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LOCATION SPILLOVERS AND GROWTH AMONG BRAZILIAN STATES

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Location spillovers and growth among Brazilian states

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Abstract

The objective of this study if to provide empirical evidence on the importance of location for the growth of per capita income among 25 Brazilian states in the period 1985-1997; we also investigate the possible sectoral sources. First we estimate growth spillovers among the state economies; we then investigate the possible sectoral channels through which these spillover effects might operate. Our results indicate a strong presence of geographical growth spillovers. Moreover, the growth of neighbor states seems to be more important for growth than the growth of trade partner states. The detected spillover effects do not seem to reflect interstate sectoral labor productivity spillovers.

1. Introduction

Growth spillovers among neighbor economies, either related to technology or human or physical capital, are quite common. Several models and empirical studies show that the distance among economies is an important condition for variables that directly affect growth, such as foreign direct investment (Eaton and Tamura, 1994), transmission and absorption of technology (Jaffe, Trajtenberg and Henderson, 1993; Eaton and Kortum, 1994, 1996), trade of goods and services (Frankel and Wei, 1993; Frankel and Romer, 1996), and labor migration (Braun, 1993; Barro and Sala-I-Martin, 1995). However, empirical evidence on the direct effect of such spillovers are scarce; it is even harder to find evidence of such influences through different sectors of the economies.

The purpose of this study is to provide empirical evidence on the importance of location for the growth of per capita income among Brazilian states for the period 1985-1997, and to explore the possible sectoral sources involved in such a process. In the first step, the importance of location spillovers for growth is directly identified and estimated; the possible channels through which such spillovers operate are then investigated. The results indicate that per capita income growth of states is significantly affected by their neighbor's growth. Moreover, the growth of neighbor states seems to be more important than the growth of trade partner states. The importance of spillovers is not significantly affected by a possible absolute convergence dynamics, as measured by the traditional growth equations. However, we did not find any evidence that growth spillovers could reflect sectoral labor productivity spillovers in agriculture or manufacturing.

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In the next section we present a review of the literature on geographical growth spillovers. In section 3 we present and discuss the data sources used in this study. In section 4 we present some evidence on the geographical distribution of per capita income levels and growth rates for Brazilian states, and calculate some spatial statistics. Estimates of direct growth spillovers through different proximity measures are provided in section 5. In section 6 we analyze modifications in the previous results in a convergence after the introduction of control variables traditionally used in this sort of study. The possibility that the observed geographical spillovers could reflect the presence of sectoral spillovers is explored in section 7. In section 8, we present our conclusions.

2. Location and spillovers: theories and evidence

Several reasons can be identified for the existence of geographical spillovers. A trivial factor is related to the non-economic way the borders of different spatial units are defined: borders are usually not related to the geographic (physical and human) and economic background of the jurisdictions, providing a favorable situation for intense interaction. Lower transportation costs and some indivisibilities in communication technology make the interaction among neighbor economies easier and faster, through the flow of goods, factors and information. Neighbor economies tend to experience common shocks, such as wars, political instabilities or even weather-related events, such as droughts, excessive rain, etc., factors that could condition their economic performance in a similar fashion. All these factors could be responsible for the occurrence of spatial autocorrelation in important growth-related variables.

The formalization of such effects is relatively recent. Influenced by the pioneering works of Arrow (1962) and Romer (1986) on the importance of externalities resulting from technical progress that are not fully captured by private agents, and Lucas (1988) on the importance of externalities related to human capital, Chua (1993) developed an interesting study. The author develops a growth model with neoclassical characteristics, incorporating explicitly in the production function of a specific spatial unit within the region, investments in physical and human capital existing at the regional level. He hypothesizes that such regional investments affect technical progress directly in the production function of spatial unit *i*, and therefore its growth. Using a Cobb-Douglas production function and taking the usual hypotheses of the neoclassical growth model, the author shows that growth in spatial unit *i* depends on the spillovers generated by investments in human and physical capital in the region at large.

Goodfriend and McDermott (1994) explore the direct influence of technical progress in neighboring economies, incorporating location as a key factor in the determination of the degree of income convergence in a growth model with technological spillovers. Barro and Sala-i-Martin (1997) propose a model in which the growth of leading economies, based on the discovery of new products and technologies, is latter diffused to follower economies, thus promoting their growth. In their model, per capita product growth (g_y) around the steady state (*) in the follower economy (*i*) can be expressed by

$$g_{yi} = g_{Aj} - \mu\left[\log\left(\frac{y_i / y_j}{\left(y_i / y_j\right)^*}\right)\right], \qquad (2)$$

with j indicating the leading economy, A_j representing technical progress, and μ being a constant related to imitation costs. Introducing location spillovers implies that μ is dependent on the location of economies i and j.

