The New Economic Geography and Regional Growth in Brazil and India

by

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Abstract

This dissertation tries to contribute to empirically assess hypotheses of the "New Economic Geography". Specifically, we tested the relevance of the combination of lower transportation cost with the role of economies of scale in explaining the regional distribution of total activity and of industrial activity. Economies of scale are assumed to be due to "backward and forward" linkages among firms. We also took into account congestion effects and asymmetry among regions.

The model was tested for the regions of Brazil, in the period 1950-1995 and 1970-1995, and for the regions of India, in the period 1961-1991.

Using panel results, we observed that transportation costs were generating concentration of total activity in the periods 1950-1995 and 1950-1970. For these samples, there is evidence that economies of scales were a cause of concentration of total activity. Other forces, not explained by the model, were generating dispersion and so were congestion effects.

For the period 1970-1995, we found that congestion effects and lower transportation cost were helping to disperse economic activity, in the panel

results. Economies of scale were not, contrary to the model's predictions, helping economic growth.

In the case of Brazil, for the 18-state samples, industrial activity tended to concentrated due to the effects of lower transportation cost, although higher industrial growth rates were a characteristic of the states with less economies of scales.

In the case of India, strong concentration effects were taking place, both due to lower transportation cost and due to other reasons. Economies of scale were not important in the explanation of the path of India activity.

Note: this dissertation contains 89 307 words (from Introduction to Conclusion). The extension of the printed pages is due to the usage of double space and to the insertion of tables.

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Introduction

Among different schools of thought, there has been a resurgence of interest in regional economics in the last decades. The persistence of high levels of inequality among countries and states, especially in the developing countries, the concern with the impact of globalisation on these inequalities, and the observation of important changes in the distribution of activities among regions, are some of the items that explain this renewed interest in the subject.

From a theoretical perspective, the debate on regional economics was further encouraged by the assessment of the mainstream attempt to discuss the impact of increasing returns and imperfect competition in regional economics, while maintaining the general equilibrium set up. The beginning of this process can be dated in 1991, with the publication of Krugman's "Increasing Returns and Economic Geography" (Krugman, 1991a) and "Geography and Trade" (Krugman, 1991b).

In 1999, the main ideas developed by the so-called "New Economic Geography" were condensed in a textbook - "The Spatial Economy", which was crucial to the establishment of its contents in the mainstream literature. As Junius (1999) comments, the

"New Economic Geography" (NEG) is still at the beginning of the second phase of a theoretical development, which is the empirical testing of its inferences and hypothesis.

Our objective in this dissertation is to make a contribution to this second phase, by testing if some predictions of the NEG are not refuted by the data. More precisely, heavily based on Krugman and Venables (1995), we want to investigate if economies of scale in the industrial sector (or in the industrial and service sectors taken together), in a context of decreasing transportation costs, are important to determine the distribution of total and industrial activity among regions.

Our assessment will be restricted to developing countries, which are particularly interesting because they tend to be characterised by high rates of inequality in the distribution of their economic activity, but the empirical methods which we use would be equally well applied to advanced countries.

Two countries will be discussed: Brazil and India. The comparison between them seems interesting because of their large size and the presence of significant internal markets (in both cases imports represents only about 10% of GDP). They are similar as well in terms of political division, which facilitates our empirical work.

In the case of Brazil, we will observe the distribution of total activity in the period 1950-1995, excluding the states of the North from our sample, because of lack of data availability before 1970. The sub-periods 1950-1970 and 1970-1995 are also discussed. Our fourth sample for Brazil includes the states of the North, which are peculiar since they have a large area of land occupied by forest, and in some sense represent a "frontier economy".

In the case of India, our data set includes the period 1961-1991, with 20 states.

The impact of (external) economies of scale with decreasing transportation cost on the distribution of activity will be measured by the performance of the states' total growth rate of income (or industrial growth rate).

It is important to note that we are not trying to explain the per capita values of these variables (as is common in growth regressions) because migration decisions are one of the determinants of regions' relative economic weight and therefore a significant element of what we are trying to explain.

If our investigation supports NEG ideas, we can not only better understand the regional development of Brazil and India, but also make some conclusions about the appropriate direction of economic policy.

The structure of the dissertation is as follows.

Chapter I displays the ideas on which we will base our empirical work, and discusses the impact of an asymmetry in parameters and congestion effects on the models.

We will base our empirical investigation on the importance of changes in transportation cost, associated with external economies of scale, in the distribution of activity among regions. Following the models, we expect that economies of scale generate concentration of activity, when transportation cost lie within a certain range. Economies of scale can be dispersing economic activity, if transport costs take a different value.

Congestion effects are forces that help to disperse economic activity, while asymmetries among regions can lead to strong patterns of concentration.

Chapter II incorporates a review of ideas that are usually critical to the mainstream approach in regional economics. We want to observe the relevance of their criticisms and if possible extract theoretical and empirical improvements from them.

In this Chapter, although our view of the economic distribution of activity was enriched, we did not find feasible empirical hypotheses to test.

Chapter III displays our empirical specification that will be used to assess the theoretical ideas displayed in Chapter I. We will use two main techniques: cross-section and time-fixed panel regressions.

Our empirical specifications are constructed to measure the impact of transport availability, economies of scale and congestion effects on the growth rate of total income and on the growth rate of industrial income. We can infer if these variables are generating concentration or dispersion of activity. We control all the equations for per capita income, since we need to take into account asymmetries among states. Another set of equations measures how changes in transportation cost affect the coefficient of per capita income, more directly measuring what kind of distribution of activity is being generated by a decline in transportation cost.

Chapter IV shows the cross-section results for Brazil, using all samples and the two dependent variables: the growth rate of total output and the growth rate of industrial output.

Few significant results were found for the cross-section results for Brazil. For the 18-state samples (excluding the North), the main information obtained is that congestion effects were dispersing economic activity and that the Centre-West states were experiencing an outlier positive performance.

Observing all significant coefficients and coefficients with high t-statistics, we could infer that lower transportation cost has acted towards a concentration of economic activity in the whole period, 1950-1995, and in the first sub-period (1950-1970). In the second sub-period, lower transportation cost has contributed to disperse total income.

In the 24-state sample (including the North), there was a movement of economic activity towards richer states. On the other hand, there was a dispersion of activities towards the less industrialised states. Without controlling for the states of the North, transport availability was not helpful for growth. States with low population density were growing less and the regional dummy (North) seems to be important.

Analysing the industrial growth rate, we can observe that there was a dispersion of industrial activity towards poor, less industrialised and (in the case of the 1970-1995 period) agricultural states. With the exception of the behaviour of the 24-state sample with INDGSP, higher industrial growth rates were associated with higher proximity to markets, and a decrease in transportation cost was generating concentration of industrial activity.

Chapter V shows the panel results for Brazil, only discussing the dependent variable growth rate of total output. In this chapter we refine our research by discussing the impact of the Northern states, the existence of structural changes and omitted variable problems, while we also develop an additional test for NEG model.

We found more significant results in the panel exercises. In the period 1970-1995, poor states were growing more, and lower transportation costs were helping this dispersion. In the period 1950-1970 and in the whole period - 1950-1995 -, this dispersion of activity was reduced by lower transportation costs, resembling the "core-periphery" phase of the NEG model.

The hypothesis that "backward and forward linkages", in the industrial sector or in the industrial and service sectors taken together, were generating concentration of activities is not refuted in the first sub-period (1950-1970) and in the whole period (1950-1995 - only when considering the industrial and service sectors together).

We also found that there were few significant changes in coefficients between the two sub-periods, that economies of agglomerations were generating concentration of activities and that the Northern states have a strong influence on the signs of the transportation cost variables, although the dummy for these states is not significant in the relevant specifications.

Chapter VI repeats the exercises of Chapter V with the industrial growth rate as the dependent variable.

For almost all samples industrial activity was becoming more evenly spread across Brazil in the sense that the growth of industrial output is negatively correlated with the initial share of industry in the state output. An exception is that, for the sample 1950-1970, we still find positive coefficients for the initial share of industrial and service sector taken together, but they are not significant.

A lower transportation cost reduces the dispersion of industrial activity in the samples 1950-1995, 1950-1970 and in the sample 1970-1995 (18-States). It decreases the negative coefficient of per capita income and of the initial share of industry. For the larger sample of the period 1970-1995, the impact of transportation costs is unclear.

The coefficients of the share of industrial and service sectors taken together (in the state's output) and of the population density variable have changed between the two sub-periods (1950-1970 and 1970-1995) of the period 1950-1995. The North was an important variable to explain the behaviour of transportation costs in the larger sample. Finally, economies of agglomeration help to concentrate economic activity.

Chapter VII discusses both cross-section results and panel results for India.

In the cross-section results for India, we found evidence that transport availability and proximity to richer markets generated concentration of economic and industrial activity in the period 1961-1991. In the few equations where we found a significant coefficient for per capita income, we could conclude that there was a faster growth of economic and industrial activity in the richer states of India, particularly if combined with proximity to markets.

Information about the importance of "backward and forward" effects was scarce, but the significant coefficients are negative, refuting the hypothesis of the model.

The panel results (bases on three ten-year periods) were very inconclusive, although we confirmed that a lower transportation cost favoured the growth of richer states and that the growth of industrial activity was faster in less industrialised states.

Chapter I - Theoretical Framework

Introduction

The aim of this dissertation is to empirically test some hypotheses of the so-called "New Economic Geography". In this chapter we are going to highlight the main features of this theoretical branch.

In Section I.1 we will present a broad view of what "New Economic Geography" is; in Section I.2 we will present the models that are supporting our empirical work; in Section I.3 we will introduce some modifications to the original model of Krugman (1991); and in Section I.4 we will show how links were established between the ideas of "New Economic Geography" and "New Economic Growth".

I.1 - "New Economic Geography"

The publication of Fujita, Krugman and Venables, "The Spatial Economy"[1], in 1999, was an event that signalled the consolidation of "New Economic Geography" as an organised branch of study in mainstream economics.

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[1] - References to Fujita, M., Krugman, P. and Venables, A.J. (1999) will be abbreviated to FKV (1999).

"New Economic Geography" (NEG) is a theoretical branch that wishes to highlight the importance of space in the economic process, modelling the traditional ideas of urban and regional economics and of location theory (Fujita, Krugman and Venables, 1999). It is also influenced by the concepts discussed in the New Trade theory.

This book appeared eight years after the first attempt to bring back the importance of space in the economic process. Krugman, in "Geography and Trade" (1991b), tried to explain the history of the American manufacturing belt by using a new model that combined increasing returns, transportation cost and the role of demand. The existence of increasing returns and imperfect competition creates, in this model, incentives for firms and population to be unevenly distributed in space.

As explained by Krugman (1998 a and b), "New Economic Geography" is an attempt to explain why some distribution of production and population occurs in space (in a city, a country, or in the world). The main concepts used by NEG are not new in the literature. The contribution of NEG was to model these ideas in a specific way. Krugman (1998b) explained that the models are built as a tension between the existence of immobile resources and the impact of different sizes of markets. These forces are part of the list of "centripetal" and "centrifugal" forces highlighted by Marshall. Marshall listed market-size effects, pure external economies and concentrated labour markets as the main forces that lead to the concentration of production in some areas. Acting in the opposite direction are the existence of immobile resources, pure external diseconomies and land rents, helping to sustain a more even distribution of space. The choice of immobile resources and market-size effects in this list reflects modelling considerations and a desire to find ways to include distance in the model, which is achieved by the highlighting of transportation costs and by the inclusion of immobile resources. Krugman also wanted to avoid working with extremely general concepts such as external economies (Krugman, 1998b).

The tension between immobile resources and market-size effects is framed within a general equilibrium approach, in which the distribution of demand and the distribution of non-natural inputs are endogenised. This endogenisation is considered the main improvement of NEG compared to traditional theories (Krugman, 1998b).

Krugman (1998b) also explains that the absence of consideration of space in mainstream economics in the past can be explained by the lack of necessary tools to deal with a set-up that includes increasing returns and imperfect competition.

This problem was solved by incorporating some theoretical improvements that were used in the "New Industrial Organisation" and "New Economic Growth" theories. More specifically, NEG uses two important devices: the Dixit-Stiglitz (1977) model and iceberg transportation costs. The Dixit-Stiglitz model assumes monopolistic competition, allowing the treatment of increasing returns to be consistent with the general equilibrium approach. Iceberg transportation costs, in their turn, simplify the modelling process, since they do not require a separate transport sector in the model, and they do not affect the elasticity of substitution of demand (Krugman, 1998b).

We are especially concerned with three models: Krugman (1991a), Krugman and Venables (1995) and Puga (1999). They will provide the theoretical support for our empirical work.

I.2 - Krugman (1991a), Krugman and Venables (1995) and Puga (1999)

We are going to focus on three "New Economic Geography" models: Krugman (1991a), Krugman and Venables (1995) and Puga (1999).

The choice of these models as the models that we are going to analyse reflects two main factors. Firstly, they, in different ways, raise questions about the possibility of inequality among regions, which is one of our major concerns; secondly, they help to establish a contact between economic growth and NEG, and we will try to explore this in Section I.4.

Krugman (1991a) develops in a more formal approach the ideas of "Geography and Trade". In this work, the main question is why a dispersion of manufacturing production can occur. There is a tension between market-size effects and the existence of an immobile group of peasants. The market-size effect is driven by the number of workers in a region that not only affects the demand for the products, but also affects the wage cost of the firms. Although considered a very simplified model by the author, this model provides the main idea of NEG.

The movement of workers between the regions gives the "dynamics" of the model. Although NEG models have a static framework, they have an *"ad hoc"* dynamic characteristic (FKV, 1999, p. 62). The dynamics of the main original models are given by the movement of the economic agents, stimulated by the geographical differences in current returns. Given differences in current real wages or in profits between the regions, workers or firms will migrate until the factors' markets have been cleared. A natural way to model this would be to allow factors to move at the end of each time period.

Some recent papers have however shown that some results of the main models remain unchanged when dynamics are formally addressed. Baldwin (2001) gives a very good review of the literature on this issue. He highlights that the "core-periphery" model involves two main difficulties to analyse dynamics: one is that it is based on non-linear differential equations, and discussing global stability with forward-looking expectations is a major mathematical problem. Recent works are dealing with the subject, which requires some modification of the original model and/or a limited range of parameters. Baldwin takes the option to follow the ideas of the "core-periphery" model, introducing forward-looking expectations for the migrants. He proves analytically that the "break" and "sustain" points with forward-looking expectations are the same as the ones calculated with the model with myopic workers, if the costs of migration are high. Also, numerically, the global stability of the model with forward-looking expectations is the same as in the original "core-periphery" model.

The second model is Krugman and Venables (1995). This model discusses an international issue. It assumes that labour is the immobile resource and that economies of agglomeration are due to backward and forward linkages among the firms. The existence of a larger market stimulates the footloose firms to concentrate in one place, due to the existence of increasing returns in manufacturing. On the other hand, the existence of a large number of firms producing a variety of intermediate goods decreases the cost of the final goods firms. The tension in Krugman and Venables' (1995) model is between labour as an immobile resource, since it is an international trade model, and market-size effects due to the "backward and forward" linkages among firms. The question raised by the paper is if openness will decrease the real wage of the North (the advanced region) or, in a broader way, if openness is a force against inequality.

