output.

Table 3 presents the results of this decomposition since 1999. Our sample's first full year is 1998, so growth rates are available since 1999. We broke down the results in average growth rates for 4-years intervals. This is related to different governments in Brazil and also has the benefit of segregating the most recent years, when labor productivity apparently decreased (too much workers hired for a small increase in GDP growth).

In table 3A we present the decomposition results up to 2013 using the "old" GDP methodology. In table 3B we present data up to 2014 using the current (changed in early 2015) GDP data. The current GDP data is

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[4] *Bonelli and Fontes (2013) present a similar decomposition of GDP growth in Brazil using a different data set than the one used in the present paper.*

higher than the old one and GDP growth was higher according to the revisited GDP data. However, this difference is not big enough and in both cases it is possible to see the reduction in labor productivity in Brazil.

Table 3A: Growth decomposition ("old" GDP methodology)

	Output	*Labor productivity*	*Hours per worker*	*Employment level*	*Participation rate*	*Labor force*
Period	**Y**	**Y / H**	**H / E**	**E / L**	**L / N**	**N**
1998 - 2002	**1,7%**	-0,2%	-0,1%	-0,5%	0,7%	1,8%
2003 - 2006	**3,5%**	1,7%	-0,5%	0,8%	-0,2%	1,6%
2007 - 2010	**4,6%**	1,9%	-0,3%	1,3%	0,0%	1,5%
2011 - 2013	**2,1%**	0,9%	-0,3%	0,6%	-0,3%	1,2%

Average growth rate during each period. Output data provided by IBGE and all other variables provided by Dieese. Note that the first period is composed of 5 years. All other periods are composed of 4 years that coincide with presidential mandates.

At least four important stylized facts can be described using table 3. The first one is the sharp labor force growth in the 1990's and early 2000's (last column in table 3). This period was marked by high and rising unemployment rate. Santos (2013) discusses this aspect of labor market in Brazil in more detail. Another stylized fact is the increase in employment level (*E/L*) over the last ten years. This fact is also studied by Santos (2013). The third stylized fact is the downward trend in average hours of work (*H/E*) we discussed in previous sections of this paper. The last stylized fact is the rise and fall of labor productivity (*Y/H*) in Brazil since the late 90's.

Table 3B: Growth decomposition ("current" GDP methodology)

	Output	*Labor productivity*	*Hours per worker*	*Employment level*	*Participation rate*	*Labor force*
Period	**Y**	**Y / H**	**H / E**	**E / L**	**L / N**	**N**
1998 - 2002	**1.7%**	0.1%	-0.1%	-0.6%	0.7%	1.8%
2003 - 2006	**3.5%**	1.8%	-0.5%	0.8%	-0.2%	1.6%
2007 - 2010	**4.6%**	1.9%	-0.3%	1.3%	0.0%	1.5%
2011 - 2014	**1.6%**	1.3%	-0.3%	0.4%	-0.4%	1.1%

Average growth rate during each period. Output data provided by IBGE and all other variables provided by Dieese. Note that the first period is composed of 5 years. All other periods are composed of 4 years that coincide with presidential mandates.

Table 3B shows the GDP growth decomposition using the most recent GDP data. There is only minor differences between 3A and 3B. The same trends observed in 3A are present in 3B. A possible refinement of this analysis would be to decompose the variables into trends and cycles. This could indicate if the recent slowdown in productivity is a new trend or just a cyclical slowdown. Finally, it is important to highlight the implication of our results to potential GDP growth. The last two columns in table 3 show that working age population is growing but the growth rate is slowing. This will probably not change in the future. The average workweek is decreasing. In this situation, it is becoming more important to achieve higher rates of labor productivity growth to sustain GDP growth. Without higher productivity, Brazil will hardly return to above 4% GDP growth in the coming years.

6 Conclusion

This paper estimates the Okun coefficient for Brazil using data from 1998 to 2013. Our results indicate that the Okun coefficient for Brazil is close to the ones observed in other countries. Using GDP disaggregated by sector does not improve the estimation results. On the opposite, using disaggregated GDP data result in a lot of not statistically significant parameters. Using both employment and GDP disaggregated by sector result in better model fit. However, the estimated coefficients are not supportive of the view relating strong job creation to hither Okun's coefficient in the service sector. All in all, our results indicate that the relation between GDP and job creation weakened in the last years, particularly the contemporaneous and short-term relation. Job creation was high relative to GDP growth in 2012 but low in 2013. Using the average growth rates of these variables between 2012 and 2014 eliminates the apparent puzzle of strong job market in a weak economy.

Using a time-varying parameter model to study the relation between job creation and GDP growth we find a reduction in the elasticity of job creation to GDP growth after 2010. However, it is not clear if this reduction is only an artifact of the weakening contemporaneous relation between these variables or a *de facto* reduction in this structural relation. This hypothesis is a direction for future research. The fact the reduction occurs at the end of our sample makes it particularly difficult to study using filtering tools such as the Kalman Filter / time-varying parameters model. A longer sample will probably help to solve this puzzle in the near future.

Adjusting the employment level by the average workweek does not lead to any clear improvement or difference in results. The elasticity of hours worked to GDP growth is similar to the elasticity of employment to GDP growth. The model fit is again lower in the end of our sample.

Finally, our results indicate that labor productivity decreased in Brazil over the last years. This is the strongest indication that elasticity of job creation to GDP have increased: due to lower labor productivity growth, more workers are need to produce a one percent GDP growth nowadays than ten years ago. The recent decline in labor productivity has a cyclical component but most of it comes from more permanent factors: labor productivity growth is declining since 2005 according to our estimation.

7 References

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