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DEMOGRAPHIC CHANGE AND REGIONAL ECONOMIC GROWTH IN BRAZIL

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Abstract. In this paper we investigate if demographic change plays a role in the dynamic of regional economic growth in Brazil. The Brazilian economy has presented a very fast demographic transition because fertility and mortality rates of population have significantly decreased over the last decades. It is expected that demographic change affects the growth performance over the time since changes in the population structure imply in changes on the consumption and savings decisions, labor supply and productivity and in public investments as pension system expenditures tend to increase. Additionally, the pattern of demographic change and structure is not homogenous among Brazilian regions. This paper explores how the regional demographic structure has changed over the last decades among Brazilian regions and estimates convergence equations conditioned by demographic factors. The extent of the demographic effects on economic growth and its sensitiveness to different specifications for the econometric models are investigated.

JEL classification: J11, R11, R12

Key words: Brazilian states, demographic change, income convergence

1 Introduction

The regional structure of the Brazilian economy can be characterized by high and persistent inequality. For instance, Northeast is the poorest region of Brazil and its per capita income accounted for 48.3 percent of the national per capita income in 1970. In 2010, the per capita income of Northeast accounted for 61.5 percent of the national per capita income. These data suggest the existence of dynamic convergence among Brazilian regions that seems to be very slow. In fact, Azzoni (2001) showed that the speed of convergence for Brazilians states is 0.68% per year in the case of absolute convergence and 1.29% in the case of conditional convergence. Then total equalization

* This is a paper in progress whose results are preliminary. At this stage of the research, we used OLS panel data methods to estimate convergence equations conditioned by demographic factors. Other econometric methods more robust to spatial dependence and endogeneity will be further applied.

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of per capita income among Brazilian states would be achieved only after many decades.

Several other empirical studies have been developed in order to identify the forces explaining regional growth and convergence in Brazil. Some studies show that initial conditions such as physical and human capital, industrialization and infrastructure do matter for the dynamics of regional growth (Coelho and Figueiredo 2007, Gondim, Barreto and Carvalho 2007, Barreto and Almeida 2008, Magalhães and Miranda 2009, Canêdo-Pinheiro and Barbosa Filho 2011). Geographical aspects such as location, agglomeration and spatial dependence also seem to be important for the dynamic of convergence among Brazilian regions (Silveira-Neto 2001, Silveira-Neto and Azzoni 2006, Resende 2011).

Recently, the literature on endogenous economic growth models has searched to achieve a better comprehension about the relationship among demographic factors and income convergence (Fukuda and Morozumi 2004, Prettner and Prskawetz 2010). As fertility and mortality rates have significantly decreased over the last decades but countries present differences in their demographic transition process it seems important take into account demographic factors as another force influencing the economic dynamics among countries. A more detailed specification of demographic factors into growth models, for instance, the population age structure, is relevant because agent decisions change over the cycle of life. The literature assumes that the channels linking demography with economic growth would be associated with the effect of demographic change on consumption preferences, saving decisions, labor supply and productivity of the workforce and the need for more public expenditure to support pension systems.

In this paper we investigate how demographic factors can influence the economic dynamics of Brazil in a regional perspective. The empirical literature has dedicated little attention to the role of demographic factors as a potential force explaining regional economic growth in Brazil. As well in other countries, demographic transition has rapidly evolved in Brazil because fertility and mortality rates of population have significantly decreased over the last decades. The ageing of population is not yet the main aspect of the Brazilian age structure but certainly will be in few decades. However, it can be observed important differences among Brazilian states in terms of their demographic structure whose effects on regional economic dynamics are not yet known. Therefore, the aim of this paper is investigate if demographic change plays a role in the dynamics of regional economic growth in Brazil. The sensitiveness of the demographic parameters also is evaluated through different specifications for the convergence equation and the use of different estimation methods.

The paper is organized in six sections including this introduction and the final remarks. The second section presents a brief review of the theoretical and empirical literature on economic growth models putting in evidence the role of demographic factors. The third section explores the characteristics of the population age structure and demographic change among Brazilian regions over the last forty years. The methodological procedures adopted for estimating the convergence equation are presented in the fourth section and the results are discussed in the fifth section. It is worth noting that that these results are preliminary since this paper is in progress and other estimation methods will be further applied in order to estimate the convergence equations.