Puga (1999) worked on a more general model, allowing both migration and linkages among firms to generate changes in the distribution of activities. Since our empirical work will be focused on regional differences within a country, we must use a theoretical framework that allows for migration. But since we are also interested in the importance of commerce among firms as a source of "backward and forward linkages", Puga's model is the appropriate theoretical support for our empirical work.

Although migration is allowed in our empirical work, the main ideas that will be tested were already in Krugman and Venables' (1995) model.

For carrying on our empirical work, we need also to make some modifications to these models. First of all, we will not assume total symmetry between regions, since there exist large differences between the regions in the countries we will study. Secondly, we will allow for the existence of diseconomies of agglomeration (congestion effects). These modifications to the model are also of interest because they allow us to understand its structure better. The resulting theoretical inferences, in which we will base our empirical work, will be called K&V(m)((m) stands for modified) model.

I.2.1 - Krugman (1991a)

The model developed in "Increasing returns and economic geography" (1991a) has a clear task: "... I shall ask why manufacturing in general might end up concentrated in one or a few regions of a country, with the remaining regions playing the 'periphery' role of agricultural suppliers to the manufacturing 'core'" (Krugman, 1991a, p. 485).

Two features of the model are stressed by Krugman: the importance of pecuniary externalities and the importance of initial conditions.

In a set-up of perfect competition, there is no role for demand to affect the behaviour of production in the long run. But, if imperfect competition is assumed, the production decisions of the firms can be affected by the behaviour of the demand.

Since "cumulative causation" is assumed by the model, and since the model also assumes increasing returns, a small change in parameters hugely affects the results.

The model consists of two regions and two sectors of production: manufacturing and agriculture. The agricultural sector has constant returns to scale and is characterised by perfect competition. Also of importance is that there are no transportation costs for agricultural production: this is performed by peasants, who are not allowed to migrate between regions. Peasants cannot work in manufacturing. Finally, the number of peasants is equally divided between the two regions in question.

The number of peasants in each region is: $(1-\gamma)/2$, where γ is the fixed proportion of manufacturing labour in the economy (and also, by choice of units, the proportion of manufactures in consumption).

The manufacturing sector is characterised by increasing returns and imperfect competition. The production of manufactured goods requires only labour. Calling L_1 and L_2 the amount of manufacturing labour in the two regions, it is necessary that

$$L_1 + L_2 = \gamma \qquad (1).$$

The production of manufacturing goods requires a fixed and a variable amount of labour:

$$L_{mi} = \alpha + \beta x_i \qquad (2),$$

where α = fixed requirement of labour; β = marginal requirement of labour; x_i = quantity of output i; and L_{mi} = necessary amount of labour to produce product i.

It is extremely important that the manufacturing sector faces transportation costs. Krugman assumes the "iceberg" type of transportation costs, which means that it is assumed that for each unit of goods shipped, a fraction τ ($\tau<1$) arrives at the destination. If the fraction of goods that arrives is small, it means that the firms face huge transportation costs.

In this economy, there are several firms. Because of the presence of increasing returns, each firm produces only one type of goods, and because consumers are assumed to like variety, the number of firms in the economy is equal to the number of goods in this economy.

The firm sets its price (p) following the mark-up rule:

$$p_1 = (\sigma/\sigma-1)\beta\ w_1 \qquad (3),$$

where σ = elasticity of substitution of demand; and w_1 = wage rate in region 1.

Since the same specification applies to region 2, the relative price between the regions is:

$$p_1/p_2 = w_1/w_2 \qquad (4).$$

Assuming free entry, profits will be zero. So,

$$(p_1 - \beta w_1)x_1 = \alpha w_1 \qquad (5),$$

and by substituting from (3) $x_1 = x_2 = \alpha(\sigma-1)/\beta$ (6).

Equation (6) implies that the total production of manufacturing goods in region n will be proportional to the number of workers:

$$n_1/n_2 = L_1/L_2 \qquad (7).$$

The demand side of the economy assumes individuals that maximise their utility, subject to a budget constraint. Consumers like variety, and they consume manufacturing and agricultural goods.

The utility function (U) is:

$$U = C^{\gamma}_{M}\, C^{1-\gamma}_{A} \qquad (8),$$

where γ = share of expenditure in manufactured goods; C_M = consumption of manufactured goods; and C_A = consumption of agricultural goods.

The utility derived from the consumption of manufacturing is represented by a CES sub-utility function, and the love of variety is expressed in the parameter σ, the elasticity of substitution of demand.

$$C_M = [\sum_{(i=1\ldots N)} c_i^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)} \qquad (9),$$

where c_i = consumption of a manufactured good of type i.

Taking the quantity of labour in each region as given, it is possible to identify the level of income of each region.

Maximising the utility function subject to the budget constraint,

$$Lagr = ([\Sigma_{(i=1...N)} c_i^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)})^{\gamma} C_A^{1-\lambda} - \chi(p_1C_{11} + (p_2/\tau)C_{12} - w_1L_1 + (1-\lambda)/2)$$

where χ = shadow price; C_{11} = consumption of region 1 of a manufactured good from region 1; and C_{12}= consumption of region 1 of a manufactured good from region 2.

The two derivatives of the Lagrangian (Lagr) are:

$$\partial\chi/\partial C_{11} = C_A^{1-\lambda} (\lambda\sigma/(\sigma-1)) [\Sigma_{(i=1...N)} c_i^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)-1} ((\sigma-1)/\sigma) c_{11}^{(\sigma-1)/\sigma-1} -\chi p_1$$

$$\partial\chi/\partial C_{12} = C_A^{1-\lambda} (\lambda\sigma/(\sigma-1)) [\Sigma_{(i=1...N)} c_i^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)-1} ((\sigma-1)/\sigma) c_{12}^{(\sigma-1)/\sigma-1} -\chi p_{2/\tau}$$

Since the two derivatives must be equal:

$$C_{11}/C_{12} = (p_1\tau/p_2)^{-\sigma} = (w_1\tau/w_2)^{-\sigma} \qquad (10).$$

If Z_{11} is defined as the ratio of expenditures of region 1 of its own manufacturing compared to the expenditure on manufacturing that comes from region 2, and if Z_{12} is defined as the ratio of expenditures of region 2 on manufacturing from region 1, compared to its internal consumption of manufactured goods:

$$Z_{11} = (n_1/n_2)(p_1\tau/p_2)(C_{11}/C_{12}) = (L_1/L_2)(w_1\tau/w_2)^{-(\sigma-1)} \quad (11),$$

$$Z_{12} = (n_1/n_2)(p_1\tau/p_2)(C_{11}/C_{12}) = (L_1/L_2)(w_1/w_2\tau)^{-(\sigma-1)} \quad (12).$$

Total income (Y) is the sum of workers' and peasants' income (each peasant is assumed to have an income of one):

$$Y_1 = (1-\gamma)/2 + w_1L_1 \quad (13),$$

$$Y_2 = (1-\gamma)/2 + w_2L_2 \quad (14).$$

Workers' income in each region is equal to expenditure in manufacturing produced in that region:

$$w_1L_1 = \gamma\ [(Z_{11}/(1+Z_{11}))\ Y_1 + (Z_{12}/(1+ Z_{12}))\ Y_2] \quad (15),$$

$$w_2L_2 = \gamma\ [(1/(1+Z_{11}))\ Y_1 + (1/(1+ Z_{12}))\ Y_2] \quad (16).$$

Another element stressed by Krugman is the decrease, in the long run, in the price level of the region with the higher population.

If $f = L_1/\gamma$, or the share of region 1 in the total manufacturing labour force,

$$P_1 = [f(w_1)^{-(\sigma-1)} + (1-f)(w_2/\tau)^{-(\sigma-1)}]^{-1/(\sigma-1)} \quad (17),$$

$$P_2 = [f(w_1/\tau)^{-(\sigma-1)} + (1-f)(w_2)^{-(\sigma-1)}]^{-1/(\sigma-1)} \quad (18),$$

$$\omega_1 = w_1 P_1^{-\gamma} \quad (19),$$

$$\omega_2 = w_2 P_2^{-\gamma} \quad (20),$$

where P = manufacturing price index; and ω = real wage.

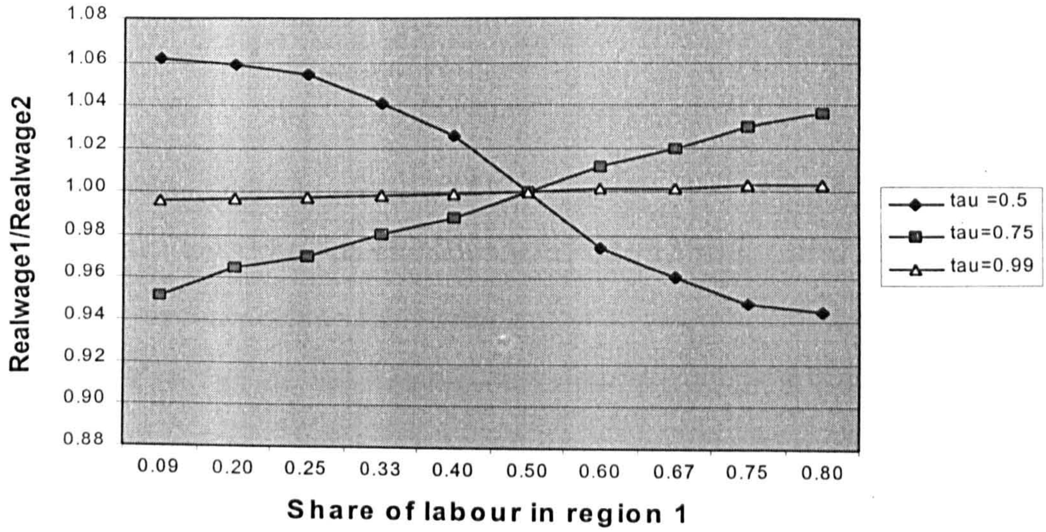
What happens to the distribution of production, based on equations (15) to (20), depends on the amount of labour in each region. If labour is equally split, real wages in the two regions will be equal and two equally sized regions will exist.

Uneven distribution of labour usually creates a gap between the real wages in the two regions. This implies that, if for example $\omega_1 > \omega_2$, labour will migrate to region 1 until the labour market clears, and the core-periphery outcome will prevail in the long run.

The ratio, ω_1/ω_2, is not only a function of the amount of labour in region 1 (compared to the total labour force). It is also a function of the level of transportation costs. More precisely, the slope of the function $\omega_1/\omega_2 = z(f)$ depends on the level of transportation costs.

Figure 1 illustrates Krugman's (1991a) model. At a high level of transportation cost (τ=0.5), the slope of the function is negative, having symmetry as the long-run equilibrium. At lower levels of transportation costs, the slope of the function is positive and the path is unstable, since all the manufacturing labour ultimately ends up in one region. Agglomeration will take place under low values of transportation costs.

FIGURE 1 - KRUGMAN (1991a)



Another way to understand the movement of the ratio ω_1/ω_2 is to relate it to the underlying forces of the model. When labour migrates to region 1, "centripetal" forces will tend to generate a higher real wage in this region. These forces are the "home market effect" and the "price index effect". The "home market effect", represented by equations (11) to (16), is the increase in income that is due to the higher amount of expenditure, since transport costs bias expenditures towards the home region. The "price index effect" is represented by equations (17) and (18). If more workers are in the region with more manufacturing, the price index of this region is lower, because a smaller proportion of goods will be imported (facing transportation costs) (FKV, 1999).

Acting on the other side is the "centrifugal force", which is the effect of a larger supply of workers in competing down wages. The value of ω_1/ω_2 depends on the relative strength of these "centrifugal and centripetal forces", which is influenced by the distribution of labour and by the level of transportation costs.

It can also be observed in Figure 1 that the negative slope when $\tau=0.75$ is higher than with $\tau=0.99$, showing, at each level of f, a higher real wage gap. This means that the forces that generate agglomeration eventually decline as transportation costs fall. When there is no transportation cost, the firms will be indifferent about location.

What further determines the shape of the function that links the real wage ratio to the share of manufacturing labour in region 1 are the elasticity of substitution of the demand and the fraction of expenditure on manufactured goods. A lower elasticity of substitution would imply the presence of higher economies of scale that stimulate agglomeration. A higher expenditure on manufactured goods would increase the strength of the "home market effect". If we have an initial difference in the distribution of labour among the regions, these parameters would generate a positive relationship between the real wage ratio and the share of the labour force.

Krugman (1991a) investigates the conditions that are necessary for the core-periphery to be unstable. To answer this question, he considers a situation where all manufacturing is concentrated in region 1 (f=1).

Since:

$$Y2/Y1 = (1-\gamma)/(1+\gamma) \qquad (21).$$

Total revenue per firm in region 1 is:

$$V_1 = (1/n)(\gamma)(Y_1 + Y_2) \qquad (22).$$

Since utility must be the same in all regions:

$$w_2/w_1 = (1/\tau)^{\gamma} \qquad (23).$$

If a firm is considering moving from region 1 to region 2, it will take into consideration the total revenue (V) in region 2:

$$V_2 = [\gamma/n][(w2/w_1\tau)^{-(\sigma-1)}Y_1 + (w2\tau/w1)^{-(\sigma-1)}Y_2] \qquad (24).$$

Using (21)-(23), the relative revenue for a defecting firm would be:

$$V_2/V_1 = [(\tau^{-(\gamma+1))})^{-(\sigma-1)}(1+\gamma) + (\tau^{(1-\gamma)})^{-(\sigma-1)}(1-\gamma)]/(1+\gamma+1-\gamma)$$

$$V_2/V_1 = (1/2)\tau^{\gamma(\sigma-1)}((1+\gamma)\tau^{(\sigma-1)} + (1-\gamma)\tau^{-(\sigma-1)}) \qquad (25).$$

But since the nominal wage in region 2 must compensate the workers for having to import more expensive products from region 1, V_2/V_1 must be greater than $w_2/w_1 = \tau^{-\gamma}$. Adjusting the relative revenue (v),

$$v = (1/2)\tau^{\gamma\sigma}((1+\gamma)\tau^{(\sigma-1)} + (1-\gamma)\tau^{-(\sigma-1)}) \qquad (26).$$

It is possible now to understand the impact of the main parameters of the model in the sustainability of the core-periphery equilibrium, analysing the derivatives with respect to these parameters in the vicinity of v=1 (Krugman, 1991a).

The derivative of v with respect to the share of expenditures in manufactured goods is negative, reflecting the importance of a higher market as one of the forces of the model:

$$\partial v/\partial\gamma = v\sigma(\ln\tau) + (½)\tau^{\sigma\gamma}(\tau^{\sigma-1} - \tau^{-(\sigma-1)}) < 0 \qquad (27).$$

When transportation costs are high, firms are dispersed. At the other extreme, when transportation costs are very small, v equals one, showing the indifference of the firms' decision with respect to this parameter (Krugman, 1991a).

The relationship between v and transportation costs shows a U-shaped curve. At high transportation costs, activities are dispersed. When transportation costs fall, there is a range of values compatible with the core-periphery equilibrium. When transportation costs fall more, then transportation costs are not important in the location decision of the firms (Krugman, 1991a):

$$\partial v/\partial \tau = \gamma\sigma v/\tau + [\tau^{\gamma\sigma}(\sigma-1)((1+\gamma)\tau^{\sigma-1} - (1-\gamma)\tau^{-(\sigma-1)}]/2\tau \quad (28).$$

Finally, close to v=1,

$$\partial v/\partial \sigma = \ln(\tau)(\tau/\sigma)(\partial v/\partial \tau), \text{ is positive} \quad (29).$$

This last result shows how high economies of scale lead to the agglomeration of the activities.