Some imperfect markets and returns to scale models developed without geographical inspiration have also been used to point out the importance of spatial effects on growth. Murphy, Shleifer and Vishny (1989a, 1989b) propose a model for a small economy in which the growth of an export-oriented leading sector generates enough internal market to make industrialization possible, stressing the importance of the location of such a small economy for growth. The well-known "big push" model emphasizes the importance of the simultaneous growth of all sectors in an economy for its growth. The same argument can be easily transferred to small economies trading among themselves: they can experience simultaneous "big pushes", thus providing reciprocal markets and fostering their simultaneous growth (Moreno and Trehan, 1997).

Recent empirical evidence on these locational effects is very solid. Case (1992) showed, for Indonesian regions, that individuals are strongly influenced by their neighbors in the adoption of new technologies. Case and Rosen (1993) provide solid evidence that government expenditures in American states are positively affected by the expenditures of neighboring states. Jaffe, Trajtenberg and Henderson (1993), studying patent citations in American states, indicate that knowledge spillovers present strong geographical constraints. Ades and Glaeser (1994) show that regional highway density was an important factor for the growth of American states in the period 1849-1890. The results of Rey and Montuori (1998) and Rey (1999), applying spatial econometric tools to study income convergence among American states, indicate that shocks in a specific state do affect neighboring states, making the transition convergence dynamics more complex than without considering such spatial effects. Chua (1993) finds that investments in human and physical capital in neighbor countries are important growth determinants for a specific country. Barro and Sala-i-Martin (1995) and Easterly and Levine (1995) indicate that the growth of per capita income in a country is significantly affected by the performance of neighbor countries. Ades and Chua (1997) show that political instabilities in the neighborhood have a negative impact on the growth of countries. Moreno and Trehan (1997) verify the influence of neighbor countries on growth, but find out that this influence is not fully explained by common shocks and or by trade flows among countries. In the Brazilian case, few studies consider spatial effects in analyzing the growth of Brazilian states. Magalhães et al (2000), working with Brazilian states, indicate that traditional cross-section studies present specification errors for not considering spatial effects. Mossi et al (2000) present spatial statistics that indicate the presence of spatial autocorrelation among Brazilian states.

3. The Database

The main data source for this study is the regional account information developed by IBGE, the Brazilian official data agency (IBGE, 1999), covering the period 1985-1997. We use product per capita and value added in agriculture and manufacturing for 25 Brazilian states[1]. Employment data for agriculture come from the IBGE census of 1985 and 1996; the IBGE industrial census of 1985 and industrial survey of 1997 provide the data for manufacturing. Data for the trade flow among states

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[1] The state of Tocantins is added to Goiás, since the former was part of the latter in the initial years of the series. The Federal District (Brasília) is excluded from the sample, due to the strong and erratic influence of the federal government wage policy on its per capita income.

come from CONFAZ (National Council on Finance Policy) and are available for 1985 and 1997. For a flow variable indicating investments in human capital we use the education index developed by UNDP/IPEA, that is the average of the illiteracy rate and the combined enrollment rate. For proxies of the stock of human capital we use the average of schooling years for the population as a whole and for the employed population. Both the flow and stock variables come from a national survey of a sample of households (PNAD), also developed by IBGE.

4. Spatial statistics evidence

The spatial distribution of per capita income in the Brazilian territory is highly unequal, as can be observed in Figure 1, with the Southeastern states presenting higher income levels; it is also quite stable over time, as pointed out by Magalhães et all (2000). As for the growth rates, portrayed in Figure 2, it can be observed that the Central and some neighboring Northeastern states present better performances in the period considered in this study. In order to analyze these spatial aspects, we model the influence of the other spatial units j on spatial unit i through the weighted average of their influences, or

$$Ly_i = \sum_j w_{ij} y_j \quad , \qquad \forall j \in \mathrm{S}_i \, , \tag{3}$$

with y_i being the per capita income of i (an element in the y variable vector), S_i representing the set of neighboring spatial units, w_{ij} corresponding to the element i,j of matrix $\mathbf{W}$ and L being the spatial lag operator. The values of Ly_i for each geographical unit i represent the spatial lagged values for y. As for matrix $\mathbf{W}$ we use Moran´s scatterplot and Moran's I; in this section we use a contiguity matrix with standardized weights $w_{ij} = 1$if spatial units i and j are contiguous, and $w_{ij} = 0$ otherwise, or if $i = j$. The standardized weights $w_{ij}^{p} = w_{ij} / \sum_j w_{ij}$ assume values between 1 and 0.

Figure 3 portrays Moran´s scatterplot, with the horizontal axis presenting the standardized income growth and the vertical axis presenting income growth of neighbors (spatial lagged, standardized). It can be observed that the majority of states are either in quadrants I or III, that is, states tend to be clustered together with states with similar performance, conforming a clear pattern of spatial concentration of growth rates. It is interesting to note that this growth rate pattern differs from the pattern observed for per capita income levels by Magalhães et all (2000). Thus, it does not seem to be a correspondence between the two ways of analyzing the regional economies.

