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CONVERGENCE OF WAGES OF BRAZILIAN AGRICULTURE WORKERS FROM 1992 TO 2009

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Abstract: The aim of this study is to examine differences of wages of temporary and permanent workers of the agricultural sector in the Brazilian states from 1992 to 2009. We used the spatial econometric models to verify the wage convergences in the states Brazilians (β absolute and conditional β and σ) and we used data from the National Survey of Household Sample. For β conditional convergences were used the average schooling and experience (capture the effects of human capital) of each segment of workers and power tractors (capture the effects of fixed capital). The exploratory analysis of spatial has revealed an inverse distribution between the growth rate of wages of permanent and temporary workers in the Brazilian states, that it show us how the forces of demand and supply local labor markets are important. The clusters of the temporary workers have similarity spatial data while the clusters of the permanent workers have dissimilarity for spatial growth rate of wages. The results revealed that existence of convergence absolute and conditional. The speed of conditional convergence is faster than absolute convergence both segments, also revealing that inequalities wages between states tend to decrease. The convergence σ shows a decrease in wage inequality by the fall in the dispersion of wage levels.

Key works: agricultural wages, convergence, spatial econometrics.

JEL: Q19; Q18; R23.

1 INTRODUCTION

Sectorial policies for modernization of agriculture implemented in Brazil in 1970 were paramount to the numerous changes that the sector has faced in the last four decades. The sector contributed to the country's economic development by generating surplus production, foreign exchange and demand for industrial products, as well as the occupation of the national territory by the expansion of agricultural frontiers and boosting inland cities away from the large urban centers. On the other hand, it deepened the disparity in productivity of factors of production in the states of the Midwest, Southeast and South over the North and Northeast (GASQUES, 2001; FREITAS, BACHA, 2004; FREITAS et al., 2007), and the levels of income and the degree of poverty in agriculture in regional terms (HOFFMANN and KAGEYAMA, 1984).

The agricultural labor market has undergone major impact in the 1970s with the reduction of the rural population. In that decade the urban population in Brazil was higher than that rural due to the intense rural-urban migration, changed the demographics of the country in a short period of time, and the growth of the rural population began to decrease compared to

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the urban population. The labor market had strong impact particularly on the demand because of the new production organization that concentrated rural properties and new laws (Statute of Worker and Land) implemented in this decade discouraged the traditional production arrangements (partnership, sharecropping and others), on the other hand, the manpower readily available see their job opportunities to increase in urban centers in expansion (ALVES, 1995; STADUTO, et al., 2004; CUNHA, 2008). In the early 1990s, the agricultural labor market again suffered great impact of the technological innovation cycle that advanced on the production of tropical products, such as sugarcane, coffee and orange, helping to reduce jobs in agricultural production (STADUTO, et al. 2004).

In each Brazilian state, the agricultural labor market has peculiarities of production structure and the level of technification, which influence the quality of the job and wage dispersion as well as the institutional particularities as the regional minimum wage (STADUTO et al. 2008). The job market in each state can also be influenced by the neighboring states, so-called neighborhood relationships which influence the wage determination (EBERTS, SCHWEITZER, 1994; AZZONI et al., 2000; CASELLI and COLLEMAM 2001; BARRETO and ALMEIDA 2008)

From the evidence on the disparity of wages of agricultural workers - permanent and temporary - among Brazilian states, there is the following question: do states with lower wages will pay the same wage levels that states with higher wages at long-term? For such, it is necessary that the states with low wages have higher rate of wage growth than that of the states with higher wages. This implies a possible downward trend in wage inequality among Brazilian states over time.

Studies of convergence on per capita income are frequent; however, there are few studies examining the convergence of wages and mainly, the workers in the agricultural sector. Thus, we intend to contribute to understanding the mechanisms of adjustment of the labor market of permanent and temporary segments. In this context, the aim of this paper is to examine the differences of salaries of permanent and temporary workers in the agricultural sector through convergence tests in the period 1992-2009, applying the methodology of spatial econometrics.

2. THEORETICAL REFERENCE

Convergence is a process in which the same variable (eg, income *per capita*, land productivity) has different values between countries, regions or states, but this difference decreases over time, indicating that inequality has decreased (LOPES, 2004; BARRETO, 2007;

ALMEIDA E BARRETO, 2008). To measure convergence, we will adopt the concepts proposed by Barro and Sala-i-Martin (1990, 1991), who considered the variable income per capita. In this study, this variable will be replaced by the average of agricultural wages of two segments of workers from Brazilian agriculture, as well as it has been done in some studies, for example, Caselli and Coleman (2001), Temel (2000) and Menezes and Azzoni (2006).

The β absolute convergence occurs when poor economies grow faster than rich economies. Sala-i-Martin (1995) considered $\gamma_{i,t,t+T} \equiv \log(y_{i,t+T} / y_{i,t}) / T$, i.e. the growth rate of GDP (Gross Domestic Product) per capita for the period, and for a cross-section data with the following regression:

$$\gamma_{i,t,t+T} = \alpha - \beta \log(y_{i,t}) + e_{i,t} \quad (1)$$

The GDP growth rate is among the initial time t and initial time added to the final time $t+T$, $\log(y_{i,t})$ is the logarithm of the economy (i) of GNP per capita over time t , e is the random error (SALA-I-MARTIN, 1995). The β absolute convergence shows that the different individual economies within certain GNP distribution per capita have the same stationary state. This means that the observed differences in initial levels of GDP per capita are due to short-term deviations in the stock of physical capital of savings.

Convergence σ can be defined when the units of one group of economies are converging towards decreasing the levels of real GDP dispersion per capita over time:

$$\sigma_{t+T} < \sigma_t \quad (2)$$

Where σ_t is the standard deviation of $\log(y_{i,t})$ of time t in the economy i . Over time, the GDP levels per capita of two economies (poor and rich ones) become more similar due to the growth of the poor economy. The concepts of convergence σ and absolute β convergence are mutually related. "The existence of convergence β tends to generate the convergence σ (SALA-I-MARTIN, 1995, p.1021)".