2 Literature Review

There are different theoretical perspectives addressing the issue of income convergence, being the main ones the neoclassical models and the endogenous growth models such as the linear and neoclassical-Schumpeterian models. The classical model proposed by Solow (1956) and Swan (1956) went on to become the landmark study of economic growth, since it served as a source of inspiration for many other models that emerged in the literature, from which new features are incorporated or simply the existing characteristics are modified.

Solow explored the role of technological change in the American economy in the period 1909 to 1949, concluding that approximately 90% of its growth could be attributed to the technological factor, namely only the production factors (capital and labor)[1] do not hold the long term economic growth rate, indicating that this rate is exogenous in the sense that it is not determined by the model (Jones, 2000). Thus, technology, inserted exogenously into the model, known as the Solow residual, is the responsible factor for

[1] It is assumed that output function has constant returns to scale, implying that when both production factors are increased together, the product increases proportionally.

the growth of the economy. It is important to emphasize that this result is also found in other models, but the technology is treated endogenously, characterizing the endogenous growth models. In this sense, the Solow's growth model inspired many other models that emerged in the literature.

Several other studies appeared to evaluate the economic growth searching endogenous explanation inspired by Lucas (1988) and Romer (1990). According to the first author, it is necessary to postulate appropriate variations in the parameters related to technology and preferences. This adjustment reflects the mobility of factors so that it is no longer possible to pay them for their marginal productivities, since the world is not competitive. This seems to be the major distinction between what the neoclassical theory predicts and the pattern of trade observed. Using a similar technique to that used in the models of Arrow (1962), Uzawa (1965) and Romer (1986), Lucas adds to the neoclassical model what Schultz (1963) and Becker (1964) called "human capital" in order to address these aspects. The increase is explained by economic incentives such as higher returns for higher levels of education. Thus, an economy with more human capital grow faster, since higher levels of education have incentives in the form of higher returns, having a positive impact on the wages of individuals.

The development of the endogenous models gave rise to new theories of endogenous economic growth which differs from the original model of Solow for using increasing returns to scale (Martin and Sunley, 1998; Clemente and Higachi, 2000). These theories can be classified in two groups: the first one includes the models of Lucas, (1988), Romer (1986), and Rebelo (1991) treating technology as a public good (in exception of Lucas) and the second one, the neoclassical-Schumpeterian models of endogenous growth, includes the models of Romer (1990) and Aghion e Howitt (1993) treating technology as general goods subject to appropriation, introducing the idea of imperfect competition. The model of Rebelo (1991) is an example of linear models, assuming that the basic sources of economic growth is physical capital, human capital and research, adding these factors in a broad measure of capital so that the output is a linear function of the capital measure. The neoclassical-Schumpeterian models attribute to innovation the key role in explaining economic growth in the long run. Technological progress is explained by the pursuit of higher profits. Considering imperfect competition, investment in research and development (R&D) permit the creation of a variety of new products with higher quality, ensuring the achievement of profit.

The analysis of the relationship between changes in demographic structure and economic growth is recent in the literature. Previously, the population variable was limited by the extent of its total growth and size, considering the population age structure constant, and concluding that it had no impact on economic growth. However, the relationship between these variables has been studied by several authors mainly from the 90's, since it was realized that the change in the demographic structure is a significant variable for explain economic growth. Regarding the implications of the process of demographic change for the economic sphere, Miles (1999) mentions the impact on the rate of savings, the capital formation, the labor supply, the interest rate and the real wages. Wong and Carvalho (2006) consider important the impact on labor supply, since the population who are active in working age (25-64 years) will grow at least until 2045. However, this supply of labor can only be exploited if it has abilities to develop their productivity, maintaining the equilibrium between the economic, social and intergenerational balance.