Table 1 presents the values of Moran's I statistic for two different proximity measures: the weighting matrix described above and the inverse of the distance between the capital of the states. The latter allows for the influence of all states in the sample and its weights are given by

$$w_{ij} = \frac{1/d_{ij}^{2}}{\sum_j \left(1/d_{ij}^{2}\right)}, \tag{5}$$

With d_{ij} corresponding to the distance between the capital cities of states i and j. The values in the table indicate that the coefficient is significant at levels below 2% for both measures of proximity, thus supporting the spatial dependence hypothesis.

Table 1 – Spatial dependence test
Moran´s I for per capita GDP growth of states

Contiguity	Inverse of distance^2
2.111 (0.017)	2.413 (0.008)

p-value in parenthesis

5.Location and *spillovers*: evidence from an spatial econometric model

In this section we show additional evidence of the existence of spillovers and to measure them. We use the model proposed by Moreno and Trehan (1997), in which a relationship between the growth rates of states is postulated. A simple growth spillovers model can be represented by

$$g_{yi} = \rho \sum_{j=1}^{n} w_{ij} g_{yj} + \varepsilon_i \ , \qquad i = 1,\ldots\ldots\ldots\ldots\ldots n; \qquad \text{or} \tag{6}$$

$$\boldsymbol{g_y} = \rho . \boldsymbol{W} . \boldsymbol{g_y} + \boldsymbol{E} \ , \tag{7}$$

Where w_{ij} corresponds to the elements of matrix **W;** bold letters indicate vectors and matrixes, and $\boldsymbol{E} \sim \mathrm{N}(0, \mathrm{I}\sigma^2)$. Since this model does not allow for the identification of the channels through which the geographical impacts operate, it provides only a gross first step towards their identification.

As demonstrated by Anselin (1988), the econometric problem comes from the simultaneous presence of the growth rate in both sides of equation (7), what makes $\mathrm{E}((\boldsymbol{Wg_y})'\boldsymbol{E}) = \mathrm{E}\{[\boldsymbol{W}.(\mathbf{I} - \rho\boldsymbol{W})^{-1}\boldsymbol{E}]'.\boldsymbol{E}\}$ to be null if $\rho = 0$ only. Since the OLS estimator is inadequate in this situation, the Maximum Likelihood estimator is used in the majority of spatial models. For the above model, the log likelihood function is given by

$$\boldsymbol{L} = -\frac{\boldsymbol{n}}{2}\ln\pi - \frac{\boldsymbol{n}}{2}\ln\sigma^2 + \ln\left|\boldsymbol{I} - \rho\boldsymbol{W}\right| - \frac{\left((\boldsymbol{I} - \rho\boldsymbol{W})\boldsymbol{g_y}\right)'\left((\boldsymbol{I} - \rho\boldsymbol{W})\boldsymbol{g_y}\right)}{2\sigma^2} , \tag{8}$$

where $\boldsymbol{n}$ corresponds to the number of geographical units and the other variables are the same as in the previous equations. The term with a determinant in the right-hand shows up because of the change in the density function, since $(\boldsymbol{I} - \rho\boldsymbol{W})\boldsymbol{g_y} = \boldsymbol{E}$. The estimates are obtained through non-linear numerical optimization using the *maxlik* extension of GAUSS.

The results obtained using a contiguity matrix (standardized) are presented in column I of Table 2. They indicate that the estimated parameter is highly significant, resulting in a strong evidence of regional growth spillovers among Brazilian states. The estimated value for the parameter ρ indicates that a growth of 1% in the neighboring states is associated to a growth of .63% in spatial unit *i*; that is, more than half of the percentual growth is transferred to neighboring states.

As Moreno and Trehan (1997) pointed out, the above specification does not provide any information on the causes or channels through which the spillovers operate. The remaining of this study will investigate the possible ways the spillovers operate in the case of Brazilian states. Given the variety of possibilities, it is important to investigate now the sensitivity of the results to the use of different proximity measures. Columns II and III of Table 2 show the same results using different ways of measuring geographical proximity. The spillover coefficient using (inverse of distance)^2 is significant and its value is quite similar to the one previously estimated; however, using the inverse of distance makes proximity non-significant. Note that in this latter case the importance of contiguous neighbors is less important than in the other two cases. In column IV the inverse of distance is weighted by the size of the neighbor's economy, giving more weight to bigger states (as represented by their GDP size). In this case, ρ becomes marginally significant. This result favors the idea that interstate growth effects tend to be limited to closer states and are not disseminated to farther states. The last column presents results in which trade flows (in the initial year) are used as a proximity measure, providing results similar to the ones in column I. The results indicate that the use of the contiguity matrix is quite reasonable, specially considering its lower standard deviation and better results as far as the information criterion is considered.