In this last exercise, Krugman is calculating the level of transportation costs where the core-periphery equilibrium becomes stable, also called the "sustain point". Two questions are highlighted in NEG's approach. At each value of transportation cost, is an equal distribution of activities between regions a stable equilibrium ("break point")? And, at each value of transportation cost, is asymmetry between regions possible ("sustain point")? The calculation of these "bifurcation points" ("critical values of parameters at which the qualitative behaviour of the economy's dynamics changes") (FKV, 1999, p. 34) is sometimes only possible through numerical solutions. Their values describe the tension between the centripetal and centrifugal forces in the models (FKV, 1999). An interesting outcome is that the set of conditions that stimulates workers and firms to act in a way that would destroy the symmetrical equilibrium is different from the set of conditions that would make a core-periphery distribution be transformed into an even one. In the majority of the models, the "sustain point" is smaller than the "break point" (FKV, 1999).

I.2.2 - Krugman and Venables (1995)

In "Globalization and Inequality of Nations" (1995), Krugman and Venables developed a model that tried to address the debate about the impacts of the globalisation process.

The main differences from the 1991a model are that labour is immobile (reflecting barriers to international migration), and, especially, the external economies of scale are not due to changes in wage costs, but to the "backward and forward" linkages among firms. It emerges that there is a possibility of a further convergence after a period of divergence.

Having an opportunity of serving a larger market is profitable to an imperfect competition firm that has increasing returns ("backward linkages"). But the fact that a larger market attracts manufacturing firms to a specific region decreases the cost of the firms in this region, due to the greater availability of inputs ("forward linkages").

Two regions are assumed: North and South.

Both regions can produce agriculture and manufacturing goods.

Workers are one source of demand in this economy, both for manufacturing and for agricultural goods. Workers (L) receive only their wage (w) and their expenditure function can be represented by:

$$Q_A^{(1-\gamma)} Q_M^{\gamma} V$$

where γ = share of expenditure in manufacturing goods; Q_A = price of agriculture goods; Q_M = price index of manufacturing goods; and V = utility.

Since workers only receive a wage as income, the budget constraint is:

$$wL = Q_A^{(1-\gamma)} Q_M^{\gamma} V \qquad (1).$$

Q_M is the price index of manufacturing goods that are aggregated through a CES sub-utility function. If n is the number of firms (and products) in the North, p the price of each good produced in the North, p* the price of goods produced in the South, t is the transportation costs (t is the inverse of τ: "a proportion 1/t of the good arrives" at the destination (Krugman and Venables, 1995, p. 862), and t>1), and σ is the elasticity of the demand, the price index will be:

$$Q_M = (np^{1-\sigma} + n^* (p^*t)^{(1-\sigma)})^{1/(1-\sigma)} \quad (2).$$

As in the previous model, agriculture is subject to constant returns to scale and does not face transportation costs. In this model, agricultural production uses labour and the choice of units guarantees that

$$w \geq 1 \quad (3).$$

The manufacturing sector is characterised by imperfect competition and increasing returns to scale. It uses labour and a variety of manufacturing goods as inputs, combining these factors through a Cobb-Douglas technology. Firms produce for the domestic market (y) and for export (x). The total cost (TC) of the firms is expressed by:

$$TC = w^{1-\mu} Q_M^{\mu} (\alpha + \beta (y+x)) \qquad (4).$$

Workers spend a fraction, γ, of their income on manufactured goods from the North. Firms also are a source of demand for manufactured goods, since a fraction, μ, of their costs is due to the usage of intermediate goods. So the expenditures (E) in North will be:

$$E = \gamma wL + \mu(x+y)\, pn \qquad (5).$$

The second term assumes a zero profit condition, so that revenue, $(x+y)pn$, is equal to total costs, and a fraction, μ, of total revenue is used to buy intermediate (manufactured) goods.

Firms set their prices through mark up:

$$p\,(1-1/\sigma) = w^{1-\mu} Q_M^{\mu} \beta \qquad (6).$$

The demand for y and x can be expressed by the following equations:

$$y = p^{-\sigma} Q_M^{\sigma-1} E \quad \text{and} \quad x = p^{-\sigma} t^{1-\sigma} (Q_M{*})^{\sigma-1} E{*} \qquad (7).$$

With the conditions set above, the size of the firms will be:

$$y+x = (\sigma-1)\alpha/\beta \qquad (8).$$

By (7) and (8) and the choice of units $((\sigma-1)\alpha/\beta = 1)$, the zero profit condition can be written as:

$$1 = p^{-\sigma} (Q_M{}^{\sigma-1} E + t^{1-\sigma} (Q_M{}^*)^{\sigma-1} E^*) \qquad (9).$$

Krugman and Venables (1995) stress the role of the number of firms (n) in the profits of the firm. If n increases, the price index decreases, decreasing the profits of the firm. But, if there is commerce among firms, if n increases, the cost of the firms will decrease ("forward effect") and more firms also represent a greater demand ("backward effects"). This source of increasing returns is different from the one in the previous model, where the "backward and forward" effects were driven by the movements in real wage.

The model shows several possible outcomes depending on the parameters, specially depending on the transportation cost value.

At high levels of transportation cost, both countries will produce manufacturing and agricultural goods and the real wage will be equal to unity. As transportation cost decreases, the symmetrical equilibrium is a possible outcome, but divergence also can happen. At a critical point of transportation cost (lower), the symmetrical equilibrium is unstable and manufacturing will be concentrated in one of the regions. This region will have a higher real wage.

The critical level of transportation cost that would break the symmetrical equilibrium is lower if the share of expenditures in manufactured goods is higher. If consumers buy more manufactured goods (γ is high), the incentive for firms to concentrate in a region and exploit the benefits of its increasing returns will be higher. If firms use intermediate goods heavily in their production (μ is high), the stronger linkages among the firms will encourage agglomeration.

If transportation costs fall still further, then firms may reallocate their production to the other country, to take opportunity of the lower real wage.

I.2.3 - Puga (1999)

Puga (1999) made the first attempt to merge Krugman (1991a) and Krugman and Venables (1995), by creating a model where each of these would appear as special cases. He also incorporated the impact of the determinants of agglomeration in the labour market.

In Puga's (1999) model we have two regions, each one provided with K_1 and K_2 units of arable land, which is the immobile resource. Labour (L) is mobile between agriculture and industry.

The agricultural output is traded without cost, and its price is the numeraire of the model. The production in this sector is subject to a constant return technology that uses labour and arable land. The restricted profit function (R) of the agricultural sector (symbolised by the superscript A) is:

$$R(p_i^A, w_i, K_i) = \max\ (p_i^A y_i - w_i L_i^A \mid y_i = g(L^A_i, K_i)) \quad (1), \text{ or}$$

$$R\ (1, w_i, K_i) = K_i\, r(w_i) \quad (2),$$

where $r(w_i)$ represents profit per unit of land.

Expressing the agricultural sector through the restricted profit function and using the properties of a homogeneous function, we can find the labour/land ratio:

$$r_w\ (w_i) = dr(w_i)/dw_i = -\ L_i^A\ /\ K_i \quad (3).$$

Industrial production is subject to increasing returns and uses labour as input. A variety of goods is produced, $x(h)$ being the amount produced of variety h.

The price index in the industrial sector (q_i) is:

$$q_i = [\int (p_i(h)^{(1-\sigma)}dh + \int (tp_j(h))^{(1-\sigma)} dh]^{1/(1-\sigma)} \quad (4)$$[2]

where $p_i(h)$ is the price of each variety h; σ is the elasticity of substitution; and t is the transportation cost.

The minimum cost function (C(h)) of this sector can be represented by:

$$C(h) = q_i^{\mu} w_i^{(1-\mu)} (\alpha + \beta x(h)) \quad (5),$$

where α = fixed input of labour; μ = share of intermediates used by the firms; and β = variable requirement of labour.

Preferences are expressed by the indirect utility function:

$$V_i = q_i^{-\gamma} 1^{-(1-\gamma)} w_I \quad (6),$$

where γ = share of expenditures with intermediate goods.

The demand for variety h in region i can be expressed by:

$$x(h) = (p_i(h))^{-\sigma} e_i q_i^{(\sigma-1)} + (p_j(h))^{-\sigma} e_j q_j^{(\sigma-1)} t^{(1-\sigma)} \quad (7),$$

---

[2] - All symbols $\int$ represent $\int_{(h \in Ni)}$, where N is the number of varieties.

where e is total expenditure in manufactures, including the demand from workers, landowners and manufacturers,

$$e_i = \gamma(L_i w_i + K_i r(w_i) + \int\pi(h)dh) + \mu\int C(h)dh \qquad (8).$$

The price of each firm in region i is:

$$p_i = ((\sigma\beta)/(\sigma-1))\ q_i^{\mu}\ w_i^{(1-\mu)} \qquad (9).$$

Profits (π) of manufacturing firms are given by:

$$\pi_I = (p_i/\sigma)(x_i - x) \qquad (10),$$

where x is the quantity produced of each variety in the long run,

$$x = \alpha(\sigma-1)/\beta \qquad (11).$$

Free entry requires the satisfaction of the underlying conditions:

$$\pi_i n_i = 0,\ \pi_i \leq 0,\ n_i \geq 0 \qquad (12),$$

where n = number of firms in the region.

The demand for labour (L_i) is given by:

$$L_i = (1-\mu)\ n_i\ (C_i/w_i) - K_i\ r_w\ (w_i) \qquad (13).$$

Migration among sectors requires:

$$q_1^{-\gamma} w_1 = q_2^{-\gamma} w_2 \qquad (14).$$

Puga analyses adjustment towards the equilibrium through the change in the number of firms in time:

$$dn_i/dt = \lambda\pi_i(n_i, n_j), \ \lambda>0 \qquad (15).$$

While firms have an incentive to exit a larger market due to the increase in wage costs and due to the higher competition among them, more workers and firms not only means a higher demand for the firms, but also decreases their costs.

Puga's (1999) conclusion is that, as usual, with high transportation costs, the industrial activity would be spread. As transportation costs decrease, forces toward agglomeration become strong and differences in wages appear. If workers migrate in response to this stimulus, agglomeration would prevail. If not, firms would spread to benefit from the cost differential and from the proximity to the consumer agents. As in the other models, a higher γ and a higher μ are forces that increase the tendency for the asymmetric equilibrium to prevail. For higher values of these parameters, the critical level of transportation cost that breaks the symmetric equilibrium is smaller.

It is interesting to mention the review of NEG literature made by Neary (2001). After explaining the main ideas of Krugman (1991a) and Venables (1996), he covered the extensions of these models which were summarised in FKV. The first extension was to deal with n number of regions, which was approached by considering the regions as uniformly distributed in a circumference of a circle. Starting from an even distribution, it was found a critical point where this equilibrium became unstable, as transportation cost decreased. With further decrease in transportation cost, the agglomerative equilibrium was sustainable. In other words, the results for the multiple region case resemble the results for the two region one.

Another exercise was to consider that the regions were spread along a line, with population initially concentrated at one point, allowing the existence of only one urban centre. Population growth spreads manufacturing activities, as it would be more profitable to exploit the benefits of lower transportation cost vis-à-vis the payment of higher wages in the original city.

He also compared Venables (1996) to Krugman and Venables (1995), highlighting the usage of general equilibrium approach in the latter, where the former had to rely on some partial equilibrium in the labour market.

Neary comments that the usage of the Dixit-Stiglitz framework, although allowing one to incorporate increasing returns in a competitive equilibrium, decreases the active role of firms, since only the elasticity of substitution would be determining the degree of economies of scale. He warns that the usage of NEG models to discuss industrial organisation is seriously undermined by this issue. Also the discussion of sunk costs and interactive strategies are neglected in this framework. He also criticises the causalities discussed by NEG. At the local level, he suggests that spillovers may be more important to explain agglomeration, while at the national level, endowments may explain better the distribution of activities.

I.3 - Including asymmetries and congestion in Krugman (1991a)

In this section, we will change some assumptions of the model developed in Krugman (1991a). We are going to first change the assumption that the regions are equally efficient, and then we will include congestion effects. The aim of these exercises is to better understand the dynamics of the NEG models under hypotheses that resemble more the real situation of the developing countries. In other words, we are trying to change the original model to make it more compatible with our empirical one.

Asymmetry

It would be interesting to observe how the outcomes of Krugman's (1991a) model change if we assume differences in the level of total cost between the regions.

Suppose that, in equation (2) $L_{mi} = \alpha + \beta_{xi}$,

$\alpha 1/\beta 1 = \alpha 2/\beta 2$, but $\alpha 1<\alpha 2$ and $\beta 1<\beta 2$

This assumption means that costs are higher in region (2), with the ratio of fixed to marginal costs remaining the same in both regions.

Equation (3) of Section I.2.1[3] will be substituted by:

$p_1 = (\sigma/\sigma-1)\beta_1 w_1$ (3'a),

$p_2 = (\sigma/\sigma-1)\beta_2 w_2$ (3'b),

So, $p_1/p_2 = \beta_1 w_1 / \beta_2 w_2$ (4'),

$LM_1 = \alpha_1 + \beta_1 x_1 \Rightarrow \Sigma LM_1 = \Sigma\alpha_1 + \Sigma\beta_1 x_1 \Rightarrow L_1 = n_1\alpha_1\sigma$,

since $x_1 = \alpha_1(\sigma-1)/\beta_1$.

For region 2 we will have the following number of workers:

$L_2 = n_2\alpha_2\sigma$

So, $L_1/L_2 = (\alpha_1 n_1)/(\alpha_2 n_2)$ (7').

Note that $L_1+L_2 = \gamma$.

We need also to highlight how the differences in the total cost function will affect the demand function.

$c_{11}/c_{12} = (\beta_1 w_1 \tau/\beta_2 w_2)^{-\sigma}$ (10').