Prettner and Prskawetz (2010) present a widely review on the theoretical literature on economic growth models handling with changes in the age structure of population. This review shows that the effect of demographic change on economic growth can be positive or negative depending on the framework structure adopted by each study. Population ageing can have positive impact on economic growth if saving of working-age population increases in order to support future consumption or if R&D investments increase relative to workforce's size. But a negative impact can arise if the population ageing is conditioned by declines in fertility and accompanied by reduction in population growth or if the pension systems are formulated in such way that the workforce-retirees ratio decreases.

The ambiguity of the population ageing effect on economic growth also is very clear in the overlapping-generations model developed by Fukuda and Morozumi (2004) assuming capital accumulation and uncertain lifetime horizon. The results suggest that a large share of the output is consumed by non-productive factors when the proportion of the elderly population is large, determining a negative impact on economic growth.

However, countries with a high aged dependency ratio tend to have high life expectancy and low rate of population growth which contribute to increase the saving rate of working-age population and enhance economic growth. Thus, the effective impact of the population ageing on economic growth would not be certainly clear and depend on the relative combination of these sources. The cross-country panel analyses carried out by Fukuda and Morozumi (2004) founded evidence of a positive effect between aged dependency ratio and economic growth.

Other empirical studies have analyzed the relationship between the components of population and economic growth per worker. According to Prskawetz, Fent and Barthel (2007) it seems that child dependency ratio is significantly and negatively related to economic growth. Evaluating the role of demographics for Europe, Kelley and Schmidt (2005) also found that the decline in child dependency ratio had a strong positive effect on the rate of growth in output per worker during the 1970s and 1980s. The general conclusion from these analyses is that, regardless of the method applied and set of additional control variables considered, the relationship between economic growth rate and demographic change seems to be robust.

In Brazil, the empirical literature on economic growth has mainly investigated the existence of convergence among regions and the importance of some factors such as physical and human capital suggested by theoretical models as well other structural characteristics of each region such as agglomeration, industrialization and infrastructure (Coelho and Figueiredo 2007, Gondim, Barreto and Carvalho 2007, Barreto and Almeida 2008, Magalhães and Miranda 2009, Canêdo-Pinheiro and Barbosa Filho 2011). Other studies have explored the importance of geographical aspects such as spatial dependence on income convergence in Brazil (Azzoni et al. 2000, Silveira-Neto 2001, Silveira-Neto and Azzoni 2006, Resende 2011).

Little attention has been dedicated to investigating the importance of demographic change as a potential source explaining the economic dynamics among Brazilian regions. A first study carried out by Azzoni, Menezes-Filho and Menezes (2005) using microeconomic data – household surveys – suggests that demographic structure matters for regional growth because the speedy of income convergence varies considerably across birth cohorts and demographic structure tends to be different among regions.

Recently, Menezes, Silveira-Neto and Azzoni (2011) again put in evidence the importance of demographic factors on regional inequality in Brazil. Accordingly this study, it would exist income convergence only for the older generations mainly explained by retirement payments, pension payments, and other government transfers. Thus, income convergence would not be observed when these transfers are controlled in the analysis.

In this study we investigate the role of demographic change on economic growth of Brazilian states through the estimation of income convergence equation that explicitly address demographic variables. It is expected that this analysis reveals the extent to which demographic change is effectively correlated with regional growth and inequality in Brazil.

3 The pattern of inequality and demographic change in Brazil

In this paper, we will look at demographic change as a potential channel to explain regional economic growth in Brazil, a country characterized by strong regional inequalities. Table 1 presents the extent of regional concentration and inequality in Brazil through the share of each region in the national income and the proportion of the average per capita income of each region to the national average per capita income. In 1970, the Northeast's income was 14.6% of the national income, whereas the North's income reached only 2.9% of the national total. In terms of inequality, whereas the Northeast presented an average per capita income of 48.3% below the national average, and the North reached 65.6%, only the Southeast showed indicator substantially above the national average. In 2010, the regional inequality among changed for North and Northeast while Southeast, South and Center-West reached indicators over the national average.