The rich economies did not differ from poor economies only in their capital levels, but also in technological levels, propensity to save and population growth, i.e. they also have different steady states. The conditional β convergence is tested for this hypothesis including proxy variables in the model:

$$\gamma_{i,t,t+T} = \alpha - \beta \log(y_{i,t}) + \psi X_{i,t} + \varepsilon_{i,t,t+T} \quad (3)$$

Where $X_{i,t}$ is the vector of variables that keep constant the steady-state of economy (SALA-i-MARTIN, 1996). If a negative relationship exists between the rate of GNP growth per capita and its initial value ($\beta < 0$), then there is the conditional β convergence. Its

occurrence does not mean that inequalities will decrease over time, but the economies are moving towards a long-term equilibrium situation.

3. METHODOLOGY

The spatial econometrics it is a quantitative analysis of the behavior of the exogenous relationship of the agent with another agent (independent of space interfering with the decision making) with its interaction with other heterogeneous agents in which the space comes to interfere in the relationship, being the space heterogeneous. The spatial econometrics is composed of Exploratory Spatial Data Analysis (ESDA) and the spatial econometric models (ANSELIN, 1998; ANSELIN, 1998; ALMEIDA, 2004). In spatial econometric models are estimated models to test the convergence (BARRETO, 2007; BARRETO and ALMEIDA, 2008).

The ESDA describes and illustrates the spatial distributions, identifies atypical locations or spatial outliers. Furthermore, it shows the patterns of spatial association, *clusters*, and suggests spatial regimes or other forms of spatial heterogeneity, and also checks the spatial dispersion pattern and association of attributes (ANSELIN, 1998).

A matrix of spatial weights is specified to determine the spatial arrangement of interactions resulting from the phenomenon being studied. The literature shows many ways to build a spatial weights matrix⁴ (ALMEIDA, 2004). We will use the local empirical Bayesian estimation that tests the hypothesis of random distribution of the variable θ_i being the same for all rates in the neighborhood of the area i and having common average (μ_i) and variances (σ^2) as described by Camara et al. (2002).

From the ESDA will be extracted measurements of global and local spatial autocorrelation, thus using the statistical measure I proposed by Moran (1948). The global spatial autocorrelation tests the randomness of the data of a variable and it is given by:

$$I = \frac{n}{\sum \sum w_{ij}} \times \frac{\sum \sum w_{ij} (z_i - \bar{z})(z_j - \bar{z})}{\sum (z_i - \bar{z})^2} \quad (4)$$

Where: n is the number of spatial units, z_i is the variable of interest; w_{ij} is the spatial weight for the pair of spatial units i ; and j is a measure of the degree of interaction between them. This is a statistic that informs the degree of linear association between the vectors of observed values at time t (z_t) and the weighted average of the values of their neighbors, or spatial lags (Wz_t). The values of this statistic range from -1 to +1, where -1 represents a negative linear

⁴ This paper uses the Binary-type matrix; however, there are other types of conventions of spatial weights matrix as a Inverse Distance-type matrix, General spatial weights Matrix of Cliff and Ord, socioeconomic Distance Matrix, among others, see Almeida (2004) for details.

correlation coefficient and +1 represents a positive linear correlation coefficient (ANSELIN, 1995).

The local spatial autocorrelation captures patterns of local association (*clusters* or spatial *outliers*) that can be calculated by the Local Moran's I (TEIXEIRA, BERTELLA and ALMEIDA, 2010). To identify the occurrence of local autocorrelation, Anselin (1995) proposed a breakdown into categories of the *Moran's I*, given by:

$$I_i = \frac{((z_i - \bar{z})) \sum_j (w_{ij} ((z_j - \bar{z})))}{\sum_i ((z_i - \bar{z}))^2 / n} = z_i \sum_j w_{ij} z_j \quad (5)$$

Where: n is the number of regions; z_i is the variable of interest, \bar{z} is the variable's mean, z_j is the variable of interest in the neighboring regions and w_{ij} is the spatial weight matrix.

Clusters are divided into four types of spatial association: High-High (HH) refers to a group whose spatial units show high variable values, surrounded by units that have also High values, Low-Low (LL) refers to a group whose spatial units show low values of the variable, surrounded by units that have also Low values, High-Low (HL) refers to a group whose spatial units show High variable values, surrounded by units that have Low values; and Low-High (LH) refers to a group whose spatial units show low values of the variable, surrounded by units that have High values.

Barreto (2007) and Barreto and Almeida (2008) have checked convergence analyses by applying the General Spatial Econometric Model for panel data with the aim of verifying the presence of effects or spatial externalities by establishing the following model:

$$G_{it} = \mu_i + \rho W_1 G_{it} + \beta_1 \ln(y_{i,t-1}) + X_{i,t-1} \beta_2 + u_{it} \quad (6)$$

para $i = 1, \dots, N$; $t = 1, \dots, T$

Where: μ_i is the parameter to be estimated in the model of specification of fixed effect ($u_{it} = \lambda W_2 u_{it} + \varepsilon_{it}$); i is the spatial unit (states), t is the time unit (1992-2009), β is a vector of unknown fixed parameters, W_1 is the spatial weight matrix, and ε_{it} are the error terms for every i and t with $E(\varepsilon_{it}) = 0$ and $E(\varepsilon_{it} \varepsilon'_{it}) = \sigma^2 I_{NT}$.

The wage growth rate ($G_t = \ln(y_t / y_{t-1})$)⁵ from 1992 to 2009 is represented by G ; the matrix $X_{i,t-1}$ represents the explanatory variables (Human Capital and Fixed Capital), β_2 is the vector of this coefficient; the parameter ρ is the coefficient of spatial lag (ρ), which can also be spatial error (λ) for the model of agricultural wages.

The $\ln(y_{i,t-1})$ is the logarithm of the initial agricultural wage average and the coefficient β_1 is the convergence coefficient (beta convergence). Convergence is estimated by

⁵ See Barreto and Almeida (2009) for further details.

$\frac{(1-e^{-\nu t})}{T}$, where t is the period of analysis, T is the time determined to years to reach the steady state, and ν is the convergence speed, also expressed in years. The time in years for the economies traverse halfway separating them from their steady states is called the half-life (π). The formula used to calculate the convergence speed is $\beta convergence = e^{\nu T} - 1/T$. It will be used the half-life calculation $\pi = \ln(2)/\nu$ ⁶.