The ratio of expenditures of residents of region 1 on their own production relative to their expenditures in the production of region 2 is:

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3 - The number of the equations should be compared to the ones in Section I.2.1 - Krugman (1991a).

$$Z_{11}=(n_1/n_2)(p_1\tau/p_2)(C_{11}/C_{12})=((\alpha_2/\alpha_1)(L_1/L_2)(\beta_1 w_1\tau/\beta_2 w_2)^{-(\sigma-1)} \quad (11')$$

and

$$Z_{12}=(n_1/n_2)(p_1\tau/p_2)(C_{11}/C_{12})=((\alpha_2/\alpha_1))(L_1/L_2)(\beta_1 w_1/\beta_2 w_2\tau)^{-(\sigma-1)} \quad (12')$$

Incomes in the two regions will be now defined by:

$$Y_1 = (1-\gamma)/2 + w_1 L_1 \quad (13')$$

$$Y_2 = (1-\gamma)/2 + w_2 L_2 \quad (14')$$

and

$$w_1L_1=w_1L_1 = [\gamma(Z_{11}/(1+Z_{11}))\ Y_1 + \gamma(Z_{12}/(1+ Z_{12}))\ Y_2] \quad (15')$$

$$w_2L_2 = [\gamma(1/(1+Z_{11}))\ Y_1 + \gamma(1/(1+ Z_{12}))\ Y_2] \quad (16')$$

For analysing the long run, we need to observe the changes in the price indexes in order to determine the real wages:

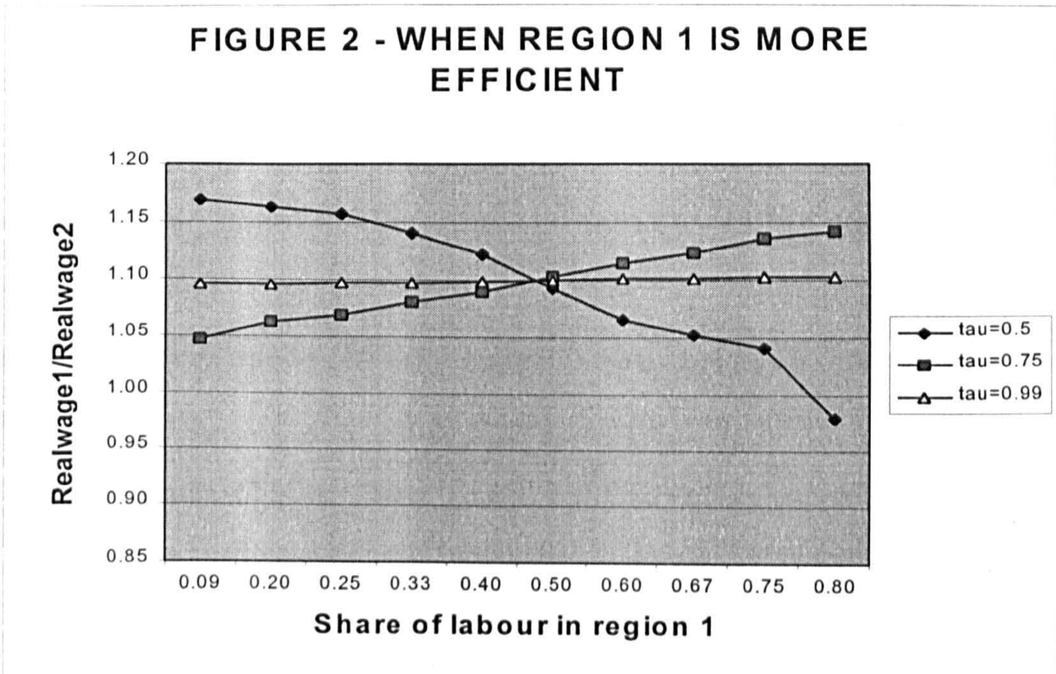
$$P_1 = \sigma/(\sigma-1)\ ((L_1/\sigma\alpha_1)(\beta_1 w_1)^{-(\sigma-1)} + (L_2/\sigma\alpha_2)(\beta_2 w_2/\tau)^{-(\sigma-1)})^{-(1/(\sigma-1))} \quad (17')$$

$$P_2 = \sigma/(\sigma-1)\ ((L_1/\sigma\alpha_1)(\beta_1 w_1/\tau)^{-(\sigma-1)} + (L_2/\sigma\alpha_2))(\beta_2 w_2)^{-(\sigma-1)})^{-(1/(\sigma-1))} \quad (18')$$

$$\omega_1 = w_1 P_1^{-\gamma} \quad (19')$$

$$\omega_2 = w_2 P_2^{-\gamma} \quad (20')$$

In order to check the outcomes of this modified model, we provide some numerical solutions for the set of equations (11′ to 20′), assuming that $\alpha_1 = 0.9 \alpha_2$ (the other parameters are the same as in Krugman (1991a)). The result can be seen in Figure 2. Although the shape of the curves is similar to the ones in Figure 1, they have shifted upwards. The main effect is that, even when industry is dispersed in long-run equilibrium (where the wage ratio is one), it is mostly located in the low-cost region. For intermediate and high levels of τ, the core-periphery solution will prevail. And even for high levels of transportation cost (τ=0.5), the equilibrium solution occurs with 75% of labour located in region 1. There are cases where industry would be symmetrically distributed with equal costs but extremely located in one region if that region has a cost advantage. The fact that advantages in cost would be determinant to the dispersion of activities was also explored numerically by Venables (1996).



We have also tried to analyse the model analytically, following the procedures of Krugman, to find the crucial relationships between the parameters that would break an assumed core-periphery equilibrium. Unfortunately, it is impossible to finish this exercise since it is impossible to generate a relative profit function without any endogenous variable in it.

Congestion

The second exercise we have done with the "core-periphery" model was to introduce congestion in it.

It is natural to inquire if congestion effects would not counteract the benefits from the "home market" and "price index" effects, decreasing the range of transportation costs that sustain the uneven equilibrium.

Junius (1999) has highlighted the importance of congestion effects in understanding why in reality there is not full agglomeration of activities in some spaces. He has introduced congestion by changing either the fixed costs or the marginal costs of the firm, through the inclusion of an exponential function of the number of firms in each region.

Junius (1999) assumes that, for generating commodity i, l_i workers are needed, being either $l_i = \alpha + \beta \exp^{\varepsilon n} x_I$, or $l_i = \alpha\exp^{\varepsilon n} + \beta x_i$. In either case, adjusting ε affects not only relative costs of production amongst regions, but also the importance of economies of scale (because alters the ratio of fixed to marginal costs). Thus his exercise does not capture a "pure" congestion effect.

Although we believe the choice of Junius was useful for his purposes, this way of including congestion is not desirable, since we are interested in not making economies of scale different among the regions (i.e., keeping α/β constant within each region).

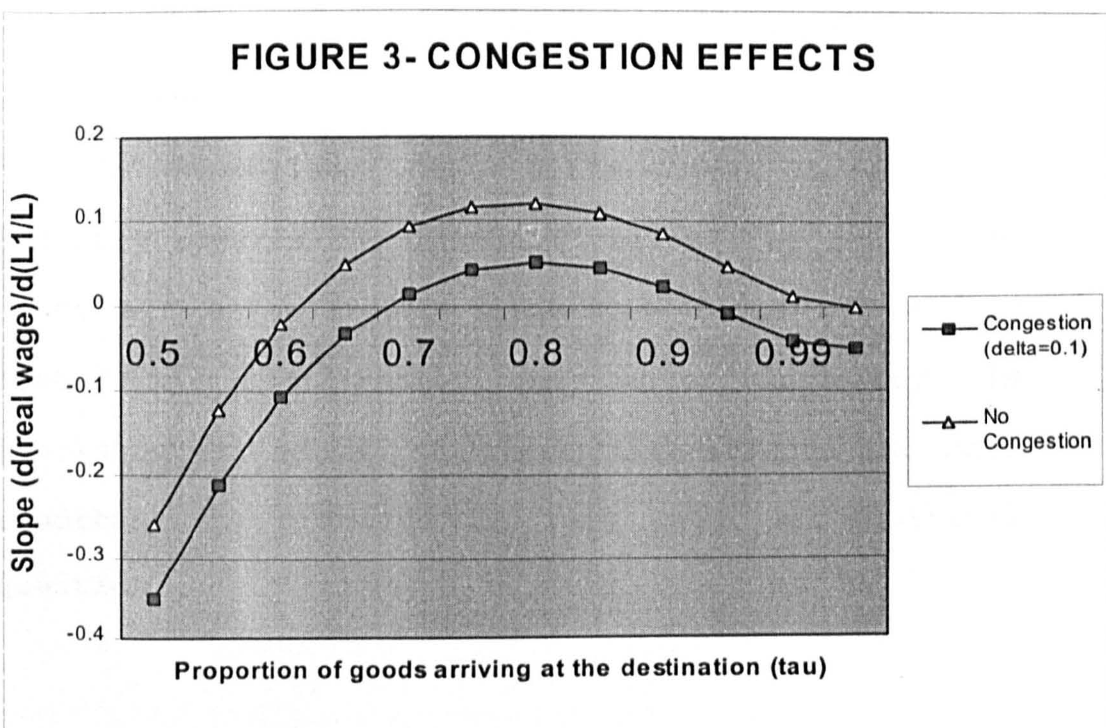
Instead we have introduced congestion in the following way. For producing variety i we need:

$L_i = (\alpha+\beta x_i) \; [\lambda((L_1/\gamma)-1/2)+1]$, and an analogous equation for region (2). Since λ is assumed to be positive, this equation says that both fixed and marginal costs rise linearly with a region's share of total labour.

When labour is symmetrically distributed [in which case $L_1/\gamma = 1/2$], no region is being harmed by congestion, which makes the term in brackets vanish. We represent congestion by saying that a region with a higher share of labour would need more labour, L_i, to produce a unit of manufactures. This is represented algebraically by the positive term in brackets, if L_1/γ is greater than a half.

The effects of this modification can be seen in Figure 3. Figure 3 presents the results in a different way, plotting the slope of the lines in Figure 1 against the inverse of transportation costs.

Recall that when the slope of the curves in Figure 1 is positive (which corresponds to a positive value of the vertical axes of Figure 3), labour will be concentrated in region 1, since the shift of labour to this region increases the real wage in region 1, relative to region 2. As can be seen, the inclusion of congestion decreases the range of transportation costs that is consistent with the core-periphery equilibrium. Not only is this range smaller, but the impact on the wage differential of an increase in L_1 is always less positive (or more negative).



In terms of Figure 1, all the curves would be rotated clockwise (not shown). In particular, when τ is close to one (very low transportation cost), the slope of the curve would be negative rather than positive, and the symmetrical equilibrium would be the outcome. This is because, in Krugman's original model, at very low transportation costs the slope of the real wage ratio curve in Figure 1 is shallow, and in the modified model congestion effects cause the slope to change sign. If congestion costs were large enough, the curve in Figure 3 would be entirely in the negative region and the core-periphery solution would never occur.

To summarise: cost differences always push industry towards the low-cost region, but congestion costs act as a strong dispersive force by raising costs in the region in which industry is concentrated. Which of these two effects is more important in practice is very much an empirical question.

I.4 - "New Economic Geography" and "New Economic Growth"

The idea that different kinds of activities or that economies of agglomeration are important to determine (per capita) growth rates has been discussed in the empirical literature. Barro (1993) included an index of output composition in a growth regression, and economies of agglomeration, usually proxied by the urbanisation rate, is commonly found in growth regressions (Barro and Sala-i-Martin, 1995). The problems with these approaches are the lack of theoretical support for the inclusion of these variables and the fact that the proxies can be capturing a broad set of determinants.

Some theoretical work has been done merging NEG with the New Economic Growth Theory.

Walz (1996) has introduced innovation as a source of growth in New Economic Geography models, basing his work on Romer (1990) and Grossman and Helpman(1991)'s models, where growth comes from the creation of different intermediate goods, as an outcome of the innovation process. The availability of a wide range of intermediate goods increases the productivity of the final goods sector, explaining the persistence of the growth rate in the long run. As in NEG's models, geographic concentration is due to the interaction of fixed costs and transportation cost. The tension in this model is built between two immobile factors: land and unskilled workers, and a mobile one, which is skilled workers.

Two forces struggle to shape the structure of the production. On the one hand, the presence of a higher market for intermediate goods stimulates their producers to avoid transportation costs and to benefit from economies of scale, by choosing to settle in this larger market. On the other hand, competition among intermediate products increases, encouraging a spread of the intermediate producers.

If there exists a higher share of intermediate producers in region A, land rent will be higher in this region and so will income. Region B, with a smaller land rent, will have comparative advantages in the production of a traditional good, and can be locked in this production.

Walz (1996) shows that if the two regions are equally sized, then if the usage of resources by the traditional sector is very high, there will be a core-periphery pattern of production of intermediate and final goods. As a consequence, innovation and growth will be restricted to the area with more intermediate production. If the traditional sector is small enough, then despite one region having a higher number of intermediate goods, the growth rate will be the same in the two regions. Finally, if one region has more endowments than the other, even if the land rent is higher, this region will be the core, concentrating all the innovation process.

Martin and Ottaviano (1999) introduced an endogenous source of economic growth due to the activities of R&D by the firms. An increase in R&D would result in new products. If facing not very high transportation costs, firms will be concentrated in the larger market.

In the set-up with global spillovers, they showed that the growth rate of the world economy was not determined by the location of the firms, although the differential between the incomes of the regions would be. The region with initial great advantage in the number of firms would have higher income. In spite of that, firms would be producing in the South, due to the smaller competition in this region. The higher the transport costs and the higher the demand that comes form labour (in opposition to capital) income, the higher the number of firms in the South.

With local spillovers, agglomeration has a positive link with the growth rate of the economy. In this case, R&D activities would be concentrated in the North, and if concentration increases, the growth rate of the world economy would increase, as well as welfare.

Martin and Ottaviano (1999) also stressed that the connection between the two theoretical lines is natural because they use the same kind of market structure and because of the existence of empirical work exploring the links between growth and location.

In Baldwin (1999), the novelty is the introduction of capital in the NEG model. The model includes three sectors of production: the constant return one, the production of manufacturing and the production of capital itself. Again, demand forces tend to cause agglomeration, while competition among firms tends to lead to a more even situation.

If capital is not mobile, an increase in the profits of some regions would encourage the entry of firms into it, generating a demand-driven agglomeration process. The fact that the change in the location of the production leads to change in the expenditure pattern is crucial for the results of this model. If this does not occur, the symmetric equilibrium would be stable. Another possibility for the stability of the symmetric equilibrium would be the existence of high transportation costs. Below a critical level, core-periphery outcomes would appear. When capital is allowed to move in this model, the symmetric equilibrium is stable, since the link between the change in production and the change in expenditure would be broken (assuming that the rent would be expatriated).

Baldwin highlights that his findings go against the evidence that support the convergence hypothesis.

Baldwin and Forslid (2000) also include a sector of production for capital goods in their model. This sector is a competitive one, which uses only labour in the production of its goods. Capital is seen as a metaphor for embodied knowledge and is the relevant immobile factor in the model. The requirement of labour for the production of capital is seen as fixed by the individual firms, but it is subject to external effects, decreasing with the increase in production.

Each final goods producer uses a specific type of capital and labour.

Consumers optimise considering their life span and migration is a function of the expected wage differences.

There are two steady states in this model, the symmetrical one, with equal growth rates for each region, and the "core-periphery" one, where the per capita income growth rate and the growth rate of capital are higher in the "core" region.

Accumulation of capital acts in the direction of concentrating economic activity. Without spillovers, the symmetrical outcome is unstable. With perfect spillovers, even at low levels of transportation cost, it is possible to sustain the symmetrical equilibrium.

Adding to the static "backward and forward" linkages, the growth linkage also causes a cumulative process that leads to agglomeration. Growing markets encourage production. Since production of a greater variety implies higher production of capital and this in turn decreases its replacement cost, investment will be further encouraged. Higher levels of capital, in its turn, increase wage differential in favour of the "core" region and encourages migration.

Conclusion

NEG models provide tools to discuss the distribution of activities in space, within the framework of mainstream economics. The models were constructed obeying the general equilibrium approach and succeeded in endogenising the distribution of demand and immobile resources, which earlier discussion of geography was not able to achieve.

The treatment of geography inside mainstream economics helps to establish connections with other areas of economic investigation. Of special importance for us is the linkage between NEG and economic growth, summarised in the last section.

The mainstream treatment is also more suitable to the development of econometric models.

We have selected three models to illustrate NEG's approach: Krugman (1991a), Krugman and Venables (1995) and Puga (1999). The selection is related to our econometric work, as will become clear in Chapter 3.