Table 1. Income and Income per capita for Brazilian Regions

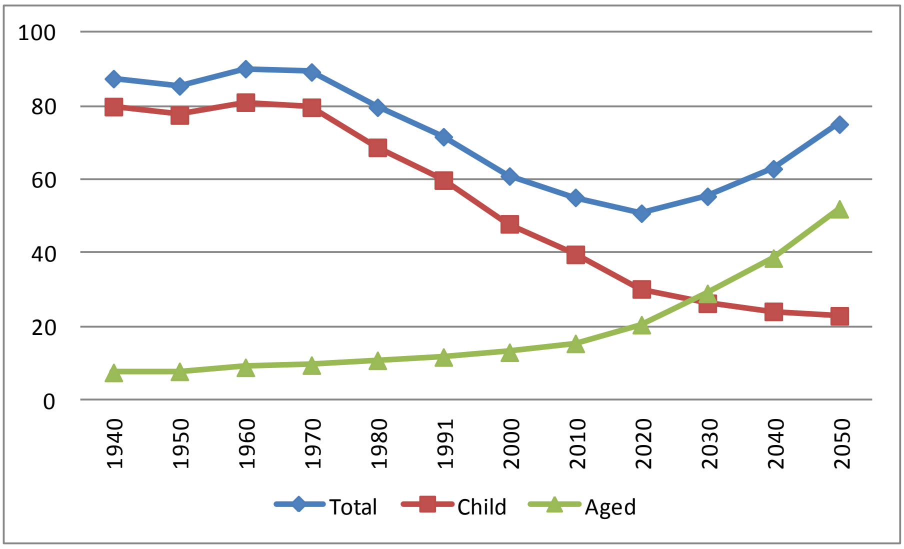
Regions	Income[a]		Population		Income per capita[b]	
	1970	2010	1970	2010	1970	2010
Brazil	100.0	100.0	100.0	100.0	100.0	100.0
North	2.9	4.7	4.4	8.3	65.6	69.2
Northeast	14.6	15.8	30.2	27.8	48.3	61.5
Southeast	62.2	52.7	42.8	42.1	145.5	119.5
South	16.1	17.9	17.7	14.4	90.8	113.1
Center-West	4.2	8.9	4.9	7.4	86.1	117.0

[a] Proportion of the income of each region to the national income.
[b] Proportion of the income per capita of each region to the national income per capita.
Source: IBGE and IPEA.

In terms of demographic structure, Brazil has experienced significant changes over the last decades. The decrease in birth and mortality rates has contributed for boosting demographic transition in Brazil. Figure 1 presents the evolution of dependency rate[2] and their child and aged components since 1940 until 2050, considering the population projections calculated by the Brazilian Institute of Geography and Statistics (IBGE). The decrease in total dependency ratio accelerates from 1970 and is projected to continue until 2020, and then starts to increase. It is very clear the domination of the child participation in the dependency ratio, but the ageing of Brazilian population tends to become more prominent each year and will govern the dependency ratio after 2030.

[2] The dependency ratio calculated by IBGE considers the population under the age of 15 and over the age of 64 relative to the population over the age of 14 and under the age of 65. Consequently, the child and aged dependency ratios correspond respectively to the population participation under the age of 15 and over the age of 64.

Figure 1. Dependency ratio for Brazil, 1940-2050



Source: IBGE, Demographic Census 1940-2000 and Population Projections for Brazil 1980-2050, revision for 2008.

The demographic transition at the regional level has been similar to the national tendency, but the demographic structure and its dynamic is not totally homogenous among Brazilian regions as showed by the data presented in Table 2. The child dependency ratio represents most of the total dependency for each region, but is more important for North and Northeast. The child dependence ratio for these regions has remained systematically above the national ratio while the opposite occurs for Southeast. In the case of South and Center-West, the child dependency ratio starts over the national ratio in 1970 but ends under the national ratio in 2010. It is worth noting that regional current pattern of the child dependency ratio replicates in some way the polarization North/Northeast versus South/Southeast that also is observed in the per capita income inequality, suggesting a negative correlation.