3.1 Model of β absolute convergence of agricultural wages

From equation (6) were estimated two equations for agricultural workers: permanent (7) and temporary (8). Where η is the term that indicates whether the model has spatial lag (ρ) and spatial error (λ). To calculate the absolute β convergence:

$$G_{iP} = \mu_i + \eta W_1 G_{iP} + \beta_1 \ln(y_{P,i,t-1}) + u_{it} \quad (7)$$

$$G_{iT} = \mu_i + \eta W_1 G_{iT} + \beta_1 \ln(y_{T,i,t-1}) + u_{it} \quad (8)$$

The β convergence is present if there is a negative relationship between wages and the growth of the initial level. Its presence suggests that Brazilian states with low average wages experienced higher wage increases than states with higher wages. Must satisfy $1 > \beta_1 > 0$, where G is the rate of wage growth from 1992 to 2009, i.e. a negative relationship is expected between the growth rate of wages $\ln(G_t/G_{t-1})$ and wage level $\ln(G_{t-1})$.

3.2 Model of conditional β convergence of agricultural wages

To test the conditional β convergence of agricultural wages are included the explanatory variables of education, experience and fixed capital. The first two variables capture the influence of human capital and the third captures the influence of agricultural fixed capital. They are represented by $X_{i,t}$ described in equation (9) for permanent workers and in equation (10) for temporary workers:

$$G_{iP} = \mu_i + \eta W_1 G_{iP} + \beta_1 \ln(y_{P,i,t-1}) + X_{i,t} \beta_2 + u_{it} \quad (9)$$

$$G_{iT} = \mu_i + \eta W_1 G_{iT} + \beta_1 \ln(y_{T,i,t-1}) + X_{i,t} \beta_2 + u_{it} \quad (10)$$

Where $X_{i,t}$ is the vector of variables that keep constant the steady state. If the estimate of β is negative, then we say that the data set presents conditional β convergence (SALA-i-MARTIN, 1996).

⁶ "If $\nu=0.68\%$ a year (102 years) or $\nu=1.29\%$ a year or 54 years" (BARRETO, 2007, p. 104).

3.3 Convergence σ of agricultural wages

The convergence σ shows the reduction of wage dispersion over time between states. According to Silva (2010), the convergence σ can be confirmed by analyzing the coefficient of variation, which is based on the ratio between standard deviation and average. Values near zero indicate equal distribution of wages among Brazilian states. If during the period of analysis the captured dispersion decreases ($\sigma_{\tau} < \sigma_{\tau+T}$) there is evidence in favor of the convergence hypothesis σ .

3.4 Data Sources and Variables Description

The main source of information is the National Research by Household Sample (PNAD)⁷ for the period 1992-2009. The PNAD has been applied in other studies, for example, Menezes and Azzoni (2006) analyzed the wage convergence between the metropolitan areas of Brazil, Cunha (2008) studied the determinants of Brazilian agricultural wages and Hoffmann (2009) and Cunha (2009) examined the inequality between permanent and temporary workers in Brazilian agriculture.

For IBGE (2006), PNAD conceptualizes the employee as a person who works for an employer, fulfilling a predetermined workday, and receives remuneration in cash, goods, products or benefits. In this research, people employed in agriculture⁸ constitute the following segmentation.

The sampling of workers includes people employed in the agricultural sector with over 10 years of age. For each segment were extracted from PNAD following variables: worker income in monthly monetary values, number of hours worked per week in the main job, education in years studied, and number of years at work as experience proxy. The data are grouped in periods of two years. In the years 1994 and 2000 there were no PNAD and are not included in the survey.

The labor income was used as a *proxy* of wages. Therefore, the variable salary is the average monthly income from main occupation of the worker in agriculture divided by the number of hours worked in the month for each Brazilian state, and it was corrected by the National Index of Prices to Consumer (INPC)⁹ calculated by IBGE on the reference week when is made the data collection by the PNAD, as described by Corseuil and Foguel (2002).

⁷ The statistics presented from 1992 to 2003 for the North Region of Brazil refer only to its urban share. The state of Tocantins was the State in the Northern Region in which the survey was not restricted to urban areas during this period. Since 2004, the PNAD was implemented in rural areas of other states that made up the Northern region of Brazil.

⁸ For IBGE, also includes the activities of forestry, livestock, plant extraction, fisheries and aquaculture, as well as ancillary services.

⁹ Based on September 2009.

The same index was used by Cunha (2009), Cunha (2008) and Hoffmann (2009). The dependent variable (G_t) of equations (9 and 10) is wage growth rate between the first and eighth period, calculated according to this procedure.

The proxy of fixed capital was calculated following the procedure adopted by Freitas (2001) in which is based the horsepower of wheeled tractors used in agriculture. We used data from the National Association of Automobile Manufacturers (Anfavea) on the power of tractors sold by Federation Unit. We adopted the following methodology to calculate the total power of each class of tractors: i) tractors with up to 49 horses, it was considered the upper limit and multiplied the total tractors of this 1st class by 49; ii) tractors from 50 to 99 horses, the total tractors of this 2nd class was multiplied by 79; iii) tractors from 100 and 199 horses, the total tractors in this class was multiplied by 150; iv) tractors over 200 horsepower, the total value of tractors of this class was multiplied by 200.

The variable fixed capital was intensified; this total horsepower was divided by the cultivable area of each state. The cultivable area (the sum of areas with permanent and temporary crops) was extracted from the Census of Agriculture¹⁰. It should be noted that this variable measures the flow of fixed capital in agriculture in the period analyzed, i.e. the capacity of sector to form fixed capital, because it was the best possible information for the period.

The variable Esc.Perm. is the average schooling of permanent workers; Esc.Temp. and average schooling of workers; Exp Perm. is the average experience of permanent workers; Exp Temp. is the average experience of temporary workers. The variables education, experience (of each segment of workers in agriculture) and fixed capital are the explanatory variables ($X_{i,t}$), shown in the general model. The neperian logarithm of agricultural wages $\ln(y_{t-1})$ aims at verifying the existence of absolute β convergence and conditional β convergence.