Krugman (1991a) has established the basic pattern of thought in these models. Centripetal forces ("home-market effects and price index effects") compete with centrifugal forces (competition in the labour market and in the market for goods) in a way that depends on the level of transportation costs. With high transportation costs, the necessity of staying near the market dominates the location decisions of firms. Assuming that labour and peasants are equally spread between regions, activities will also be equally spread. When transportation costs reach intermediate levels, any shock that creates an inequality in the distribution of labour between regions will generate a concentration of activities in the more populated one. Only in a totally open economy do we observe again an equal distribution of activities as the outcome of the model.

So, at intermediate or low levels of transportation costs, more populated states are supposed to be richer.

In Krugman and Venables (1995), instead of labour moving across regions as the main source of changes in the distribution of activities, it is the movement of firms across countries that provides the *ad hoc* "dynamics" of the model. A concentration of firms creates forward linkages because it increases the availability of intermediate products, decreasing firms' costs, since they use intermediate products as inputs. Since firms are buyers of intermediate products, there will also be backward effects, due to the increase in their markets.

Puga merges the two previous models.

The outcomes of these models are extremely dependent on the hypotheses that the regions are symmetrical. If one region is more efficient than the other, the more efficient will contain most if not all manufacturing activity, independent of the level of transportation costs.

Congestion effects, if allowed for in the models, decrease the range of transportation costs that generate the core-periphery equilibrium. In particular, they mean that the symmetrical equilibrium is stable for very low as well as for very high transportation costs. This follows from the previous result that manufacturing strongly favours the lower-cost region: with congestion effects, this is always the region with less manufacturing.

Chapter II - Other Approaches to the Regional Debate about Economic Growth

Introduction

The aim of this chapter is to discuss some of the most important alternative approaches to the NEG model in the discussion of regional growth and the distribution of total activity. We are especially concerned with ideas developed in the second half of the 20th century that do not share the same paradigmatic view of the authors associated with the main line of our investigation. The choice of authors to be reviewed was also guided by the existence of a debate among themselves and with the NEG models.

We want to observe two aspects: if these alternative works can result in testable empirical specifications and if their ideas can be incorporated into the mainstream approach.

II.1 - The Development of Economic Geography

Economic Geography has developed sharply in the last century (Scott (2000), Martin (1997)), and it is difficult to select the exact branch of literature that we need to discuss. The work that is being developed in this dissertation focuses on how changes in transportation costs allied with economies of scale among industries generate agglomeration or dispersion of economic activity, measured by the impact of these variables on states' rates of economic growth. This work should be understood not only as an attempt to identify causes of economic growth, but much more as an attempt to investigate if the variables cited above generate dispersion or agglomeration of activities among regions of developing countries.

In order to establish the debate, we select the Economic Geography literature that has tried to understand the differences in the behaviour of some special regions, the "California School", the importance of the region as a source of "comparative advantage" and the role of division of labour and of corporations in the global world, following Scott (2000).

Scott (2000) listed five branches of literature that can be characterised as having the aim to understand the unexpected positive behaviour of special regions: a) the "Italian School", which has made use of the concept of "industrial district" to analyse the sharp growth of North-East and Central Italy after the 1970s; the "California School", which tried to explain the behaviour of the Bay Area and Southern California paying attention to the roles of vertical disintegration, transaction costs, the creation of agglomerations and the labour market; the GREMI school, dealing with the combination of "local economy" and "social life" in the developing of regions.

These branches agree that the economic growth of these special regions (outside the core of capitalism) is related to the importance of innovation processes, in a moment where the economy switches from a Fordist technological paradigm to the post-Fordist one. The California School would be the one to establish as a regularity that these technological changes may bring spatial changes. The intrinsic spatial inequality of the world seems also to be associated with these views.

Trying to understand what are the elements highlighted by this literature that are important for regional growth can be a source of alternative hypotheses to the one highlighted by NEG literature (economies of scale connected with changes in transportation cost).

The discussion of the determinants of growth in these specific regions had as one of its outputs (Scott, 2000) the consideration of the region as a source of "comparative advantage", a crucial *locus* for economic development in the post-Fordist world (also Storper, 1986). This is the fourth branch of literature highlighted by Scott (2000).

Finally Scott (2000) highlights the work of schools of thought connected with the concept of the division of labour and the importance of the multinational corporation.

From the five above-cited lines of discussion, only the GREMI one will not be discussed, since it relies very much on special conditions of the regions.

We would like to make it clear that we are not trying to undertake a deep and full coverage of the alternative contributions. We will essentially choose an author that most represents the four lines of discussion (through their reference in the work of Scott (2000)). The justification for this procedure is linked with the aim of this chapter: to observe if the NEG models can incorporate some contribution from these sources, theoretically and empirically. A deep theoretical discussion of these subjects would be outside the scope of this dissertation.

II.2 - The Contribution of Piore and Sabel

It is important to highlight the work of Piore and Sabel (1984), since it has provided a common background for all the other authors discussed here.

The main contribution of Piore and Sabel (1984) was to state that "mass-production" was not a necessary outcome of capitalism. They argue that in the XIX century, both "craft" and "mass-production" were viable options of technology that could be established as the dominant one, although the one that history "has chosen" was mass-production.

They highlight that even for the political economy school (Smith) and for the critics of political economy (Marx), the development of mass-production was seen as inherent to the evolution of capitalism. Both schools observed a trade-off between opulence and loss of skills.

What makes a technological paradigm win is the relative power of the groups benefited by them in society. Government, as a centre of power, can so alter the historical outcome of a choice in technology. Institutions and particularities of each region may also affect this outcome.

In their words:

> "A first postulate of such a world is that any body of knowledge about the manipulation

> of nature can be elaborated and applied to production in various ways; some of these ways are more flexible than others. A further postulate is that the technological possibilities that are realised depend on the distribution of power and wealth: those who control the resources and the returns from investment choose from the available technologies the one most favourable to <u>their</u> interests. A third postulate is that technological choices, once made, entail large investments in equipment and know-how, whose amortisation discourages subsequent different choices" (p.38).

Craft production has tried to emphasise the increasing know-how of the workers, using a variety of inputs to create a variety of goods, satisfying a diversified demand and also creating it. Its dynamics centre in innovation. Mass-production, on the other hand, tries to use specialised inputs to generate standard products, trying to benefit from economies of scale. The dynamics of this system are driven by the demand.

Craft has never disappeared, since to produce the specialised inputs a more suitable technology was necessary.

During the 1970s, the system of mass-production entered a crisis, due to the creation of excess capacity and simultaneous saturation of some markets, due to the high costs of inputs, especially labour, since high wages were important to sustain a compatible aggregate demand, due to shocks (oil, changing of exchange rate system, change in interest rate, among others).

Three major responses to this crisis have occurred: the creation of conglomeration, considered a fragile solution, since the diversification in risk, implicit in the strategy of generating a conglomeration, implies that the markets have separated risks, which is not the case if the crisis is global. The other response was multi-nationalisation, which has benefited from the incentives of the developing countries and in low wages and weaker political power of the labour force of these countries. This strategy was also risky, since the labour movement became strong in the developing countries, governments sometimes withdrew their support and, especially, because it was dependent on a very homogeneous taste among countries.

The third and most successful strategy was a return to a flexible technology, illustrated by the cases of Third Italy, Ile de France, and famous technological areas in the USA (Orange County, Silicon Valley), Japan and West Germany. This alternative paradigm is a return to craft production, where the firm tries to attend a diversified demand, having innovation as the primary source of competition. The production is concentrated in "industrial districts", where some institutions help to generate the necessary cohesion for the economic activities. The characteristics of the institutions are classified as: "municipalism" (especially appropriate for small firms with small amounts of capital), "welfare capitalism or paternalism", more important for the large industries and for activities that need more clustering, and "familiarism", where family behaviour plays an important role in the division of tasks and in the creation of trust.

Storper (1997) comments that the most important criticisms related to Piore and Sabel can be summarised in the following way:

a) too much emphasis on the role of small firms;
b) the School only explains "traditional non-durables", "specialized supplier industries" and "luxury versions of mass-production" (p.7);
c) the analysis is so embedded in historical aspects that it brings doubts about the possibility of generalisation;
d) they fail to explain the existence of more competitive organisations that do not act in the flexible specialisation way;
e) they could not differentiate between flexible structures that had learning dynamics from the others.

The work of Piore and Sabel is not incompatible with some important concepts further developed from other schools, like "path-dependency" and the existence of a connection between the change in the technological paradigm and of changes in the geographical dispersion activities.

There is not a direct discussion of the determinants of regional growth, their work being, as previously stated, an attempt to prove the interesting idea that "mass-production" was not the unique choice in the past, and that now "flexible specialisation" is the dominant paradigm. What determines the existence of dynamic agglomeration is the historical success of some areas to encourage the usage of this form of technology.

The fact that it is well-documented that "flexible specialisation" is the main way of combining inputs in the post-1970s raises the question if the importance given (external) to economies of scale and input-output linkages by the NEG authors is in historical accordance with this new set-up. Another way to put this question is to observe if the concepts that NEG highlights are still generally important, or if they are more important in developing countries and/or in some sectors of production still connected to the old paradigm.

II.3 - "The California School"

The ideas of the "California School" will be represented by the work of Scott (1988). Scott also shares the view of Piore and Sabel that a sharp transformation has affected the mode of production towards flexibilisation, also highlighting that several ways of transforming nature can coexist.

This flexible form of production came together with a deepening in the social division of labour, through an extent of disintegration (when different stages of the production process are done by different firms) among firms.

Scott aims to give an economical explanation to this deeper disintegration of production.

The review of his work is appropriate since it shares commonalities with the NEG one (Storper, 1997) in trying to explain the desire of firms to cluster together. In his approach, transaction costs will be the main causality explaining the distribution of activities, together with some specificities of the input-output linkage.

The idea of flexibilisation is exploited within the framework established by the French Regulationists. In other words, flexibilisation will be discussed as a possibility of generating a different "regime of accumulation" with the corresponding "mode of social regulation".

For the regulationists, each long-run economic period can be characterised by a "regime of accumulation", which requires some coordination, and which comes through the "social regulation".

A "regime of accumulation", as defined by Scott, includes:

> "(a) a set of production techniques,
> (b) a characteristic way of organising production and labour relations,
> (c) a distributional mechanism governing the appropriation and redeployment of the surplus,
> (d) a process of aggregate demand driving forward the evolution or productive capacity" (Scott, 1988, p.8).

These elements usually require external sources of coordination, in order to generate a long-run pathway. The name "modes of social regulation" is attributed to the institutions (state, organisations) or customs that provide this required, but never perfected, coordination.

It is important to highlight that the institutions and habits that generate this coordination are part of the historical process, not guarding a relationship of functionality with the "regime of accumulation".

Even if we observe a successful long-run economic trajectory of the economy, it may end in crisis, due to the inherent contradictions of the capitalist system.

The so-called "Fordist" regime started facing a crisis after the 1970s, which was caused by over-production, increasing public debts of the welfare state-type of government, stagflation, oil shocks, higher unemployment and the strong competition from Japan and other New Industrialised economies.

The crisis has been overcome by the establishment of a new paradigm, the Post-Fordist one. It can be characterised by:

> "(a) revivified craft and design-intensive industries producing outputs (...) largely but not exclusively for final consumption, and (b) various kinds of high-technology industries and their associated phalanxes of input suppliers and dependent subcontractors" (Scott, 1988, p.11)

It is an electro-electronic basic technology (in contrast to the metal-mechanic of the Fordist period), and it has been characterised by the establishing of a "mode of regulation" based on greater flexibilisation of the labour market, by a decrease in the old roles of the state and by a greater interaction among units.

The "California school" highlights that a break in a paradigm changes the location distribution of economic activity. In the Fordist world, production was concentrated in poles of growth. Now we are observing changes in the economic activity that may concentrate or not in the old vigorous economic place (but that have a tendency to concentrate anyway).

After establishing the characteristics of the new paradigm, Scott will analyse how economic forces, especially transaction costs, are generating high economic growth, a tendency for agglomeration and a deeper division of labour.

There are two main patterns of growth to the firms: increasing the production, if economies of scale are high; or integrating other functions, if the economies of scope are high. As usual, the size of the firm will be the one that corresponds to the minimal average cost of producing x, for example (f(x)). Economies of scale are usually related to indivisibilities, while economies of scope are related to transaction costs.

Assume two products, x and y, and that y uses x as input. Economies of scale in the production of x exist if there is an $x>x' \Leftrightarrow f(x)<f(x')$. Assume now that g(y) is the average cost of production of y and that h(x,y) is the average cost of producing x and y within the same firm. Economies of scope exist if $f(x) + g(y) \geq h(x,y)$.

If x and y are under disintegrated production, x will be sold by p_x (price of x) to firm Y. For simplicity, Scott assumes that x and y keep a proportion of 1:1 in units. Firm X will choose to produce some y if the average cost of the integrated production I(x) is smaller than the average cost of disintegrated production D(x). Economies of scope are defined as the difference (in the minimum level of economies of scale) between I(x) and D(x).

In the level of x that minimises the average cost, the firm will observe if there are economies of scope. If they exist, there will be a joint production of x and y. In this case, the total average cost will be I(x) + g(y)(g(y)will be positive if firm Y also produce some y). This will happen if the value of x corresponds to a situation where $I(x) + g(y) < p_x + g(y)$. Otherwise, different firms will produce x and y.

Several combinations of integration and disintegration can be chosen by the firms, and the decision to integrate or not can become more complex if x and y are not produced on the same scale. Then, although it may be that the optimum size of x corresponds to an integrated production, the value of y that minimises average cost may not be compatible with this institutional arrangement.

From the point of view of the transaction cost school, the technical division of labour can be seen as a broader process of social division of labour, since "production consists of units of vertically integrated hierarchical order separated from one another <u>in a social division of labour</u>" (Scott, 1988, p.25).

This statement recalls Piore and Sabel's criticism of the world of Smith, according to Scott.

Smith (1776) stated that the division of labour was the main cause of economic growth. The process of division of labour was due to the human characteristic of having communication through language, which develops the desire for trading. The division of labour increases productivity since in dividing the tasks it helps innovation and decreases the time among tasks. According to Scott (and the transaction cost approach), there is not clear distinction between the division of labour inside a firm or among the firms, being any of them part of the overall social division of labour.

If "the ratio of internal economies of scope to external transaction costs falls" ("under identifiable scale conditions")(Scott, 1988, p.25), there will be a greater division of labour. Uncertainty, instability, difference in the scale of production among the inputs, labour market-fragmentation, growing markets and agglomeration helps these configurations.

Scott highlights that an environment with a higher division of labour leads to an increase in technology, an increase in variety and, through the work of these external economies of scale, to a decrease in costs. This environment is also propitious for innovation.

The importance of agglomeration for the decrease in transaction costs mainly comes from three forces: "linkage lengths", labour market effects and the importance of "community".

A "community" can decrease the costs, due to the higher circulation of information and the higher reliability among partners that know each other.

The decrease in labour costs is due to the operation of the law of large numbers, which makes the amount of "separations" and "accessions" (Scott, 1988, p.38) more constant.

Higher probability of benefiting for agglomeration occurs: when small flows are dominant; where the product is very differentiated; if the linkages are unstable among firms or user/producers; when there is need of "face-to-face" interaction (p.31); and when the cost of the circulating capital is higher.

Scott adds:

> "In more flexible industrial systems, where there is often no dominant set or propulsive leaders, agglomeration occurs simply as a consequence of the mutual attraction of each producer to every other producer in the complex" (Scott, 1988, p.33).

Storper (1997) criticises this school in the sense that it also cannot identify the agglomerations that are more dynamic and that some sectors ("parts-of high technology" and some "supplier-intensive" sectors) (Storper, 1987, p.12) are dynamic but do not show high input-output relationships.