Table 2 – Gross growth s*pillovers*
Dependent variable is g_y

	Contiguity (I)	Inverse of Distance^2 (II)	Inverse of distance (III)	Inverse of distance and GDP (IV)	Trade Flows (V)
Constant	0.057 (0.480)	0.067 (0.143)	0.090 (0.466)	0.101 (0,463)	0.053 (0.480)
ρ	0.635 (0.000)	0.577 (0.005)	0.457 (0.163)	0.401 (0.063)	0.666 (0.019)
σ	0.16553	0.16747	0.18630	0.17990	0.17888
AIC	-2.14803	-1.18299	-2.03587	-2.08695	-2.08496
SC	-2.05052	-1.08598	-1.93836	-1.98874	-1.98745

p-values in parenthesis; σ corresponds to the standard deviation of the residuals of the regression; AIC and SC refer to the Akaike and Schwarz information criterion, respectively.

6. Location spillovers, convergence and common shocks

In this section we start the investigation of the possible causes or channels for the existence of growth spillovers. At first we will add to the regressions some variables used in the literature to represent growth determinants, in order to observe the existence of net spillovers, instead of the gross spillovers detected in the previous section. One of such variables is the initial level of per capita income, since spillovers could reflect the initial regional distribution of some growth determinants. We also investigate the possible role of common shocks.

6.1 Growth spillovers and absolute convergence

We start by introducing into equations (6) and (7) only the initial level of per capita income in each state, in order to investigate if states are converging to a common level of per capita income over time, the absolute convergence situation. The new equations become then

$$\boldsymbol{g}_y = \rho \boldsymbol{W} \boldsymbol{g}_y + \beta \boldsymbol{y}_0 + \boldsymbol{E} \qquad \text{ou} \qquad (9)$$

$$(\boldsymbol{I} - \rho \boldsymbol{W})\boldsymbol{g}_y = \beta \boldsymbol{y}_0 + \boldsymbol{E} \qquad (10)$$

whit $\boldsymbol{y}_0$ standing for the levels of per capita income in the states in 1985. The corresponding log maximum likelihood function to be maximized is given by

$$\boldsymbol{L} = -\frac{\boldsymbol{n}}{2}\ln \pi - \frac{\boldsymbol{n}}{2}\ln \sigma^2 + \ln|\boldsymbol{I} - \rho \boldsymbol{W}| - \frac{\left((\boldsymbol{I} - \rho \boldsymbol{W})\boldsymbol{g}_y - \beta \boldsymbol{y}_0\right)'\left((\boldsymbol{I} - \rho \boldsymbol{W})\boldsymbol{g}_y - \beta \boldsymbol{y}_0\right)}{2\sigma^2} \qquad (11)$$

The traditional convergence equation is estimated with OLS; its residuals are then used for spatial dependence and specification tests. Table 4 presents the results. The OLS results do not reveal absolute convergence, at the traditional significance levels. The growth spillover coefficient is still significant but its absolute value is reduced from .635 to .490, a 23% decrease. This is an important result, considering the highly concentrated distribution of per capita income in the country. The ML estimates do not change significantly the findings of the previous section as far as convergence is concerned. The tests based on the OLS residuals indicate that the spatial dependence hypothesis cannot be rejected and, in a way, confirm the results of the previous section. The Moran's I statistic and the $\text{LM}_{\rho,\psi}$ test provide more general evidence in favor of a model specification taking into consideration spatial dependence (the subscript ψ indicates a specification explicitly assuming spatial dependence for the errors). The robust LM_{ρ} test favors equations (9) and (10).

Table 3 – Net convergence spillovers
Dependent variable is g_y

	OLS	ML
Constant	1.207	1.022
	(0.049)	(0.051)
y_0	-0.129	-0.117
	(0.085)	(0.070)
ρ	-	0.490
		(0.010)
$\overline{R}^2$	0.0850	-
σ	0.18629	0.15834
AIC	-	-4.51167

Tests for diagnosing spatial dependence

Moran's I	$LM_{\rho\psi}$	LM_{ρ} Robust
2.473	7.078	3.809
(0.003)	(0.029)	(0.051)

p-values in parenthesis; σ corresponds to the standard deviation of the residuals of the regression; AIC and SC refer to the Akaike and Schwarz information criterion, respectively. All tests have as the null hypothesis the existence of spatial dependence.

6.2 Growth spillovers, conditional convergence and human capital

The previous results have shown that the effect of neighborhood on growth remains significant even in a context of income convergence. That is, the state's stage of development accounts only partially for the presence of spatial spillovers. We now introduce investment in human capital and regional dummies in the model. The latter will be introduced to verify if spillovers can be explained by the common characteristics of states within the same region. This includes all variables with a regional pattern of behavior, such as temperature, latitude, rainfall, etc.[2]. As for human capital, we follow Mankiw, Romer and Weil (1992) suggestion to incorporate the dynamics of human capital accumulation in the Solow model in order to obtain a better empirical performance. It must be noticed that, like the initial level of income, this variable has a marked regional distribution, with neighbor states presenting similar levels of human capital and of investments in education. It is thus possible that growth spillovers do show up through this determinant of growth. Moreover, as showed by Benabib and Spiegel (1994), human capital might have an important role in the growth dynamics not only as an additional factor in the production function of the economies, but also representing the region's possibility to absorb technical progress from more advanced economies. Similar levels of education in neighbor states might thus reflect similar possibilities of technology absorption.