4 RESULTS and DISCUSSION

4.1 Spatial Analysis of Growth Rate of Wages of Brazilian Agricultural Workers

The distribution of wages/hours of permanent and temporary workers in the Brazilian states is analyzed from its growth rate (Figure 1). For permanent workers, Roraima is the state with highest growth rate and the state of Tocantins has the lowest growth rate. For temporary workers stood out Santa Catarina, Minas Gerais, Goiás, Distrito Federal, Piauí and Paraíba by higher wage growth rate, and the lowest growth rates were Roraima and Amapá.

¹⁰ Due to their particularities to get the number of cultivable area, since the availability only for the years 1985, 1996 and 2006, it was used the procedure discussed by Freitas (2001), which adopts the exponential growth rate by the formula ($V_A = V_0 [1 + i]^n$) to calculate the accumulated rate between years analyzed and thus enabling the achievement of the cultivable area per year.

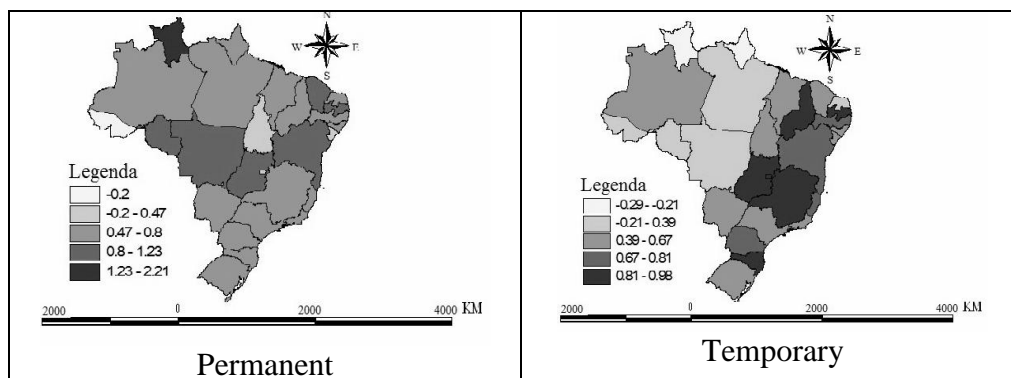


Figure 1 - Map of the growth rate of wage/hours of permanent and temporary workers for the Brazilian states between 1992 and 2009.

Source: Search Results.

Figure 2 shows the standard deviations of the growth rate of wages for permanent and temporary workers in the states, and briefly the growth rate of wage/hours of permanent workers in the Southern states, São Paulo and Mato Grosso do Sul was below the average for the period. On the other hand, the states of Rondônia, Mato Grosso, Pará, Goiás, Minas Gerais, Bahia, Ceará and Pernambuco had wage growth rate higher than the average growth rate for the period. For temporary workers of Brazilian agriculture, the Southern states had a growth rate of wage/hour higher than average growth for the period, i.e. the inverse of permanent workers, who had the growth rate below the average. The states of Mato Grosso, Rondônia and Pará had wage growth rate of temporary workers below the mean for the period, and those same states for permanent workers had growth rates above the average wage growth in the period. For some states, the South and Southeast macro-regions, is quite striking the inverse relationship between growth rate of permanent and temporary workers, demonstrating the forces of demand and supply of local labor markets. Generally permanent workers are more plentiful in the South, because the demand is also high due to the high level of technification in the agricultural sector. On the other hand, the supply of temporary workers is smaller, maintaining high rates of growth of wages of workers in this segment.

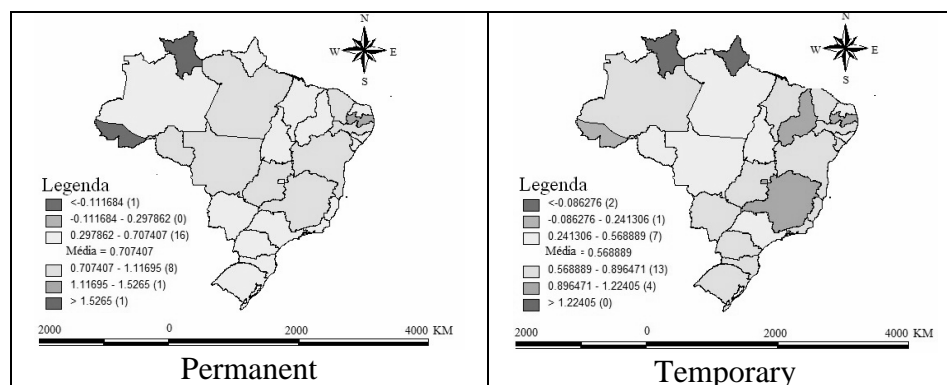


Figure 2 - Map the standard deviations of the growth rate of wages of permanent and temporary workers in the Brazilian states between 1992 and 2009.

Source: Research Results.

Table 1 shows the spatial autocorrelation in the growth rate of wages/hours of permanent and temporary workers in the set of spatial matrices. The negative sign of Moran's I coefficient shows that states with high growth rates of wage/hour of permanent workers are surrounded by states that have low growth rates of wage/hour of permanent workers (or low growth rates surrounded by neighbors with high rates); however their values were not significant. For temporary workers, the coefficient was positive, indicating that states with high growth rates of wage/hour are surrounded by states with high growth rates of wage/hour (or low rates surrounded by neighbors with also low rates), showing similarity between growth rate of wage/hour and location, it is noted that the significance of the spatial weights matrix K-3 and K-4 nearest neighbors show 5% significance for the Moran's I coefficient.

Table 1 -Univariate Moran's I Coefficient in the growth rate of wages/time of temporary and permanent workers from agriculture to the spatial matrices queen, rook and k4 and k3 neighbors

Workers' Wages Growth Rate	Queen		Rook		K- 3 neighbors		K- 4 neighbors	
	Moran's I	p- value	Moran's I	p- value	Moran's I	p- value	Moran's I	p- value
	Permanent	-0.0780	0.3860	-0.0780	0.3870	-0.1193	0.2620	-0.0385
Temporary	0.2575	0.0570	0.2575	0.0460	0.3985	0.0050	0.3540	0.0040

Source: Research results.