It also seems that there is a cleavage between the attempt to give an economic explanation to the disintegration process and the regulationist framework. Scott provides an explanation for the creation of a more flexible/disintegrated linkage among firms. But, to be coherent to the regulationist paradigm, he should have explained how the new flexible "regime of accumulation" appears as a consequence of the crisis of the old one. From his own list of elements, which biased the decision of the firms towards disintegration (uncertainty, differences in scale, growing markets, labour market flexibility and agglomeration), only uncertainty (due to the crisis itself) can be explained by the crisis of the Fordist "regime of accumulation". We can add labour market fragmentation, since he highlights that the crisis was connected to the Reagan-Thatcher period and their influence in decreasing the power of the unions.

The same criticism can be reinforced inside the discussion of the importance of agglomeration through the characteristics of the linkages. The elements listed are purely technical or probably **caused by the process that Scott tries to explain (a flexible world brings more uncertainty, involves a higher degree of relationship among economic actors and also generates, by its dynamics based on technological competition, a search for new and growing markets).**

Anyway, the work of Scott contributes to the discussion of regional growth and regional distribution of activities in highlighting low transaction costs (and characteristics of the linkages) as the main source of generating a flexible and more dynamic environment. Regions that have a higher degree of disintegration would probably be better off than others. Regions that produce goods with different characteristics, which require face-to-face interactions in order to trade, and goods that are produced in small and unstable flows, would tend to have a concentration of activities.

His work discusses only supply-side effects, according to Ruiz (Ruiz(2001) states that both Scott and Storper have a pure supply-side approach), while Krugman's work brings together elements of the demand side affecting the decision of production of the firms, merging demand and supply sides in his models.

The Krugman and Venables' (1995) model is compatible with the ideas of Scott, since the idea that availability of variety of inputs decreases cost (and increases utility) is an expression of the assumption of higher disintegration. Nevertheless it could be interesting to the NEG to incorporate transaction costs in its theoretical framework. Although "backward and forward linkages" act simultaneously, the importance of the backward effect driven by returns to scale could be replaced by transaction costs. Another idea could be to let transaction cost play the role of transportation cost.

From the empirical point of view, further research could include proxies for the level of disintegration inside a region, proxies for transaction costs and for the characteristics of the linkages. It will probably be difficult to identify the distinction between some causalities through the empirical proxies.

II.4 - Region as a Source of Dynamics

This section will be mainly focused on the work of Storper (1997), who reviews the competing lines of thought, while establishing his view of a region as a cause in the economic development. As we have already mentioned, Storper observed limits to the analysis of the former schools, and states that the evolutionist approach provides the most important understanding of regional economic development.

This work of Storper was chosen to be reviewed since it provides an understanding of how the main concepts of the evolutionist approach can impact on the discussion of the determinants of regional economics. As we will see, he will end up also establishing that we cannot think about regions as being the consequence of other economic forces, but that they can play an active role in it.

The evolutionist work (Nelson and Winter, 1982) is extremely concerned in explaining choices of technology and its pathway. They disagree with the mainstream idea that, given some set of options, firms will choose optimally among them, including being able reverse its decision. For the evolutionist, the choice of a technology is made in an environment of uncertainty, since it is impossible for the firms to know their options. The outcome of the choice of the firms is impossible to predict, being generated in history. Not only may small events shape these options, but also, after being done, they are not subject to reversibility (there exists "path-dependency"). The firms can reach several solutions.

Their work also highlights that knowledge is the centre of technological progress and that, especially with the new technologies in place after the 1970s, the most important element of the knowledge process is the non-codified one. In this sense, R&D projects are less important than spillovers and the interaction among firms/labour/institutions/consumers is extremely relevant in order to understand the technological choices.

The new paradigm, as already discussed in the first section, is associated with a higher degree of interaction among firms, due to the deepening in the social division of labour, with a higher degree of uncertainty, and with a higher importance of non-codifiable knowledge.

Framing the discussion of the technology-organisation-territories is the concept of "reflexivity". With the new technological framework (characterised by decrease in vertical integration and by an increase in specialisation and variety-production), the interaction among actors in the economy has obtained more importance. As a consequence of the higher "reflexivity", economic actors have more degrees of freedom to shape reality: "What is imagined can become reality with more probability" (Storper, 1997, p.29).

And since this is an environment that quickly changes, with a higher degree of uncertainty, the problem of coordination of capitalism becomes extremely difficult and "reflexivity" can also be seen as an attempt to coordinate the economic world.

What will determine regional growth is the ability of the economic actors to deal with these new elements. Following the biological metaphors, the firms that manage to succeed in dealing with them will survive. The same rationalisation can be applied to regions (although they will have another importance, as we will see).

Three categories are considered crucial to the understanding of regional economic development: "technology", "organisations" and "territories". These categories are not new to the regional approach, but they have been revised to better reflect their affiliation in the new environmental concepts of the evolutionist approach. The task of the firm/region will be to make the best coordination of the elements in them.

What is extremely interesting in Storper's approach is that he tries to eliminate the cleavage that was observed in the "California School". He departs from the historical characteristics and tries to observe how firms react to them. On the other hand, the answer to "why" the firm acts in one or another direction is missing.

"*Technology*"

Technology, as perceived by the evolutionist, can be categorised as standardised and unstandardised. The first one is related to the production of goods that are subject to high economies of scale, and that tend to disperse across regions.

Unstandardised technology is related to the production of varieties, using flexible techniques. This kind of technology is extremely dependent on non-codified knowledge, on the communication among economic actors, and on spillover effects (in opposition to R&D). In the Post-Fordist world, according to Storper, this is the crucial form of generating dynamics in the economic process.

According to Storper,

> "For regional and territorial economics, this means a reorientation of the central issues posed by technological change: from standardisation to destandardisation and variety as central competitive process, from diffusion to the creation of asymmetric knowledge as the central motor force, and from codification and cosmopolitanisation of knowledge to the organisational and geographical dimensions of non-codified and noncosmopolitan knowledge" (Storper, 1997, p.34).

With the change in the paradigm of production after the beginning of the 1970s, competition among firms is mainly based on innovations not subject to quick diffusion, since the feasibility of the translation of its content to blueprints is smaller, due to their dependence on the specific interaction between firms/users (sometimes in the same space) or due to its dependence on communication among workers/researchers. The change in technology is also quick, allowing firms to acquire quasi-rents, and adding another difficulty in the spreading of the innovation.

"Organisations"

Analysing trades between and within firms and institutions in the "learning economy" is not enough to map the behaviour of the organisations. Since "reflexivity" among the economic actors has intensified, the question of coordination of their actions becomes even more complicated. So it is crucial to understand the "conventions" used by the organisations (and institutions) to try to deal with the increased uncertainty of the economic environment and to the technological features, like greater degree or "deverticalisation" and the usage of flexible and specialised techniques.

The central transactions that take place among organisations are the "conventional-relational (C-R)" ones, which,

> "may be found in at least five principal domains: (1) intrafirm 'hard' transactions, as in buyer-seller relations that involve market imperfections; (2) interfirm 'soft' transactions, as in the diffusion of non-traded information about the environment or about learning (...); (3) in hard and soft intrafirm relations, as the bases for the functioning of large firms that are 'internally externalised' ...; (4) in factor markets, especially labour markets, which involve skills that are not entirely substitutable on an interindustry or interregional basis (...); and (5) in economy-formal institutional relationships, where universities, governments, industry associations and firms are only able to communicate and coordinate their interactions by using channels with a strong C-R content" (Storper, 1997, p.38).

"Territories"

The main idea related to "territories" is that they are an input for the decision-making process of the firms, since they can help in the formation of C-R transactions. Firms can choose to agglomerate independently of the traditional transactional forces, but to be in an advantageous position to change their behaviour or technology according to the routines and information that they can easily obtain in this way.

In this context, space is not a consequence of other economic process, but part of it. It is an "input" in the process of production:

> "... once proximity becomes an input into the social division of labour - by allowing firms to make choices between what they do internally and what they do externally - it in turn allows firms to experiment with different degrees of specialisation that would not otherwise be possible, and this in turn sets up dynamics of technological development that would not otherwise be possible" (p.44).

Regions are also important for their impact on the choice of technology. The region is a natural *locus* for spillovers, and may also make a difference in the choice of a particular technology. "Proximity" can also affect technology in the following way:

> "For a given level of R&D, for example, (1) *ceteris paribus*, geographical proximity increases the probability of diffusion of a given technique; (2) region-specific competences after several rounds of imitation and diffusion of techniques, become endogenised, something like a stock of competences, routines, and conventions; (3) the probability of imitation at the regional level rises with the number of firms in the region; (4) regional concentration is favoured when the degree of appropriability of knowledge is low, and vice versa" (p.66).

In core regions (those with the main part of an industry and/or being responsible for the choice of technology), the above highlighted effects of proximity can act strongly in order to create "evolutionary dynamics". In non-core regions (the ones that incorporate a small part of the industry), the technological pathway can work as a constraint.

Products and agglomeration

Storper (1997) emphasises that innovation occurs over products. Products can be divided into four categories: "standardised or specialised", accordingly to the analogous characteristics of their inputs; "generic or dedicated", accordingly with the kind of demand that they attend.

Products are also subject to production under "consolidation" (where the producer tries to sell a great variety or large amounts to decrease the risk) or "specialisation" (when it is necessary to hire specialised people to comment on the possible acceptance of the product in the market).

Depending on technological restraints, the four categories of products can be produced under a "consolidated" or "specialised" way, corresponding to the following categories: "Market World"; "Interpersonal World"; "Industrial World"; and "World of Intellectual Resources". These "worlds" have different characteristics of production and innovation that can influence the degree of agglomeration.

The "Market World" is the one that produces dedicated products subject to conditions of consolidation, usually trying to expand its variety. The process of innovation involves creating new varieties. The production of the "Market World" is weakly concentrated, since it requires a small degree of proximity.

The "Interpersonal World" is the one that combines the production of dedicated products with specialisation. Innovation consists of continuing the search for variety using specialised resources. Proximity is an important input in this process, and these sectors tend to agglomerate.

The "Industrial World" combines generic products with standardised production. It does not require proximity for the development of its innovation.

The "World of Intellectual Resources" combines generic with specialised production and does not require proximity in all its moments, but they are important in the process of combining specialised inputs (in the innovation process).

The main ideas of Storper can be summarised in the following way. Considering the technological change that capitalism has been experiencing after the 1970s, the understanding of economic development requires an extreme attention to the roles played by non-standardised **technology**, conventions among economic actors and the benefits of proximity.

Although some of the deverticalisation process that has been observed can rely on traditional transactional costs, the desire of the firms to benefit from non-traded knowledge and C-R transactions can be the main determinant of the profile of the decision to agglomerate. These elements are also the main determinants of the performance of the regions.

Without ignoring the difference in the methodologies beyond the models, we can consider it interesting to observe the role of technology, of the C-R linkages among firms and of proximity to economic growth and to the allocation decision of the firms in the neoclassical paradigm. These two elements could be included with changes in the theoretical models. In the empirical discussion, the problem is to find suitable data for these enquiries.

The main criticism of the NEG model from Storper's point of view would be that it does not consider the importance of C-R linkages, relying instead in "input-output" transactions of final demand impact, which would be more coherent to the studying of the mass-production period (or some sectors of the economy). This could be a subject of research. Since all authors assume that although the dominant paradigm has changed, several paradigms do coexist, it may be interesting to observe if, considering the criticism of Storper to be true, the old paradigm is still dominant in developing countries, as our exercise can identify, or in sectors of these countries, which could be a subject of further research.

Also Storper said that Krugman's model could create more concentration outcomes if incorporating some of his elements. Storper's view is of a world with a higher probability of agglomeration. Our argument here would follow along two lines: it may be that the elements highlighted from Storper may induce more agglomeration inside the model, but again, he does not highlight elements that could go in the other direction, like congestion effects. On the other hand, it is difficult to interpret NEG's model as predicting a symmetrical world. Observing Venables (1996), only if the economy fits the very restricted assumption of the models would we observe the symmetrical equilibrium. These assumptions would be difficult to meet in reality especially in developing countries.

Storper's approach is methodologically different from the mainstream one, and it clearly contributes to our understanding of the choices, aims and kinds of competition where the economic actors have to choose. The evolutionist approach seems to clarify and update historical elements that will impact on the production set, preferences, constraints and policy behaviour in the real economy.

But, as already mentioned, we are still lost as to why some choices are made rather than others. Another problem is that the characteristics of the post-Fordist paradigm are not clearly justified. Counteractive effects are not well exploited. For example: if proximity seems important to help in the communication of the non-codifiable knowledge, how can this importance be decreased by outcomes of the same environment, such as the computer system. Or, another example, the problem of coordination got worse with the increase in the interaction, but we have new institutions and again a higher power of communication than we had before.

Storper is aware of this problem, but rather than prove it, he seems to state that some forces are stronger than others.

It seems that the evolutionist analysis applied to the regional world must try more to balance the overall effects of the causalities they highlight. A more formalised approach is necessary. On the other hand, a formalised approach that would include elements like conventions and interactions is most likely to produce a mosaic of models, without a clear specification of the most important variables in determining agglomeration.

The importance of the region as an "input", and the categorisation of type of worlds based in the products seem to help in understanding regional evolution.

II.5 - Corporation Approach

The hypothesis of Markusen (2001) is that corporations and unions have differentiated responses to the environmental conditions. Their responses will then have different regional and allocation impacts. She emphasises the importance of case studies for the understanding of regional development.

The main theoretical framework used by Markusen is well described in Markusen (1986). She is concerned both with the disindustrialisation of old important economic areas and, on the other hand, with the claim that the developed areas will always have an advantage, especially in technology.

She is clearly concerned with the distribution of activities and with the determinants of regional growth, which is the reason why she is reviewed here. Her debate with the previous school is small, except from a methodological point of view, as we will report in the end.

For Markusen (1986), the traditional theories that deal with regional development do not discuss innovation, the role of the oligopoly, while thinking of corporations as passively determined by the free-market forces. She intends to support the profit-cycle approach, which highlights that the decision of the firms are not only due to the free-market determinants, but involve organisation-building, risk, mistakes and even political forces. Obviously, she will emphasise the role of the oligopoly in modern capitalism.

The main driving force of the decisions of the firms is of generating profit, understood here as differences between revenues and cost. Profits are determined by the rate of growth in the demand of the product (among competitive industrial groups) and by the degree of cost reduction due to standardisation of production.

The idea is that the firm has a history that goes though five stages: "zero-profit", "superprofit", "normal profits", "normal profit and normal-minus profit", and "negative profit".

The "zero-profit" phase is the innovative one. The product is not consolidated in the market; more precisely, there is still no market for it. Few investments in plant exist, unemployment of low-skilled labour is small, while skilled workers do the job. No organisation building is yet necessary and spatial "concentration" (Markusen, 1986, p.44) is high. Availability of natural resources and "historical accident" (p.45) may be important to determine the location of the units of production.

Demand ("the use value of the purchaser", p.30) is the main determinant of prices, while high unit costs, on account of production being small, also play a role.

The "superprofit" stage clearly depends on rent due to the innovative process, in a very Schumpeterian flavour. Small competition is also important, since the new industry may be protected by patents or because of the difficulties in imitating or creating a closer substitute for the new product. Nevertheless, there is some entry, which decreases concentration, while the size of the firms increases due to investment in productive capacity. Output grows quickly and so do all kinds of employment.