After introducing these variables, the model estimated in the previous section becomes

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[2] Azzoni et all (2000) have shown that such variables did have an important role in the growth of per capita income of Brazilian states in the period 1981-1986.

$$\boldsymbol{g}_{\boldsymbol{y}} = \rho \boldsymbol{W} \boldsymbol{g}_{\boldsymbol{y}} + \boldsymbol{X}\beta + \boldsymbol{E} \qquad \text{or} \tag{12}$$

$$(\boldsymbol{I} - \rho \boldsymbol{W})\boldsymbol{g}_{\boldsymbol{y}} = \boldsymbol{X}\beta + \boldsymbol{E}, \tag{13}$$

Where $\boldsymbol{X}$ is a matrix containing initial income and human capital; β is the associated parameter vector[3]. This is a typical conditional convergence equation, augmented to include the growth of neighbors, but we will be particularly interested in the channels for the operation of growth spillovers. Education is introduced in two alternative ways: investments in education, as represented by the education index presented in section 3 for 1981, or the average of schooling years in 1985, as a proxy for the initial stock of human capital.

The results are presented in Table 4. In the first column we only add regional dummies to the previous model and conditional convergence is observed; the dummy coefficients (Northeast is the omitted region) present the expected signs, with only the North region presenting a non-significant dummy coefficient. The spatial lag coefficient is further reduced, as compared to the absolute convergence estimation, but remains significant. This indicates that it is capturing effects that are not related to the regional variables, suggesting that spillovers are not fully explained by common regional

Table 4 – Net spillovers and conditional convergence
The dependent variable is g_y

	ML (I)	ML (II)	OLS (III)
Constant	2.698	2.691	2.836
	(0.000)	(0.000)	(0.002)
y_0	-0.344	-0.358	-0.404
	(0.000)	(0.000)	(0.001)
Education	-	0.224	0.699
		(0.338)	(0.281)
Dummy Southeast	0.387	0.351	0.290
	(0.000)	(0.003)	(0.073)
Dummy South	0.393	0.360	0.318
	(0.000)	(0.003)	(0.047)
Dummy Center	0.317	0.294	0.261
	(0.000)	(0.001)	(0.016)
Dummy North	0.079	0.055	0.009
	(0.109)	(0.247)	(0.920)
ρ	0.358	0.309	-
	(0.040)	(0.055)	
σ	0.104898	0.105174	0.129759
AIC	-5.046170	-4.980029	-
$\overline{R}^2$	-	-	0.5561
Moran's I			0.624
			(0.260)

p-values in parenthesis; σ corresponds to the standard deviation of the residuals of the regression; AIC refers to the Akaike information criterion.

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[3] The log likelihood function is similar to equation (9), with human capital modifying only the last term. Within the terminology proposed by Anselin (1988) for linear spatial models, this is a *regressive-spatial autoregressive model*.

characteristics. In column II the education index is introduced[4] and it does not appear as significant. Since this variable has a marked regional distribution, the regional dummies already capture its influence. The spatial lag coefficient is slightly reduced but remains significant at 5.5%. The Moran's I statistic, calculated from the residuals of the regression presented in column III, now does not indicate the presence of spatial dependence.

6.3 Spillovers and common shocks

In this section we explore the possibility that spatial dependence is due to geographically located shocks, common to determined regions and states[5]. We use the following specification

$$\boldsymbol{g_y} = \boldsymbol{X}\beta + \boldsymbol{E} \quad , \quad \text{where} \tag{14}$$

$$\boldsymbol{E} = \psi \boldsymbol{WE} + \mu \tag{15}$$

With $\mu \sim N(0, I\sigma^2)$. Thus, the same geographical pattern assumed for growth rates is imposed on the shocks (same **W** matrix) and the spatial influence parameter is now given by ψ. This specification indicates that growth in as state is not attached to the growth of the neighbors, as such, but that they are all subject to common shocks affecting their growth rates.

The Maximum Likelihood estimates are presented in Table 5. The first column represents the traditional conditional convergence situation and the second column presents the results of the new model. The estimated values for the different coefficients in the two specifications are quite close and the coefficient of the model with spatial

Table 5 – Net spillovers, education and common shocks (S*patial error dependence*)
Dependent variable is g_y

	OLS	*ML - Spatial Error*
Constant	2.122 (0.00)	2.76 (0.00)
y_0	-0.382 (0.01)	-0.400 (0.000)
Education	1.07 (0.07)	1.849 (0,000)
ρ, ψ	-	-0.140 (0.328)
$\bar{R}^2$	0.00	-
σ	0.5084	0.14071
AIC	-	-1.37348

p-values in parenthesis; σ corresponds to the standard deviation of the residuals of the regression; AIC refers to the Akaike information criterion.