Table 2. Dependency ratio of population for Brazilian regions, 1970-2010

Regions	1970	1980	1991	2000	2010
Dependency ratio					
Brazil	82.4	73.1	65.4	55.0	45.9
North	96.4	95.4	83.7	69.3	55.7
Northeast	93.7	91.5	80.1	63.5	50.9
Southeast	72.8	62.1	57.1	49.4	42.5
South	83.9	66.9	58.5	50.9	42.7
Center-West	88.8	77.4	62.7	51.9	43.5
Child dependency ratio					
Brazil	76.6	66.1	57.5	45.9	35.1
North	92.0	90.0	78.1	63.1	48.6
Northeast	87.5	83.1	71.0	54.0	40.1
Southeast	66.8	55.3	49.0	39.9	30.9
South	78.6	60.5	50.6	41.5	31.2
Center-West	85.2	72.7	57.4	45.5	35.1
Aged dependency ratio					
Brazil	5.8	7.0	8.0	9.1	10.8
North	4.4	5.4	5.5	6.2	7.1
Northeast	6.2	8.4	9.1	9.5	10.8
Southeast	6.0	6.8	8.1	9.5	11.5
South	5.4	6.4	7.9	9.4	11.6
Center-West	3.7	4.7	5.3	6.5	8.4

Source: IBGE, Demographic Census 1970-2010.

In the case of aged dependency ratio, only Northeast's and Southeast's aged dependency ratio was above the national ratio in 1970. But in 2010, only Southeast's aged dependency ratio remained above the national ratio in 1970 and same position was shared by South. The Northeast's aged dependency ratio seems to be evolving in a trajectory converging to the national aged dependency ratio. Although not well defined as in the case of the child dependency ratio, the polarization North/Northeast versus South/Southeast observed in the per capita income inequality also has being replicated for the case of the aged dependency ratio. What is different in this case is the position occupied by the regions since the correlation between aged dependency ratio and per capita income inequality seems to be positive.

These results imply that the demographic transition process tends to carry on more quickly for the South and Southeast. As mentioned before, the demographic change can affect the growth dynamic by several channels and it would be expected that demographic change could be another source explaining the dynamic of regional inequality in Brazil. Thus, the relevance of this source is empirically investigated through the estimation of convergence equation models for the Brazilian states as discussed in the next section.

4 Methodological procedures

The methodological approach designed in this study follows the usual specification presented in Durlauf et al. (2005) where the convergence equation is estimated as a panel data regression. In the conditional form, β-convergence is evaluated trough a regression where the dependent variable is the growth rates of per capita income and the independent variables are the initial values of the income per capita level and other variables representing the structural characteristics of each region. The basic panel data specification for the convergence equation is represented as follow:

$$g_{i,t}=\beta y_{i,t}+\delta X_{i,t}+\mu_i+\varepsilon_{i,t} \quad (1)$$

where $g_{i,t}$ represents a vector with observations for average per capita income growth rates for each state i at each decade t (i = 1, …, 27; t = 70's, 80's, 90's)[3]. Moreover, $y_{i,t}$ is the initial income per capita, $X_{i,t}$ is a vector of explanatory variables containing those determinants that are suggested by the growth model literature as well variables representing structural and demographic characteristics of the states, μ_i are the individual-specific effects and $\varepsilon_{i,t}$ is the vector of error terms. The explanatory variables are considered in terms of the initial values in each decade and their descriptions are presented in Table 3.

We are particularly interested in evaluate the signal and significance of the demographic variables and their sensitiveness to different estimation methods and different specifications for the convergence equation. Thus, use we two alternatives OLS estimation methods for panel data and three specifications for equation 1 where vector $X_{i,t}$ is different in each one. The methods are the pooled panel model (Pooled method)

[3] The average per capita income growth rates was calculated using a formula equivalent to (ln $y_{i,t}$ - ln $y_{i,t-1}$)/10. The per capita income data comes from the demographic census for the 1970-2000 period, where there are data available only for 1991 instead 1990. Thus, the denominator of that formula is 10 only for 1970-1980 and is 11 for the 1980-1991 and 9 for 1991-2000.

and the individual-specific fixed effect model (FE method). The definition of equation 1 is equivalent to the FE panel model and the Pooled model imply that $\mu_i = \mu$. One advantage of using panel data approach is its ability to deal with the omitted variable bias problem usually observed in cross-section regressions by controlling for omitted variables that are constant over the time assuming individual-specific effects. In this case, the FE method would be superior to the Pooled method as the first one allows for differences in the aggregated production function across regions (Islam, 1995).