Standardisation of the process of production decreases unit costs, generating a downward pressure in prices. But they are still demand-driven, being higher if the new product decreases the necessary social time to pursuit a task, if it decreases the time of household tasks, or if improves the quality of life. Markusen calls this state the "agglomeration" (p.45) one, since the firms need to rely on a high-skilled pool of the labour market and also need to be in touch with a differentiated range of suppliers.

The "normal profit" stage corresponds to the entry of firms into the market, with competition decreasing profits. The level of output is high, although its growth path is decreasing, and the same pattern can be found for employment.

Mechanisation and organisation procedures take place in order to decrease costs. Vertical and horizontal integration generate an increase in the size of the firm.

From the point of view of localisation, the competition among the firms and the desire to cut costs will encourage firms to spread their units closer to the markets (and also search for new ones). This "dispersion" (p.45) can also be driven by opening plants in areas of low-cost inputs.

As competition gets stronger, including the possibility of the existing firms being threatened by new products, the firms go to the fourth stage, of "normal-plus and normal-minus profits". "Normal-minus" profit occurs when firms do not manage to sustain their markets shares. Output and employment will decline.

The alternative scenario is the consolidation of oligopoly structures, which will receive a higher than normal profit. Employment may decrease, in order to cut costs, while more machines are used. The size of the firm increases, with a corresponding decrease in their number. Prices increase due to market power, and the growth of output is not determined, since, due to oligopoly behaviour, it should decrease, but the attempt to increase markets may counteract this force.

If oligopolisation occurs quickly, the tendency for dispersion in the later state will be decreased. Markusen calls this phenomenon "retardation" (p.46). "Retardation" can also be encouraged by political benefits received by the large corporations.

On the other hand, if the strategy to open new markets through product differentiation is very important, proximity to the markets will diminish the concentration tendency of this phase.

If oligopolisation takes place in later periods, then the search for lower costs may induce dispersion of economic activity, or its "relocation" (p.47).

Finally, an intense decrease in output and further decreases in employment take place when the firm becomes obsolete. Because of the closing of plants, Markusen calls the spatial consequence of this state an "abandonment" (p.48).

Markusen (2001) criticises the literature in economic geography for forgetting the main actors of the economic process (firms, unions, government), while centring their approach in such misleading causalities as "agglomerations" and "technology".

About Storper (1997), for example, she observers:

> "Both the Walker piece and Michael Storper's *Regional World* (1997) accord technology an endogenous causal role in economic geography … But technology is not a disembodied force. It is the product of concerted acts by corporations, governments and individuals …" (Markusen, 2001, pp.6-7).

The same kind of criticism is directed towards the NEG.

Her criticism can be questioned, since both (following the examples) Storper and Krugman do not forget the action of the firms. In the Storper example, as we have observed, the importance of technology is that the economic actors must face decisions related to adopting a non-standardised type of production process, and also that all firms' decisions are surrounded by an environment with more uncertainty and interaction among them.

In the case of Krugman, firms are clearly described in the model, taking the usual procedures of maximising profits given their objective function and subject to constraints. Their decisions, affected by the impact of a changing transportation cost, will either generate agglomeration or not.

On the other hand, Markusen seems caught in a framework that makes her firms passive of a given historical cycle. Only one degree of freedom is really given to the firm, which is to engage in oligopoly practice or not.

Walker (1989) adds other criticism to this approach. The corporation school insists that small firms have a different locational pattern from large ones, which is not observed consistently from data and history. It also claims that agglomeration can be changed by the redefinition of activities within the firm, and that there is a hierarchical pattern of location of the internal activities. According to Walker, this phenomenon is just an aspect of a broader change in the division of labour. Walker also points out that there is little evidence that corporations have few linkages and thus are not so encouraging of economic growth, as the corporation approach suggests.

Conclusion

Our review of this debate brings the following possibilities of theoretical improvements for NEG: it could incorporate the discussion of transaction cost and of C-R transactions and include elements of proximity that act in the opposite direction to the decrease in transportation cost.

Empirically speaking, further research will depend on the availability of data for trying to observe the presence of these two types of transaction, characteristics of linkages and proxies for the elements of proximity.

NEG approaches could benefit from rethinking conditioning its agents to reflect more elements of the post-Fordist world. The criticism that mainstream is an historical approach can be refuted if it is clarified that the authors are aware of the connection between history and the specifications of the models.

It is important to highlight that NEG does incorporate some features of the post-Fordist world, as when it discusses the importance of variety in decreasing cost and the process of cost decreasing of this environment.

Chapter III - The Econometric Model

Introduction

In this chapter, we will specify our econometric models, based on the ideas expounded in Chapter I.

In Section III.1 we will review empirical work based on the New Economic Geography literature. In Section III.2, we will present our econometric models, which will be explained in Section III.3. In Section III.4, we will comment on some variations of the basic specifications that will also be tested. In Section III.5 we will propose some changes to the dependent variable. In Section III.6 we will discuss how to deal with the "omitted variable" problem. In Section III.7 we will specify the countries and periods for which we will apply the models. Finally, in Section III.8, we will make a brief comparison between our empirical work and empirical tests of New Economic Growth models.

III.1 - Review of the empirical work based on NEG

As Fujita, Krugman and Venables (1999) and Krugman (1998a and b) stressed, there is little empirical work based on the "New Economic Geography", and some of the attempts to test its hypotheses were not successful. In this section, we will present the main empirical work in the area, in order to observe the different ways that NEG's hypotheses has been tested.

The empirical work based on NEG is more concentrated in the analysis of the location/concentration of activities. The usual procedure is to confront the results with the predictions of the Heckscher-Ohlin (HO) model. Some exercises are particularly interested in the distribution of specific types of activities, which is a question not directly related to our work.

Venables (1998), reviewing the existing empirical evidence, observes that the HO model does explain a major part of inter-industry trade, but it is not successful in explaining the consequences of the recent decrease in tariffs and technical progress. According to the HO model, given this scenario, activities should spread according to the comparative advantages of the countries. But the actual pattern of industrial change in the developing countries is characterised by concentration of activities in few countries, contradicting the higher equality forecast by that model. Also, in the USA, where labour is highly mobile, and in Western Europe, where endowments are similar, the HO model predicts that activities should be spread over these areas, while they are indeed concentrated over them.

Venables (1998) also mentions that proximity to big markets and low transportation costs seem to be important in the determination of the location of activities and shows that per capita income and its growth rate are higher in countries with a high proportion of the population close to the borders and in countries that are near the USA, Europe and Japan. This evidence is compatible with the ideas developed by NEG models.

Another empirical fact that seems in accordance with the NEG models is the above-mentioned fact that activities are spreading in an uneven way to the developing countries, as illustrated by the case of East Asia. According to Puga and Venables (1998), activities concentrate in a country benefiting from the positive externalities of a higher market. This creates an upward pressure on the wage of this country. The development of other countries is dependent on this wage gap. Once this gap is significant, activities will migrate to another specific country, leading to its development. Activities will not spread for the rest of the countries evenly, because the country that has a small advantage will attract them.

Amiti (1998) provides a good review of the empirical work that has been done in this area, while also showing that there has been a recent increase in specialisation and concentration of production among European countries (as measured by Gini coefficients). This evidence is strongly against the HO hypothesis, since endowments and tastes are similar among European countries. She suggests that a better access to large markets, economies of scale and linkages among firms, especially among firms that use intermediate goods in an intensive way, could be the reasons behind the concentration and specialisation, once the European countries started to decrease the obstacles in their trade.

The empirical work of Kim (1995) has been highlighted as a successful attempt to discuss the hypotheses of NEG and New Trade Theory. Kim analysed the behaviour of US firms from 1860 to 1987, trying to test which kind of theory supported the pattern of concentration and specialisation in manufacturing activities that he found. He found that concentration and specialisation in manufacturing increased from 1860 to the First World War, reached a maximum in the interwar period and decreased afterwards. Since transportation costs were declining in the USA during this period, this pattern is consistent with the idea (developed in Chapter I) that, at intermediate levels of transportation costs, activities are concentrated, while at lower levels of these costs, we observe dispersion of activities.

Since Research and Development activities, the level of skill of workers and the rate of technological innovations have increased since the Second World War, and since the index of concentration and localisation has decreased in the same period, Kim concluded that external economies cannot be a good explanation.

Through a panel approach, he tested if resources (raw material intensity) and economies of scale (average plant size by production workers) were important for the determination of the trend of localisation and specialisation and he found that these factors were important in the period analysed, supporting both the HO model and models based on the importance of economies of scale, like NEG's models. It is worth noting that the historical evolution of the pattern of concentration in US manufacturing observed by Kim is consistent with the congestion model discussed in the last chapter.

Kim (1999) tried to refine the attempt to identify if clustering was occurring due to spillovers or due to existence of natural resources. He based his empirical work on the Rybczynski theorem, which establishes a relationship between production and factor endowments. He used cross-section techniques to estimate the following specification:

$Y = \alpha + \beta_1$ labour $+ \beta_2$ capital $+ \beta_3$ agriculture $+ \beta_4$ tobacco $+ \beta_5$ timber $+ \beta_6$ petroleum $+ \beta_7$ minerals $+ \varepsilon$,

Y being the value added of twenty (two-digit) industries in US, for 1880, 1900, 1967 and 1987.

The residual of this specification (ε) could be attributed to spillovers causalities (or other factors). He found that, over the period 1880-1997, this residual has increased.

Davis and Weinstein (1996) showed evidence that the HO model was the most important model to explain the distribution of industrial output in an international data set. But they guessed that, in a regional set, there could be more causalities determining the distribution, not of total activity, but of specific industries.

Davis and Weinstein (1999) studied the case of 40 prefectures in Japan, analysing the behaviour of

19 industries. Their idea is that comparative advantages and "economic geographies" may have different degrees of influence according to the different "levels of production". Factor endowments would be important in explaining the distribution of industry, while increasing returns could be more relevant in shaping the distribution of the types of goods produced inside each industry.

To analyse this idea, they aggregate the 19 industries in 6 levels, according to the ratio of college/non-college labour in each industry.

The first exercise aimed to establish the idea that factor endowments matter. Regressing the value of production in each of the six aggregates on a list of factor endowments (college, non-college, capital and land), they found a high average fit for the equations. On the average of the 40 regions, factors explained approximately 80% of the aggregate value of their production.

The second exercise was to run a regression with the output of the 19 industries as the dependent variable, and three independent ones: factor endowments, IDIODEM and SHARE. IDIODEM captures the deviation of the regional demand in each industry from its average demand in Japan. SHARE captures the following idea: in the absence of increasing returns, a region could have different values of industrial product, but the distribution of the specific activities within the industries should be the same. The main focus of this exercise was to observe the coefficient of IDIODEM. The hypotheses were:

a) if costs are not important, this coefficient should be zero;

b) if comparative advantages and costs are important, changes in demand should create changes in production on, at most, a one-to-one basis, so the coefficient should be greater than zero and smaller than (or equal to) one;

c) finally, if "economic geography" matters, the coefficient should be greater than one.

The result was: including endowments in the exercise, the coefficient of IDIODEM was smaller than one; only excluding endowments did its coefficient support the last hypothesis.

Davis and Weinstein suspected that this result was biased by the fact that "economic geography" is important only for sectors that have increasing returns. So they decided to run the same regression (without the variable endowments) for the six aggregates, observing that for two of them the coefficient was higher than one, and that these aggregates did include industries that are identified with increasing returns.

Finally they estimate 19 regressions, for each of the industries (over the 40 regions), including the output of these industries on the right-hand side and the IDIODEM, SHARE and factors on the left-hand side. They found a significantly greater than one coefficient for IDIODEM in 8 of the 19 industries analysed.

The conclusion is that endowments are important to determine the distribution of aggregate levels of industries but, on a more disaggregated level, in a regional scenario, "home-market effects" are important to determine the distribution of specific industries.

Another kind of research was developed by Fujita and Tabuchi (1997), showing first that the breaking of the Tokyo-Osaka bipolar system was followed by the change in activity from light to heavy industries. Activity in Japan, in the heavy industry era, was dispersed through the Pacific industry belt. From the mid-1970s onwards, another structural change has occurred: the system has changed from heavy industries to high tech and services ones and this occurred at the same time that activities were concentrating in Tokyo (Tokyo monopolar system). In this later movement, there was also a reallocation of the activities of the industries, with management and knowledge-intensity activities concentrated in the "core" of Tokyo and the other activities forming several layers of belts in the periphery of this city. The same relationship is found between Tokyo and the rest of the country.

One empirical work that tries directly to test some of the NEG hypotheses is Junius' (1999) one, although his empirical work has been conducted in a very different way from ours. More specifically, he surveyed the empirical literature, showing the importance of economies of scale to the spatial concentration of industrial activities. He has also surveyed the empirical literature related to the importance of trade costs and tested with a gravity model if the recent strong integration of markets has decreased the economic importance of trade costs. In the third part of his empirical work, he tested if spatial concentration followed a U-shaped pattern with economic development. In order to do this, he did a regression with the primacy ratio ("share of the largest city in the total urban population") as the dependent variable and per capita GDP and per capita GDP squared as the main independent variables. He found support for the hypothesis tested.

Some of the NEG's main causalities were tested in studying the behaviour of cities. Although, again, the object of enquiry of these papers is not the same as ours, the modelling methods of these empirical works are closer to our approach, making it worthwhile to review them, since it can help us to construct our model.

Some of the best-known empirical research (Krugman, 1998a) based in NEG ideas is Ades and Glaeser (1995). The authors were directly testing the hypotheses of NEG, while also debating with the empirical discussion of Krugman and Livas (1992) about the growth of Mexico City.

Their aim was to understand the concentration process (percentage of people in the main city) in a sample of 85 countries studied, in the period 1970-1985. This percentage was their dependent variable.

Krugman and Livas (1992) stated that the growth of Mexico City was caused by protectionist policies. Ades and Glaeser tested this hypothesis (against the hypothesis that concentration is caused by comparative advantages in international trade) through two variables that reflected the degree of openness: the share of import duties in imports and the share of exports over the GDP. The results supported Krugman and Livas' hypothesis that less open economies tend to be more concentrated.

The authors included the land density and population in the beginning of the period as independent variables. Controlling for population, the bigger the area (i.e., the smaller the density), the smaller the concentration, which could imply that high transportation costs discourage concentration, in accordance with the core/periphery models.

Government expenditures in transport and communications have a negative coefficient, again supporting the idea that low transportation costs decrease the agglomeration of activities in some areas. Also, availability of roads had a negative coefficient, supporting the same hypothesis.

The idea that industrialisation can generate agglomeration was tested with the variable "employment outside agriculture", which showed the expected positive sign.

Per capita GDP was also included on the right hand side, not showing any significance. A dummy representing if the city was a capital city showed a positive sign.

Not directly concerned with NEG, they also presented evidence that dictatorship and political instability tend to generate a concentration of population in the main city.

Glaeser, Scheinkman and Shleifer (1995) also tried to understand the growth of population (and income), in the period 1960-1990, for a sample of 203 cities of the US. This work is not so connected with the ideas of NEG, but it is worthwhile to observe that in it the share of manufacturing activities had a negative sign. Also, manufacturing employment in 1960 was negatively correlated with the growth of the US cities.