Note: The empirical pseudo-significance is based on 999 random permutations.

Note: $E(I)=-0.0385$.

Figure 3 shows the *outliers* to the growth rate of wages/hours of permanent and temporary workers. For permanent workers, Roraima stands out for distancing from the highest growth rate, forming a high outlier. The *outlier* of lowest growth rate of wages of permanent workers is the state of Acre. There was no formation of high and low outliers for the growth rate of temporary workers. This indicates no major distances between values that may be associated to the high mobility of temporary workers, thus increasing the arbitration of salaries between states, as describe STADUTO, BACHA and BACCHI, 2004.

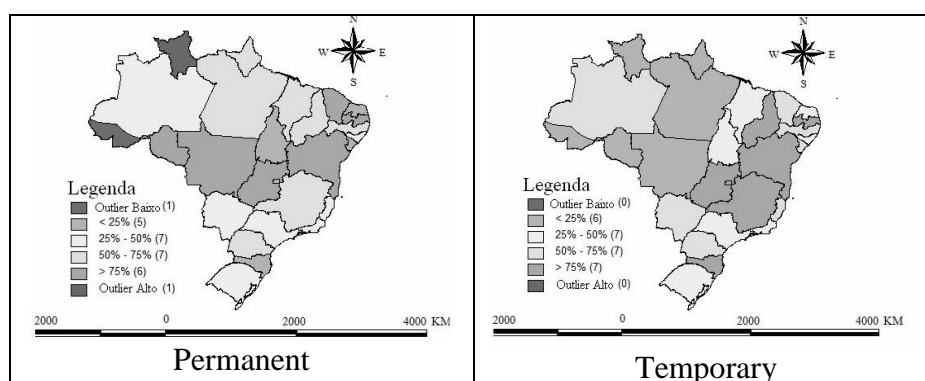


Figure 3 - Map of the growth rate of wages/hours of permanent and temporary workers for the Brazilian states by outliers

Source: Search Results.

Figure 4 shows formation of clusters in the growth rate of wages/hours of permanent and temporary workers, and reveals the growth trajectory of agricultural wages. For the segment of permanent workers there was only one type of cluster, the LH in Acre state, i.e. that state is surrounded by states with high growth rates, while its own wage growth rate is low. The presence of clusters for the growth rate of wage/hour of temporary workers is more intense than that of permanent workers, we can see all kinds of clusters and spatial similarity data. The growth rate of wages/hours of permanent workers is almost absent, occurring strong dissimilarity in wage growth in this segment.

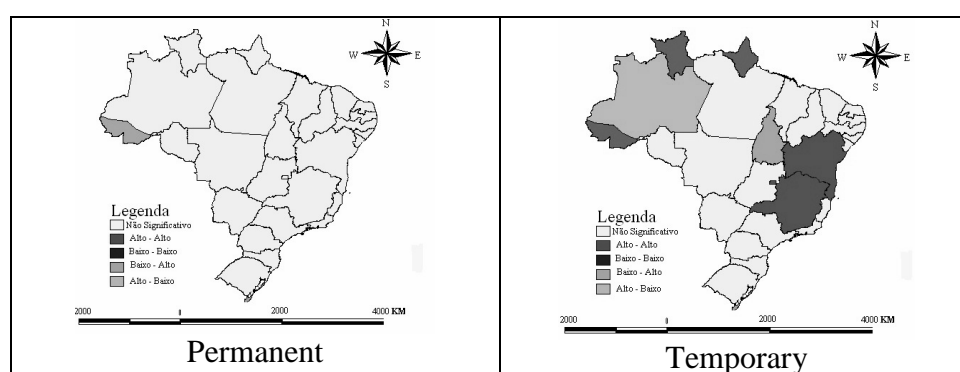


Figure 4 - Map of univariate clusters of growth rate of wages/hours of permanent and temporary workers for the Brazilian states.

Source: Research Results.

4.2 Analysis of the presence of spatial dependence

Table 2 show the estimates of equations 7 and 9 by the method of Ordinary Least Squares of permanent workers, and equations 8 and 10 of temporary workers for absolute β convergence and conditional β convergence, respectively. The F test value was significant, and less than 50 for the absolute β convergence of temporary and permanent workers. For conditional β convergence, the F test was significant and indicates the active participation of the variables in the model. The explanatory power of regressions by OLS is above 58%, according to the R^2 .

Table 2 - Results and diagnostics by ordinary least squares for absolute β convergence and conditional β convergence of wages of permanent and temporary workers

Description	Permanent				Temporary			
	Absolute β convergence		Conditional β Convergence		Absolute β convergence		Conditional β Convergence	
	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value	Coefficients	P-value
Fixed effect	0.9919 (14.5505)	0.0000	0.6154 (1.4632)	0.1575	0.6828 (16.8294)	0.0000	0.0421 (0.1725)	0.8646
β -Convergence	-0.7343 (-6.2038)	0.0000	-1.0391 (-9.8471)	0.0000	-0.6662 (-7.0448)	0.0000	-0.8302 (-8.8853)	0.0000
Esc. Perm.	-	-	0.1731 (2.6589)	0.01433	-	-	-	-