For each estimation method, the first specification of equation 1 (model 1) corresponds to the unconditional convergence equation where is assumed that $\delta = 0$. The second (model 2) and third (model 3) specifications corresponds to the conditional convergence equation assuming $\delta \neq 0$, but the second one considers the variables AEST, DENS and DPR into the vector X while the third one considers the variables AEST, DENS, CDPR and ADPR into the vector X. These specifications for the convergence equation are useful to analyses the sensitiveness of the demographic parameters. Moreover, the third specification allows identifying the extent of the influence of each component of the total dependence ratio. As suggested in the discussion of the previous section, the correlation of child and aged dependency ratio with the regional inequality seems to be quite different.

Table 3. Explanatory variables in the convergence equation

Code	Description
INC	Logarithm of initial per capita income
AEST	Logarithm of average years of schooling
DENS	Logarithm of population density
DPR	Dependency ratio (total)
CDPR	Child dependency ratio
ADPR	Aged dependency ratio

Notes: All variables are assessed at the initial of each decade, that is, 1970, 1980, 1991. The data were collected from IPEADATA (Institute of Applied Economic Research) and from the Demographic Census elaborated by IBGE.

Another issue investigated is whether the errors of these regressions are spatially correlated. If spatial dependence is presented in the error term, ignore it would still yield unbiased estimates for the parameters but the parameter’s variance would be biased. A convergence study carried out by Silveira-Neto and Azzoni (2006) about the GPD per capita dynamics among Brazilians states showed that spatial dependence is more relevant for unconditional than conditional convergence equation. The spatial dependence problem is less relevant if the explanatory variables included into convergence equation are associated with the spatial linkage among regions. Other study conducted by Resende (2001) on the importance of spatial dependence for the convergence per capita income in Brazil showed that the more fragmented the spatial unit the more important is the spatial dependence. Accordingly to Resende (2001) as well to Silveira-Neto and Azzoni (2006), the relevance of spatial dependence need to be evaluated but it would be expected be lees important for territorial units such states.

The spatial dependence problem can be evaluated by using the global spatial autocorrelation measure known as Moran's I statistics (Anselin 1988). This statistics is calculated for the cross-section errors generate for each time span in the panel models estimated, providing information on the spatial autocorrelation effects across the three decades (1970s, 1980s and 1990s). Moran's I statistics is represented as follow:

$$I = \frac{\sum_i \sum_j w_{ij}(\varepsilon_i - \bar{\varepsilon})(\varepsilon_j - \bar{\varepsilon})}{\sum_i (\varepsilon_i - \bar{\varepsilon})^2} \qquad (2)$$

where ε_i and ε_j are the values of the cross-sectional errors, $\bar{\varepsilon}$ is the mean of the errors and w_{ij} are elements of the spatial weighting matrix that is row-standardized, that is, the elements w_{ij} in each row sum to 1. We used two different spatial weight matrices to calculate Moran's I statistics: Queen and K-nearest (distance matrix). The weight matrix calculated over the Queen form is a first-order contiguity matrix, that is, all states bordering one specific state is considered as neighborhood to calculate the weight matrix. In the case of the K-nearest form, the number of neighborhoods is specified a priori. The statistics for the K-nearest matrix were computed assuming the number of neighborhoods changes between 1 and 5, which is useful to evaluate how sensitivity is the spatial dependence to different levels of neighboring.

It worth noting that at this stage of the study we only test for spatial dependence problems across the states in each regression. Once identified such a problem, its correction need can be implemented by estimating spatial panel models. This issue as well other potential problems like endogeneity will be further handled in the research agenda.