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[4] The results do not change if the average number of years of schooling is substituted for the education index.

[5] Droughts in the Northeast and frosts in the South are good examples of such shocks.

dependence in the errors (*spatial error model*) is not significant. By the criteria presented, this spatial error model is inferior to the spatial lag model presented in the previous section. Thus, the other variables included in the regression, especially investment in human capital, seem to be capturing any influence of common shocks on the growth of neighbors.

7. Sectoral locational spillovers

The interstate influences detected in the previous sections could be explained by, or reflect, interactions due to the growth dynamics of sectoral productivity. That is, high productivity growth in manufacturing or agriculture in neighboring economies could positively affect productivity growth in spatial unit *i*. Silveira-Neto and Azzoni (2000) have shown that the per capita income dynamics of Brazilian states reflects reasonably well the dynamics of the aggregated product per capita (or productivity); and that the aggregated productivity dynamics reflects the dynamics of sectoral productivity. The authors show that convergence results are practically the same either for per capita income of for productivity (product per worker).

In this section we investigate this aspect for agriculture and manufacturing[6] only, since data for the service sector are not available. As in the previous part of this paper, we first provide information on spatial statistics and then move on to estimate the econometric model of equations (6) and (7).

7.1 Sectoral spillovers: spatial statistics evidence

Figure 4 and 5 show Moran's scatterplots for agriculture and manufacturing and Figures 6 and 7 present mappings of growth rates. It is clear that in these cases we have more states in quadrants II and IV than we had with aggregated per capita income (Figure 3), and the association of the performance of a state with its neighbors is less evident. The Moran's I statistics presented in Table 6, using the contiguity matrix W, confirm that no regional pattern of productivity growth is present. The estimated statistics are not significant, especially for manufacturing.

Table 6 – Testing for spatial dependence: Moran's I for productivity growth

Agriculture	Manufacturing
1.171	0.285
(0.121)	(0.388)

p-value in parenthesis

7.2 Sectoral Spillovers: econometric model evidence

In spite of the results obtained in sub-section 7.1, we obtained additional evidence on the importance of location for the presence of growth spillovers for labor productivity in the two sectors studied. The estimated model corresponds to equations

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[6] "Manufacturing" includes mining activities.

(6) and (7), using the contiguity matrix **W** to represent the structure of interactions among states.

The results presented in Table 7 are consistent with the spatial dependence tests developed above. The spillover coefficient is not significant at the traditional confidence levels for both sectors. Therefore, in spite of the existence of growth spillovers for the aggregated per capita income, these regional influences do not occur through the growth of labor productivity in agriculture and manufacturing. This important result must be qualified: it may be due to the high level of sectoral aggregation used, since manufacturing as a whole is quite a complex and diversified sector and individual sub-sectors could present regional dependence; besides that, sources of sectoral regional influences other than the one tested could also be the relevant way through which spatial dependence takes place, and our tests did not capture them.

Thus, even having found no evidence of sectoral influences on the structure of spatial dependence, it might as well be that these could be present in specific sub-sectors within those broad sectors or between different sectors of different states. This perspective is sustained by Glaeser et al (1992), in their study of the growth of cities: as for knowledge spillovers, the authors suggest that inter-sectoral effects are more important than effects involving firms within a sector. Gracia-Milá and McGuirre (1998) provide evidence that the variety of the productive mix of American states has positive influence on regional employment growth. Another point refers to interstate trade flows: a relative increase in inter-regional (and a relative decrease in intra-regional) trade flows is observed between 1985 and 1997, that is, trade with neighboring states is decreasing, relatively. Since trade may be an important source of influence among states, the results obtained for agriculture and manufacturing, sectors with mostly tradable products, are consistent with this trend.

Table 7 – Labor productivity growth spillovers

	Agriculture	Manufacturing
Constant	0.017	0.071
	(0.449)	(0.172)
ρ	0.245	0.009
	(0.176)	(0.486)
σ	0.674328	0.367709
AIC	-1.552019	-2.967340

p-values in parenthesis; σ corresponds to the standard deviation of the residuals of the regression; AIC refers to the Akaike information criterion

8. Conclusions

We have provided in this paper empirical evidence on the importance of location for regional per capita income growth among Brazilian states. We have investigated its importance in convergence regressions before and after including the variables traditionally considered in such sort of analysis. The statistical and econometric results have registered important influences of neighboring economies on the growth of a state's economy; these influences do not seem to take place through agriculture or manufacturing. The proximity measures calculated have shown that spillovers are important mainly among adjacent or closer neighbors, and that their effects diminish markedly with distance. Another important finding is that proximity is more important than trade relationships for growth: the weighted product growth of neighbors is a better predictor of state growth than the weighted growth of trade partners.