Esc. Temp.	-	-	-	-	-	-	0.1663 (3.1687)	0.0044
Exp. Perm.	-	-	-0.0397 (-1.1997)	0.2430	-	-	-	-
Exp. Temp.	-	-	-	-	-	-	0.0047 (0.02463)	0.8075
Fixed capital	-	-	0.2236 (1.0428)	0.3069	-	-	0.1475 (0.8824)	0.3873
F test	38.4877	1.7298	24.6974	7.3142	49.6303	2.1990	21.8637	2.1173
R ² Adjusted	0.5904	-	0.7847	-	0.6516	-	0.7624	-
R ²	0.6062	-	0.8178	-	0.6650	-	0.7990	-
Half-life	21.44	-	17.07	-	23.17	-	19.63	-
Convergence speed (%)	0.0323	-	0.0406	-	0.0229	-	0.0353	-
Akaike criterion	6.2343	-	-8.5837	-	-10.1903	-	-17.9819	-
Schwarz criterion	8.8259	-	-2.1045	-	-7.5985	-	-11.5027	-
LIK*	-1.1171	-	9.2918	-	7.0951	-	13.9339	-
Condition Number	2.2607	-	28.0495	-	1.5253	-	18.9339	-
Jarque Bera	0.3564	0.8367	1.1561	0.5609	1.9326	0.3804	0.2311	0.8908
Breusch-Pagan	1.0183	0.3129	1.2759	0.8654	0.0647	0.7992	4.0910	0.3938
Koenker-Basset	1.2238	0.2686	1.3438	0.8538	0.1573	0.6916	4.3888	0.3559
White	9.0142	0.0110	13.3663	0.4979	0.8422	0.6562	17.7049	0.2205
N	27	-	27	-	27	-	27	-

Source: Research results

Note: The value in brackets refers to the t test. * LIK is the value of the maximum likelihood function.

The negative sign for the variables β absolute and β conditional indicates the presence of wages convergence these workers, and they are statistically significant coefficients. It is an indication that the agriculture wage gap between Brazilian states has decreased over time. According to Barreto (2007), when there is absolute β convergence there is often incidence of conditional β convergence resulting that poorer regions tend to grow faster, the situation observed in the results of the salaries of permanent and temporary workers.

Table 2 shows that the tests of *Condition Number*¹¹ for absolute β convergence of permanent and temporary workers were 2.25 and 1.52 respectively indicating no multicollinearity. The *Condition Number* test for conditional β convergence for regressions in permanent and temporary segments were 28.04 and 18.93, respectively indicating suspicion of multicollinearity. The Jarque Bera test indicates that errors have a normal distribution. The tests Breusch-Pagan and Koenker-Basset are above 10% not rejecting the null hypothesis and thus there being no evidence of heteroscedastic errors. By the White test for the calculated values there is no evidence of misspecification of the various regressions, indicating that the errors are homoscedastic.

The tests of Moran's I for spatial autocorrelation identify what the most appropriate spatial econometric model, i.e. the dependent variable (spatial lag) or the error term (spatial error). For this, Almeida (2004) suggests the use of the Lagrange Multiplier (LM) and Robust

¹¹ According to Pinheiro (2007), this coefficient can find high correlation between observations of the variables included in the model specification, bringing the bias effect, high variance and few coefficients with statistical significance, even if the regression as a whole seems to be well adjusted. According to Anselin (1992), the Condition Number is the square root of the ratio of largest and smallest value in the matrix $X'X$, after standardization.

Lagrange Multiplier (LM robust); the decision will be made by the statistical significance of each multiplier considering its highest value, if there is no significance of Moran's I coefficients, the spatial lag (lag) and spatial error models are estimated by considering the criteria of Akaike and Schwarz to present higher values indicating the best model. According to Table 3, there was spatial autocorrelation in models absolute β convergence and conditional β convergence by Moran's I test. For the choice of the spatial weight matrix (queen, rook, k3 e k4 neighbors), the matrix to be used in spatial regressions will fall on that one with highest value and significance of the Moran's I test.

In Table 3, according to the tests of Moran's I, the absolute β convergence of permanent workers, the convention of spatial matrix chosen was k4 neighbors and the criterion of Lagrange Multiplier (LM) indicates the spatial lag model (lag) even not significant. The same matrix convention was chosen for absolute β convergence of temporary workers and the model chosen was the spatial error significant at 1%. In the conditional β convergence of agricultural workers, the spatial weight matrices were sensitive to the results. The convention of spatial weight matrix for the permanent worker with better result and significance fell at the convention queen, significant at the 5%, but with ML indicating the spatial lag model (lag), but not significant. For temporary employees, the matrix was chosen convention k4 nearest neighbors, significant at the 5% that assigning the ML indicates the spatial lag model (lag) which was not significant.

Table 3 - Diagnostic of the regression estimated by OLS for absolute β convergence and conditional β convergence of wages of permanent and temporary workers.

Absolute β convergence								
Weight matrix	Permanent				Temporary			
	Queen	Rook	K3	K4	Queen	Rook	K3	K4
Moran's	1.3798 (0.1676)	1.3698 (0.1667)	1.4800 (0.1388)	2.3359 (0.0194)	3.4918 (0.0004)	3.4489 (0.0008)	4.6062 (0.0000)	6.4362 (0.0000)
ML (lag)	1.3284 (0.2490)	1.3288 (0.2480)	2.5319 (0.1115)	2.6616 (0.1027)	0.0002 (0.9876)	0.0002 (0.9866)	2.4741 (0.1157)	3.0312 (0.0816)
ML (lag) robust	7.9842 (0.0047)	7.9842 (0.0046)	10.6771 (0.0010)	13.0757 (0.0002)	5.9465 (0.0147)	5.9865 (0.0148)	1.8552 (0.1731)	2.5553 (0.1099)
ML (error)	1.0652 (0.3020)	1.0652 (0.3028)	0.6983 (0.4033)	1.8414 (0.1747)	8.4520 (0.0036)	8.9520 (0.0006)	10.5019 (0.0011)	18.2316 (0.0000)
ML (error) Robust	7.7209 (0.0054)	7.7609 (0.0051)	8.8434 (0.0029)	12.2555 (0.0004)	14.3983 (0.0001)	14.3983 (0.0005)	9.8831 (0.0016)	17.7558 (0.0000)

Conditional β convergence								
Weight matrix	Permanent				Temporary			
	Queen	Rook	K3	K4	Queen	Rook	K3	K4
Moran's	1.2339 (0.0217)	1.2239 (0.0282)	-0.1315 (0.8953)	0.1728 (0.8627)	2.0219 (0.0431)	2.0010 (0.0761)	2.1190 (0.0340)	2.4448 (0.0144)
ML (lag)	0.2719 (0.6019)	0.2719 (0.6015)	2.4568 (0.1170)	3.9913 (0.0457)	0.3503 (0.5539)	0.3003 (0.0539)	1.7832 (0.1817)	1.7062 (0.1914)
ML (lag) robust	1.4827 (0.2226)	1.5827 (0.2222)	2.1052 (0.1467)	4.6112 (0.0317)	0.1460 (0.7023)	0.1460 (0.7003)	1.1549 (0.2825)	1.1281 (0.2881)
ML (error)	0.3291 (0.5661)	0.4291 (0.5061)	0.5457 (0.4600)	0.3612 (0.5478)	2.1499 (0.1425)	2.1498 (0.1205)	0.6626 (0.4156)	0.5863 (0.4438)