5 Results

As previously discussed, three different convergence equations were estimated using two OLS panel data methods (pooled and fixed effect) in order to assess how important is demographic change to the Brazilian regional growth. The results for these six models are presented in Table 4. The speedy of convergence is negative and significant for all models and varies between 3.9% (unconditional equation in model 1 estimated by the pooled method) per year and 16.7% per year (conditional equation in model 3 estimated by the fixed effect method). Also the effect of education – a proxy for human capital – is positively related with economic growth as suggest by endogenous growth models, whereas population density is not significant.

The relevance of demographic change on regional growth is evaluated accordingly the specifications in the models 2 and 3. In accordance to the results for model 2, total dependency ratio is negatively related to economic growth and such a result seems to be robust in both estimation methods. However, the results are different when the child and aged components of dependency ratio are considered separately into the convergence equation. In this case (model 3), only the child dependency ratio has a negative effect on regional growth while the aged dependency ratio has a positive effect[4]. As the parameter of total dependency ratio is also negative, it can be assumed that the child component is dominant on the growth effect identified for total dependency ratio in the model 2.

[4] We rely mainly on the results obtained by the fixed effects panel model since it is less sensitive to omitted variables bias. Also it's worth noting that Chow test for not-observed effects is favorable to the fixed effects regressions. Additionally, Hausman test confirms that fixed effects regressions are more adequate to represent the data than random effect regressions.

Table 4. Panel Data Results for the convergence equations

Explanatory Variables	Pooled Method			Fixed Effects Method (cross-section)[a]		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
INC – Initial income per capita	-0.039*	-0.1173*	-0.1250*	-0.0783**	-0.1613*	-0.1670*
	(0.0066)	(0.0096)	(0.0082)	(0.0313)	(0.0063)	(0.0066)
AEST – Education		0.0651*	0.0742*		0.0889*	0.0730*
		(0.0132)	(0.0113)		(0.0131)	(0.0057)
DENS – Population density		-0.0055*	-0.0002		-0.0049	-0.0002
		(0.0019)	(0.0019)		(0.0032)	(0.0034)
DPR – Dependency ratio		-0.1963*			-0.1478*	
		(0.0383)			(0.0383)	
CDPR – Chil Dependency ratio			-0.1702*			-0.1747*
			(0.0328)			(0.0221)
ADPR – Aged Dependency ratio			-0.9099*			0.4547***
			(0.1329)			(0.2318)
Constant	0.2272*	0.7006*	0.7394	0.4093*	0.8379*	0.8490
	(0.0308)	(0.0607)	(0.0519)	(0.1274)	(0.0214)	(0.0161)
Observations	81	81	81	81	81	81
R-squared	0.3046	0.6918	0.7813	0.6063	0.9606	0.9669
Adjusted R-squared	0.2958	0.6756	0.7667	0.4057	0.9370	0.9459
Akaike info criterion	-3.8064	-4.5461	-4.8642	-3.7332	-5.9612	-6.1104
Schwartz criterion	-3.7473	-4.3983	-4.6869	-2.9055	-5.0448	-5.1644
Chow test				1.56	13.12	10.57
Hausman test				36.2759	274.0370	193.4171
Wald test				6869.12	1.20e+07	1356.58

Note: Standard errors in parentheses, * significant at 1%, ** significant at 5%, *** significant at 10%. a Fixed effect panel model estimated with white cross-section correction.

These results are consistent with those obtained by Fukuda and Morozumi (2004) and Prskawetz, Fent and Barthel (2007). Thus, regional demographic change seems to be another relevant channel of influence on regional economic growth in Brazil. As suggested by the descriptive analysis in section 3, the higher the child dependency ratio the lower per capita income growth, and the higher the aged dependency ratio the higher the per capita income growth. As an important conclusion, the pattern of regional demographic transition in Brazil could contribute to reduce (to increase) regional income inequality if child and aged dependency ratio converge (not converge) across states.

Table 5 present the Moran's I statistics calculated for the errors estimated in each regression. The significance values for the I-Moran test show that spatial autocorrelation is present on the errors, especially at the 1980s and 1990s. Looking on the statistics calculated from the convergence equation conditioned by demographic factors and estimated through the fixed effects method, the extent of the spatial dependence identified for the 1980s seems higher than that one for the 1990s. Moreover, the spatial dependence expressively reduces when the child and aged components of dependence ratio are separately considered into the convergence equation. This is explained by the spatial heterogeneity observed in the child an aged dependency ratio as discussed in section 3 and also enhances the need to consider the demographic factors separately into the convergence equation.