When we move into conditional convergence equations, introducing variables controlling to different steady state situations, the spillovers effects are still significant but are reduced by almost half of its previous values. This indicates that only part of these effects is explained by common initial levels of development or by the regional characteristics of neighboring states. Finally, we have investigated whether or not the interstate influences could take place through agriculture or manufacturing productivity spillovers and we have found no evidence that such is the case.

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Figure 2 - Per Capita GDP Growth (%) - 1985-97

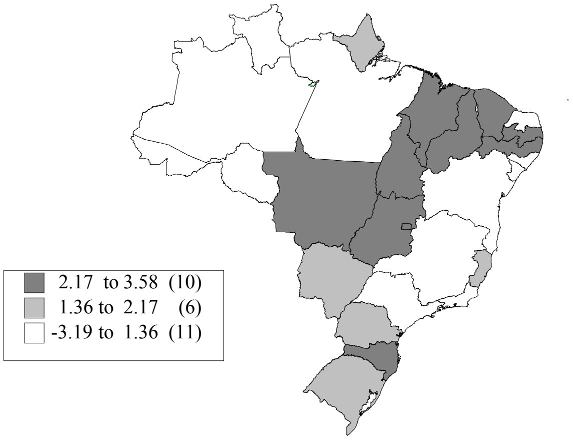


Figure 2 - Per Capita GDP Growth (%) - 1985-97

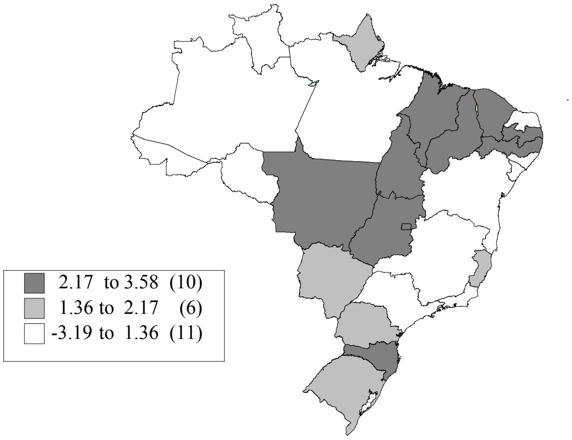


Figure 6 - Labor Productivity Growth in Agriculture (%)

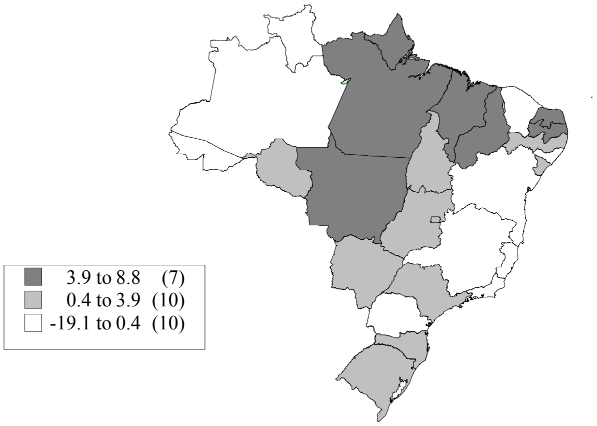
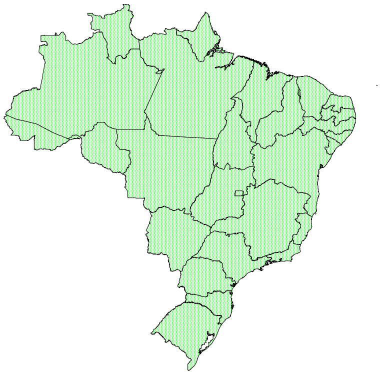


Figure 7- Labor Productivity Growyh in Manufacturing (%



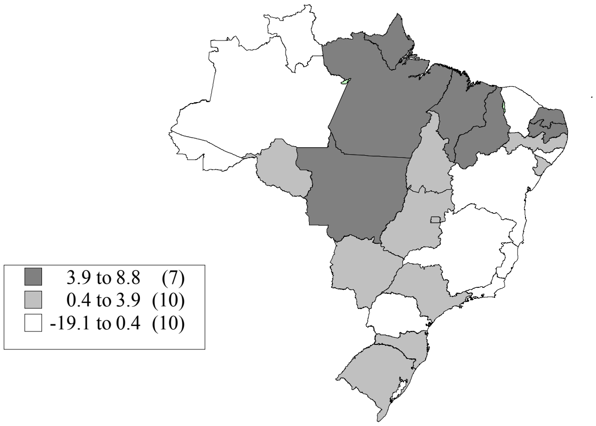


Figure 6 - Labor Productivity Growth in Agriculture (%)