ML(error) Robust	1.4446 (0.2139)	1.5446 (0.2109)	0.1941 (0.6594)	0.9811 (0.3219)	1.9456 (0.1630)	1.9756 (0.1330)	0.0343 (0.8530)	0.0082 (0.9277)
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Source: Research Results

Note: The figure in brackets refers to the p-value

We can see the Table 3, there is spatial autocorrelation therefore is more appropriated the application of spatial econometrics in the regression model. However, before the non-significance of the ML in models of absolute β convergence of permanent workers and conditional β convergence of wages of permanent and temporary workers, it is necessary to estimate the models for the spatial lag (lag) and spatial error and present the coefficients found for the model with the highest values for Akaike and Schwarz criteria as directed by Almeida (2010).

Table 4 - Akaike and Schwarz criteria for models of spatial lag (lag) and spatial error for absolute β convergence and conditional β convergence of wages of permanent and temporary workers.

Description	Permanent				Temporary			
	absolute β convergence Matrix K4		Conditional β Convergence Matrix Rainha		absolute β convergence Matrix K4		Conditional β Convergence Matrix Queen	
	Spatial lag	Spatial error	Spatial lag	Spatial error	Spatial lag	Spatial error	Spatial lag	Spatial error
Akaike criterion	2.3509	1.8606	-6.8886	-8.9083	-10.9607	-26.7526	-17.7122	-23.2946
Schwarz criterion	6.2384	4.4523	0.8867	-2.4291	-7.0742	-24.1609	-9.9372	-16.8154

Source: Research results.

The values of Akaike and Schwarz criteria shown in Table 4 indicate that the best model to be estimated for the absolute β convergence of permanent workers is the spatial lag model (lag) because its values are higher than those obtained by the spatial error model. For conditional β convergence of wages of permanent workers was chosen the spatial lag model (lag), even the Akaike criterion being lower for this configuration than for spatial error model, the Schwarz criterion has positive value for this modeling. In conditional β convergence in wages of temporary workers the choice was made by the spatial error model.

Table 2 shows that the variables conditioning the model of temporary and permanent workers for convergence β conditional (Esc.Perm., Esc.Temp., Exp Perm., Exp Temp. and Fixed Capital) were not statistically significant in its entirety, but they will be kept in the estimations to check the spatial effects. Table 5 shows the spatial econometric results, and the coefficient of R^2 shows good fit above 70% in the absolute β convergence and conditional β convergence of permanent and temporary workers. The Brusch-Pagan test indicates no heteroscedasticity for absolute β convergence and conditional β convergence in the two segments of workers.

The fixed effects are significant and positive in all estimations, indicating peculiarities in the labor market of each Brazilian state. This suggests that the spatial position of the states affects their agricultural labor market in a positive way. The regressive coefficients of spatial lag (ρ) of absolute β convergence of permanent workers shows spatial interaction of the growth rate of wages and had pattern of spatial dispersion between states of high growth rates and neighboring states with low rates (HL and/or LH patterns). However, (ρ) of conditional β convergence of permanent employees is not significant.

The estimation of the spatial error model (λ) of absolute β convergence and conditional β convergence of temporary workers indicates that the non-modeled effects have positive spatial autocorrelation, this means that in states with high values of these effects are also surrounded by states with high values and states with low values are surrounded by states of low values of these effects (HH and/or LL patterns). As the spatial dependence in the model absolute β convergence and conditional β convergence of temporary workers is in the error term, and it is not possible to know what these effects.

The growth rate of wages of permanent and temporary workers in agriculture maintained a negative and significant correlation with the initial wage level of permanent and temporary workers, evidenced wage convergence. The annual rate of absolute convergence found for permanent workers (3.20% p.p.¹²) was lower than that found for temporary workers (3.43% p.p.). There is indication that the growth rate of wages of temporary workers, towards steady state is higher.

Table 5 - Spatial econometric results by maximum likelihood for absolute β convergence and conditional β convergence of wages of permanent and temporary workers.

Description	Permanent				Temporary			
	absolute β convergence		Conditional β Convergence		absolute β convergence		Conditional β Convergence	
	Matrix K4 Spatial lag		Matrix Queen Spatial lag		Matrix K4 Spatial error		Matrix K4 Spatial error	
	Coefficients	P-value	Coefficients	P-valor	Coefficients	P-value	Coefficients	P-value
Fixed effect	1.3822 (8.2852)	0.0000	0.6804 (1.7529)	0.0796	0.6801 (8.5055)	0.0000	0.5957 (2.7620)	0.0057
Rho	-0.5537 (-2.6382)	0.0083	-0.0798 (-0.5790)	0.5625	-	-	-	-
Lambda	-	-	-	-	0.6845 (5.1885)	0.0000	0,6454 (4.4758)	0,0000
β -Convergence	-0.7259 (-7.1685)	0.0000	-1.0377 (-10.9683)	0.0000	-0.7954 (-9.8413)	0.0000	-0,8149 (-10.1728)	0,0000
Esc. Perm.	-	-	0.1672 (2.8384)	0.0045	-	-	-	-
Esc. Temp.	-	-	-	-	-	-	0.0455 (1.0106)	0.3121
Exp. Perm.	-	-	-0.0374 (-1.2456)	0.2119	-	-	-	-
Exp. Temp.	-	-	-	-	-	-	-0.0127	0.3577

¹² p.p. referes per period.