Based on the Moran's I statistics, the results for the convergence equations should be assessed carefully. As mentioned before, the consistency of those results can be affected by spatial effects and need to be properly handled in the estimation methods. This issue will be addressed in the further research.

Table 5. Moran's I statistics for spatial autocorrelation

Spatial Matrix	Pool Method			Fixed Effects Method		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Cross-sectional 1970s						
Queen	0.609*	0.397*	0.135	0.012	0.062	0.008
K-nearest 1	0.924*	0.650*	0.316	0.052	0.014	-0.110
K-nearest 2	0.734*	0.442*	0.060	0.077	0.012	-0.034
K-nearest 3	0.660*	0.464*	0.160	0.053	-0.120	-0.113
K-nearest 4	0.594*	0.435*	0.123	0.131	-0.158	-0.077
K-nearest 5	0.611*	0.442*	0.166**	0.115	-0.092	-0.011
Cross-sectional 1980s						
Queen	0.336*	0.060	-0.111	0.249**	0.530*	0.489*
K-nearest 1	0.503**	0.164	0.042	0.413*	0.795*	0.749*
K-nearest 2	0.445*	0.118	-0.076	0.556*	0.635*	0.551*
K-nearest 3	0.317*	0.087	-0.104	0.411*	0.432*	0.348*
K-nearest 4	0.284*	0.090	-0.137	0.275*	0.354*	0.294*
K-nearest 5	0.328*	0.084	-0.125	0.253*	0.333*	0.267*
Cross-sectional 1990s						
Queen	0.653*	0.295**	0.473*	0.351*	0.377*	0.227***
K-nearest 1	0.908*	0.337	0.443**	0.734*	0.614*	0.381***
K-nearest 2	0.734*	0.253***	0.404*	0.397**	0.409*	0.269***
K-nearest 3	0.653*	0.251**	0.411*	0.287**	0.185***	0.116
K-nearest 4	0.573*	0.292*	0.427*	0.182***	0.073	0.064
K-nearest 5	0.567*	0.334*	0.427*	0.107	0.092	0.084

Note: * significant at 1%, ** significant at 5%, *** significant at 10%.

6 Final remarks

As people's economic behavior change over the cycle of life, economic growth can be influenced by demographic change. In this paper we addressed the importance of demographic change to the dynamics of regional economic growth in Brazil, a country characterized by high and persistent regional inequality. Most of the empirical literature in Brazil investigates on regional convergence exist and the role of some factors postulated by the endogenous growth models such as physical and human capital. Some studies explore other factors such as agglomeration, spatial effects and urbanization, but little attention has been dedicated to better understand the demographic conditioners of regional inequality in Brazil.

Following the recent developments in the theoretical and empirical literature on economic growth where demographic change is explicitly modeled, we estimate convergence equations for evaluating how demographic change would be related with the dynamics of economic growth among Brazilian states. The main results suggest that demographic change matters for regional income convergence in Brazil. Moreover, child dependency ratio is negatively correlated with economic growth and aged dependency ratio is positively correlated. As child dependency ratio is higher for North and Northeast compared to South and Southeast, part of the persistence in regional inequality can be associated with the pattern of the regional demographic structure and its change. Thus, regional demographic transition – the change from high to low rates of fertility and mortality – could contributes to reduce (to increase) regional inequality if child and aged dependency ratio converge (not converge) across the states.

However, we emphasize that this is a paper in progress whose results are preliminary and should be carefully assessed. We proceeded to initial tests in order to evaluate the presence of spatial effects on the errors of the regressions and it seems evident the need to handle with this issue on the estimation methods. Also, as suggested by Arrellano and Bond (1991), it seems relevant to work with estimation techniques robust to endogeneity problems using GMM methods. Therefore, the advance of this research comprehends dealing with these issues in the context of the estimation of spatial panel data models.

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