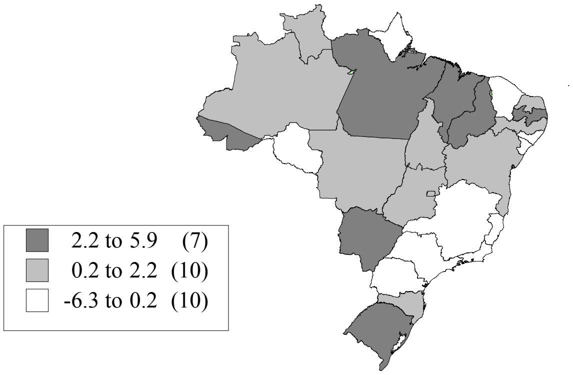


Figure 7- Labor Productivity Growyh in Manufacturing (%)

Figure 3 - Moran's Scatterplog of Per Capita GDP Growth

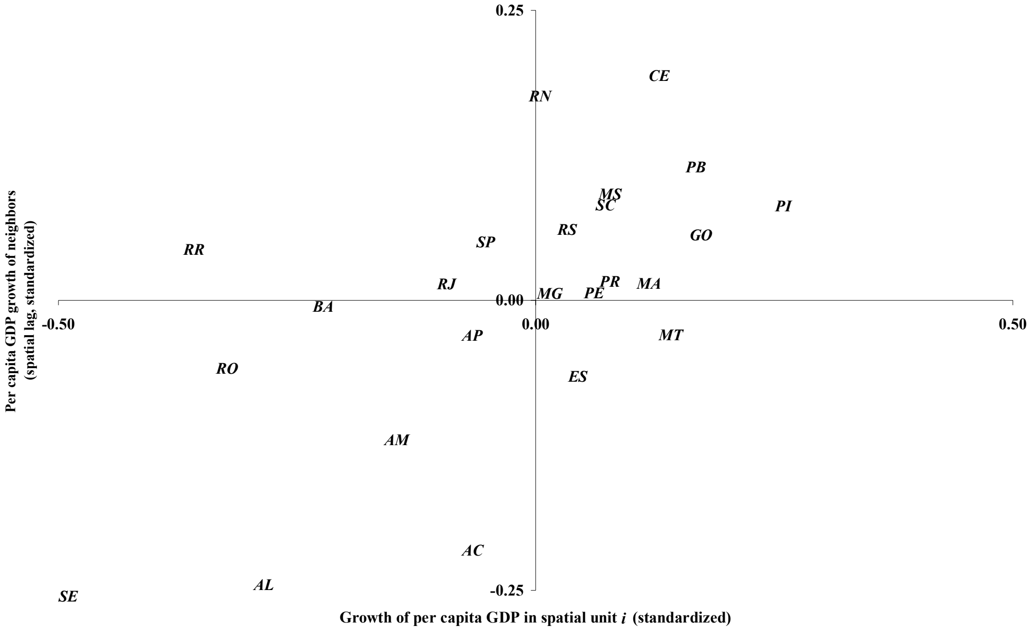


Figure 4 - Moran's Scatterplot - Productivity Growth in Agriculture

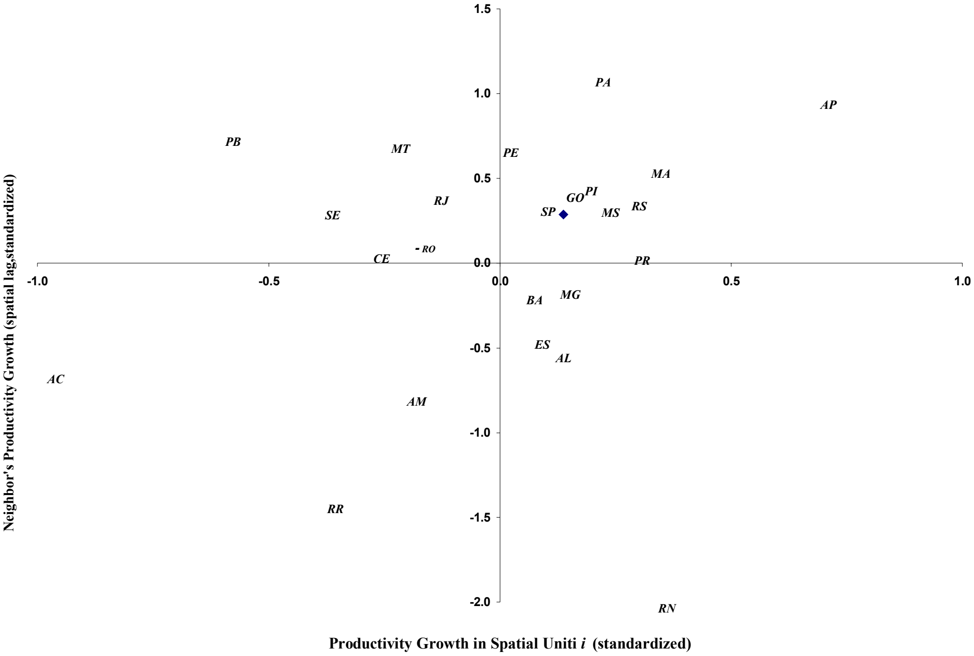


Figure 5 - Moran's Scatterplot - Productivity Growth in Manufacturing