Fixed capital	-	-	0.2307 (1.1921)	0.2332	-	-	(-0.9196) 0.0026 (0.0211)	0.3577
Half-life	21.63	-	17.08	-	20.22	-	19.8827	-
Convergence speed (%)	0.0320	-	0.0406	-	0.0343	-	0.0349	-
R ²	0.7023	-	0.8203	-	0.8442	-	0.8549	-
LIK*	1.8245	-	9.441	-	15.3763	-	16.6473	-
Breusch-Pagan	0.9317	0.3343	1.1144	0.8919	0.0761	0.7826	1,3917	0.8456
MV ratio	5.8834	0.0152	0.3045	0.5810	16.5623	0.0000	5,3127	0.0211
N	27	-	27	-	27	-	27	-

Source: Research Results.

Note: The figure in brackets refers to the z test. * LIK is the value of the maximum likelihood function.

The variables added to the models of convergence can be interpreted as determinants of wage growth of permanent and temporary workers in agriculture. Their behaviors indicate their influence on the reduction of inequality between salaries of permanent and temporary workers in the Brazilian states. The coefficient of the education variable in the permanent segment (0.1672) was higher than the coefficient found for the temporary segment (0.0455). Education in this case has greater degree of importance as a reduction in wage inequality among states for permanent workers. That does not mean it is not also responsible for the reduction of salary inequalities between temporary workers, but its influence in this segment is smaller than for permanent workers.

Barreto (2007) emphasizes regions with higher human capital using the most advanced technological resources and stresses the importance of education as a factor of increased labor productivity. Cunha (2008) shows education as reducing the wage differential of agricultural workers. According to Freitas and Bacha (2004), the higher levels of education of workers can generate or adapt more easily to production, structural and cyclical changes of agriculture, as well as the introduction of new technologies. It is believed that more skilled workers in agriculture are preferable.

The coefficient of experience variable was not significant for permanent and temporary workers. The experience does not affect wage growth, and it would not be surprising that the coefficient was negative and significant, contributing to wage inequality between workers of states. According to Staduto, Shikida and Bacha et al. (2004), technological innovations are operated primarily by permanent workers, and the oldest workers on average have no training and education enough to handle new equipment and machinery used in modern agriculture. On the other hand, temporary workers need physical strength and not exactly experience, because perform low complexity tasks requiring little cognitive ability but important work effort.

Staduto, Bacchi and Bacha (2004) found that high technical standards have larger impact on wages of permanent workers than on temporary workers. The coefficient of fixed capital was positive; however, not significant for permanent and temporary employees.

The convergence σ shows the dispersion of the salary levels, which can be seen in Figure 5. The analysis of the ratio of standard deviation and sample mean showed σ convergence for wages of permanent and temporary workers. The initial wage dispersion of permanent and temporary workers was higher than in the last period of analysis in each of the segments of the agricultural workers. This shows a tendency to equalize the wages of these workers. This result shows that the agricultural workers' wage inequalities between states have decreased. The existence of absolute β convergence was confirmed but it is not possible to identify whether any state is outside of process of wage convergence and this is an ongoing process.

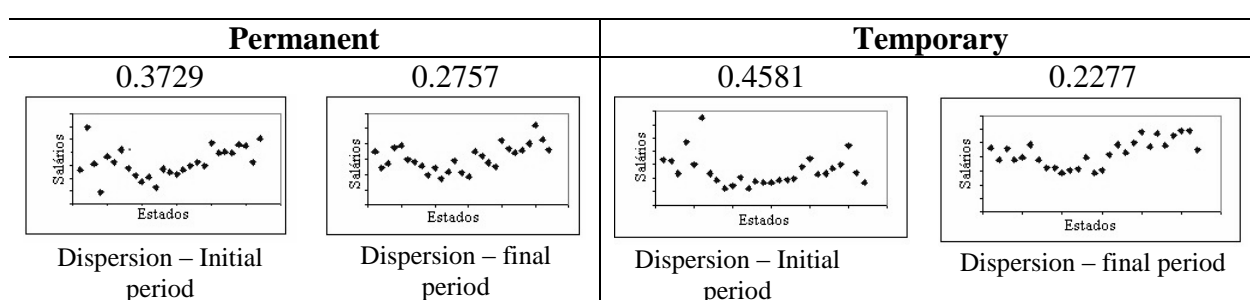


Figure 5 - Coefficient of variation and scatter diagram for wages of permanent and temporary workers in the Brazilian states

Source: Search Results.

5. CONCLUSIONS

This study examined the convergence of wages of permanent and temporary workers of Brazilian agriculture from 1992 to 2009, disaggregated by Federative Units of Brazil (states). It was possible to verify the behavior of wage differentials by dispersing the growth rate of wages of those workers in the Brazilian states and the convergence to agricultural wages, considering the spatial dependence. The particularities of each state were analyzed by applying spatial econometrics. Firstly, they were carefully analyzed with the aid of the exploratory analysis of spatial data, presenting the basic elements to contextualize the spatial distribution of the growth rate of the wage/hour of agricultural workers and the growth rate of these wages. The spatial lag econometric model was applied to test for wage convergence conditioned for permanent workers and spatial error for temporary workers.

The distribution of growth rate of wages shows that states with lower wages have higher growth rates (Santa Catarina, Minas Gerais, Goiás, Distrito Federal, Piau  and Para ba). States with higher wages, in part, had lower growth rates (Roraima, Amap ) - thus showing evidence of convergence.

Salaries of permanent employees are going to absolute convergence rate of 3.20% p.p., as well as temporary workers at a rate 3.43% p.p. Thus, the wages of temporary workers are evolving faster to steady state than those permanent. In conditional convergence, the only significant variable was the education of the permanent employee, which tends to reduce wage inequalities. Wage inequalities among Brazilian states exist but they are decreasing. Education is an important factor for reducing wage inequality.

The σ convergence wages of temporary and permanent workers of Brazilian agriculture shows decreased wage inequality by the declined dispersion of wage levels. The fall in wage inequality is more pronounced among wages of temporary workers than among those permanent.

This paper shows the importance of human capital and particularly formal education to reduce the inequality of labor income. Educational policies to support training and professional qualifications are essential, as they can increase the cognitive ability of agricultural workers to operate new technologies. In turn, they can increase productivity, and consequently earning of the work.

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