Less densely populated cities grew more and per capita income did not show any impact on the growth of cities. The cities that experienced greater growth in 1950-1960 were the ones who grew more in 1960-1990. Not surprisingly, the cities that grew more also were the ones that received a higher number of migrants. Schooling levels affected growth in a positive way, and unemployment in a negative way.

Henderson (2000) also provides some discussion of NEG models. His aim was to study urban concentration. He was particularly concerned with the "form" that urban concentration assumes, being usually characterised by the existence of extremely low populated cities on a extreme, coexisting with high populated cities. Henderson was also considering that, at lower levels of urban concentration, growth would be beneficial, since economies of scale would be exploited. But after some optimal size, urban concentration would be harmful for growth, since congestion effects and diseconomies of agglomeration would take place. He also hypothesises that the level of income and the scale of the countries would affect the results.

He estimated the relationship between growth and urban concentration for 80-100 countries, for the period 1960-1995 (using five-year intervals), using three methods: OLS, GMM and fixed effects. Urban concentration was measured by the primacy ratio (percentage of national population that lives in the largest city). He found evidence that at lower levels of income, higher primacy ratios spur growth. After a peak, higher primacy ratios are harmful. The poor the country, the smaller the peak of the primacy ratio. The larger the county, the higher the value of the peak of the primacy ratio.

He tried also to explain urban concentration. His main findings were that urban scale, national land area, investment in waterways and road density decrease urban concentration. If the larger city is the capital of the country, the primacy ratio increases. Income has a non-linear relationship with the primacy ratio. Openness decreases concentration if the larger city is not a port.

Also concerned with urban development, Henderson (1996) discussed the impact of the liberalisation policies carried on in the 1980s on the distribution of activities and of population in Java (Indonesia). Between 1980 and 1990, there was an increase of 5.3% per year in the rate of population growth of the ten largest cities (with more than 1 million habitants) in Indonesia, while 15 urban areas with more than 200.000 habitants (and less than 1 million) showed a population growth rate of 3.9% per year. In Java, the four biggest manufacturing areas had a 32% increase on its population and a 51% increase in its manufacturing employment.

There was evidence that the unincorporated firms (smaller, less export-oriented) showed small concentration than the incorporated sector (more regulated one).

The empirical work aimed to observe the determinants of the location of the private activities for both the incorporated and unincorporated activities using a logit model.

Henderson has chosen the following factors affecting the decision to locate:

a) market factors: measured by the "total annual compensation/total paid employees in all firms existing prior to 1980 outside the industry" (p. 519), which would be a proxy for wage; population in the county was also used as a proxy for internal demand;

b) industrial environment: the main proxies used were the employment in industry i(to measure for local externalities), while Jacobs externalities were measured by the Hirschman-Herfindahl index - HHI- (a lower HH index would imply diversity of activities and spillovers across activities). The "employment-weighted average of the age of all old manufacturing plants outside the own industry in the Kabupaten (county), divided by the national average for each industry" (p. 521) was used as a proxy for maturity of the industry;

c) infrastructure: provision of infrastructure was measured by the HII for all activities and with some proxy for provision of electricity;

d) distance was proxied by 50 km units of the line distance from the centre of a Kabupaten to the centre of the nearest of the four metro areas.

The results for textiles, wood and furniture, nonmetallic mineral, machinery, publishing and paper and miscellaneous manufacturing showed the expected negative sign for wages, infra-structure and distance (except for furniture). Local markets (measured by the population of the county) showed positive coefficients as maturity did. Both Marshal externalities and Jacobs externalities were found for these activities, since the coefficient of "past own industry" was positive and the coefficient of the HHI was negative. Henderson has also observed that a higher concentration in the past would make it harder to disperse economic activity.

Henderson (1999) studied the existence and the nature of external economies of scale for "traditional" machinery industry and some high-tech industries in the USA. Using plant data and panel estimates, for the period 1963-1992, he concluded that concentration has increased in high tech firms, while it has decreased for the machinery firms, both using primacy ratios (in this case, "the share of the largest city employer in national industry employment"(p. 8) and the Hirschman-Herfindahl index. He also observed that all types of industries were also increasing their participation in middle size cities.

Observing data for productivity after 1972, he added that high tech industries were subject to local externalities, since their productivity is positively affected by an increase in the number of plants in the same county (Marshall externalities). Traditional machinery industry, on the other hand, did not show to be subject to local external economies.

Contrasting the findings using "number of plants in a county" and "employment in the industry" reveals that economies of scale are due to spillovers rather than to labour market effects.

Economies of scale due to urbanisation effects (Jacobs) had only impact in few machinery firms.

Since the stronger deconcentration of machinery firms were not related to economies of scale, Henderson inferred that it was due to decreasing transportation costs in USA.

Henderson has also found that high tech industries are more mobile than machinery ones.

An interesting contribution to the empirical discussion of NEG models was made on by Fingleton (1991). He used a SUR technique that allowed him to consider differences in the coefficients among periods of time and between "core" and "periphery" regions of the European Union, in the period 1975-1995. While monopoly power and labour requirements in manufacturing remained exogenous variables, he could test if external economies of scale were important to explain the growth rate of manufacturing productivity in the period. He also enriched the model by allowing the inclusion of technological progress as a source of growth in manufacturing productivity. The overall importance of the rate of technological progress could also be tested and was also decomposed in several components: the technological gap between the less advanced and more advanced regions, the impact of human capital and of spillovers from neighbourhood regions.

He found that the variables did not have the same impact in each sub-period of time and that the tested parameters were different between the advanced and less developed regions in EU. He also observed that the "periphery" regions do not follow the exact pattern of the "core" ones, with a time lag.

Positive external economies of scale, positive impacts of human capital and spillovers were acting in favour of divergence of productivity among the regions, while forces towards convergence, as the technological gap, would be losing strength over time.

Henderson *at al* (2000) provide a good assessment of the empirical work relating to the importance of distance on FDI flows, R&D, trade and income levels and urban growth [although none of this work attempts to test directly the ideas of the theoretical models reviewed in Chapter I].

III.2 - Econometric models

In Chapter I, we presented a family of models of the New Economic Geography Literature, highlighting the ideas presented in Krugman (1991a), Krugman and Venables (1995) and Puga (1999). We have also surveyed, in Section III.1, the empirical literature based on the New Economic Geography. The family of models we are discussing deals not with the distribution of specific activities, but with the regional distribution of economic activity as a whole. One possible approach is to measure dispersion across regions and to track its behaviour over time, as does Kim (1995). The disadvantage of this is that it generates only one observation per time period. The other approach, analogous to that used by Glaeser, Scheinkman and Shleifer (1995) for the growth of cities, is to test if the model is able to explain the growth rate of gross output in different states, i.e., whether the model can explain why the economic weight of some states is increasing relative to that of others. This is the approach used here.

Two reasons led us to use the growth rate of income rather than the level of income as the dependent variable:

a) the growth rate of income is a much more stationary variable over time than income, which avoids problems with "spurious" correlation in the panel analysis;

b) with the level of per capita income as the dependent variable (we would have to use per capita income since the size of states is arbitrary), the direction of causality would not be clear in our econometric model. Our explanatory variables will be the structure of production and transportation costs. High-income states are likely to have greater availability of public goods, like roads, which decreases their transportation costs, and to have a smaller share of agriculture in consumption. Thus a regression with per capita income levels as the dependent variable is not a rigorous test of NEG theories: we would expect positive correlation with transport availability and the share of manufacturing even if NEG theories did not hold.

Tables IV.1-IV.4 illustrate this problem. Using data for 1990 and 1995, for Brazil, we can observe high correlation values among per capita income, the share of industrial output (in total output) and urbanisation, especially when we exclude from the sample the states of the North of Brazil. The presence of the Amazon forest in the North creates difficulties for the expansion of transport availability. On the other hand, population density in these states is very small, so they have an exceptionally high per capita income with small provision of roads and railways. Without considering these states, we can also see that per capita income is highly correlated with transport availability.

TABLE IV.1 - CORRELATION MATRIX - BRAZIL/1990

	Y1990	INDGSP	TR1990	URB1990
Y1990	1.0000			
INDGSP	0.4229	1.0000		
TR 1990	0.3327	0.5039	1.0000	
URB 1990	0.7705	0.2598	0.4491	1.0000

TABLE 2 - CORRELATION MATRIX - BRAZIL/1990

(WITHOUT NORTH)

	Y1990	INDGSP	TR1990	URB1990
Y1990	1.0000			
INDGSP	0.6021	1.0000		
TR 1990	0.6022	0.6007	1.0000	
URB 1990	0.8346	0.3555	0.5182	1.0000

TABLE IV.3 - CORRELATION MATRIX - BRAZIL/1995

	Y1995	INDGSP	TR1995
Y1995	1.0000		
INDGSP	0.4397	1.0000	
TR1995	0.4095	0.4440	1.0000

TABLE IV.4 - CORRELATION MATRIX - BRAZIL/1995

(WITHOUT NORTH)

	Y1995	INDGSP	TR1995
Y1995	1.0000		
INDGSP	0.5812	1.0000	
TR1995	0.5276	0.4978	1.0000

Notes:

Y = per capita income;

INDGSP = share of industrial output in total output;

TR = extension of railways and roads (inverse of TC)

URB = urbanisation rate.

Source: see Chapter IV.

It is important to remember that transportation costs are one of the main variables in the theoretical models discussed. When transportation costs are very high, there is no trade between the regions and their economic performance is related to the provision of their own markets. At a low enough level of transportation costs (compared to the benefits of selling in a larger market, in the presence of fixed costs), the trade between the regions creates the core-periphery equilibrium. At still lower levels, the location of the industries could be independent of their proximity to larger markets. The impact of transportation costs on the income growth rate of the states will also be studied.

Because there are arguments for different specifications, measurement difficulties and possible non-linearities, a variety of specifications will in fact be tested.

We are proposing the following basic econometric model for testing these ideas:

$$GRGSP_{i,T-t0} = \alpha_1 + \beta_{1i0} Y_{io} + \Omega_1 INDGSP_{i0} + \phi_1 (1/TC)_{io} + \Gamma_1 DD_{io} + \varepsilon_{1i} \quad (1)$$

i=stands for state;

o=stands for beginning of the period;

$GRGSP_{i,T-To}$ = growth rate of income (N.B. not per capita income) of state i in the period t_o-T;

Y_{io} = per capita income of state i at the beginning of the period;

$INDGSP_{io}$ = percentage share of the value of industrial product of state i in total value of the product of state i, in the beginning of the period;

TC_{io} = proxy for transportation costs of state i, in the beginning of the period;

DDio = population density of state i in the beginning of the period.

It is important to emphasise that the models reviewed in Chapter I are very abstract, ignoring the contribution of land as a factor of production and also ignoring the service sector. In these models, income would be a function only of INDGSP. In order to better apply the model to real data, we take account of land, proxied by population density (DD).

We also allow for the possibility that the service sector enjoys economies of scales similar to those of industry.

In Chapter I, we observed that the introduction of congestion changes the outcome of the core-periphery model. At low levels of transportation cost (but still not in an open economy), symmetry between regions occurs again. The model presents two "break points". The inclusion of DD aims to test the model for congestion: when population density is high, the availability of land is low relative to other factors. Congestion effects may also be captured by initial per capita income (Y), since demand for services of fixed factors will be greater when Y is higher.

III.3 - Explaining the Econometric Model

Before we explain the econometric model, it is important to bear in mind that it is going to be applied to a situation where we have n regions and where they are not equal at the beginning of the period.

Our dependent variable is not, as already discussed, the level of the income of the state, but its growth rate.

Since we are dealing with states that are unequal at the beginning of the period, we are using the per capita income in the beginning of the period to control for these differences. It is important to stress that we are not testing "beta convergence" here, since our dependent variable is not the growth rate of per capita income, but of total income.

In the economic growth literature, the dependent variable is the growth rate of per capita income. In this kind of specification, assuming that the states are similar with respect to other parameters, a negative sign for the independent variable Y means that richer areas grow slower than poorer ones. The hypothesis that poorer areas grow more than richer ones (in per capita terms) is called "absolute beta convergence". If the states have different steady states, and we control for the variables that generate the difference in the steady states, a negative sign for Y will not deny the hypothesis of "beta conditional convergence", which says that poor states will grow faster towards their steady states than richer states (Barro & Sala-i-Martin, 1995).

Beta convergence is a necessary condition to sigma convergence, which means the decrease of the dispersion of per capita income. But even if we have beta convergence, random shocks may increase the dispersion of per capita income (Barro & Sala-i-Martin, 1995).

Since our dependent variable is the growth rate of total income, a negative sign for Y would imply that poorer regions are increasing their share of total national income over time. But we can't say that a negative sign for Y would imply a decrease in the dispersion of per capita income (in the absence of random shocks) because of migration movements. If the income of the poorer states is growing faster AND the migration is in the direction of the richer states, then we would have a decrease of the dispersion of per capita income. Without taking migration into account, we cannot infer anything from our results about the dispersion of per capita income.

To proxy for economies of scale, due to "backward and forward linkages", we are using INDGSP, the percentage share of industry in each state's Gross Domestic Product (GSP).

As we have discussed, we are hypothesising that the presence of a higher INDGSP is also important to explain the growth rate of the state's income. So we are expecting a positive sign for this variable.

To proxy for the inverse of transportation costs, we are going to use two alternative variables:

extension of roads and railways (km) per area (sq km) and the inverse of a weighted average of the distances between each pair of capitals of the states. The weight is the share of the GSP of the state of destiny in the country's GDP.

We do not have an expected sign for the transportation cost variable. In the original two-region model, its coefficient should not be significant, since one region obtains all the benefit of trade, while the other is symmetrically harmed. In the n-region case, we can only observe if exposure to a more intensive communication with other regions was, on average, good (or bad) for growth. Although any sign would be accepted, we would expect to find a significant coefficient in the n-region case.

To control for diseconomies of agglomeration we are including also population density in our model (that is likely to be important in practice). Diseconomies of agglomeration are not in the Krugman (1991a) and Krugman and Venables' (1995) models. If, unlike Krugman and Krugman and Venables, we consider land as a factor of production, its fixed supply could cause diseconomies of agglomeration, for which population density is a good index. Population density is also a proxy for the inverse of natural resources per capita. We expect a negative sign for this variable, or a not significant one.

All those variables are included in Equation (1).

Equation (2) considers the possibility of the existence of a State that performs like an outlier in the country because it is atypical in some way (e.g., a capital city). Equation (3) considers the possibility of the existence also of a region (a group of states in one geographical area) that performs as an outlier, and finally Equation (4) considers only the region as the outlier.

$$GRGSP_{i,T-to} = \alpha_2 + \beta_2\ Y_{io} + \Omega_2\ INDGSP_{io} + \phi_2\ (1/TC)_{io} + \Gamma_2\ DD_{io} + \Phi_2\ MAIN\ STATE + \varepsilon_{2i} \quad (2)$$

$$GRGSP_{i,T-to} = \alpha_3 + \beta_3\ Y_{io} + \Omega_3\ INDGSP_{io} + \phi_3\ (1/TC)_{io} + \Gamma_3\ DD_{io} + \Phi_3\ MAIN\ STATE + \chi_3\ DUMMIES\ FOR\ REGIONS + \varepsilon_{3i} \quad (3)$$

$$GRGSP_{i,\ T-to} = \alpha_4 + \beta_4\ Y_{io} + \Omega_4\ INDGSP_{io} + \phi_4\ (1/TC)_{io} + \Gamma_4\ DD_{io} + \chi_4\ DUMMY\ FOR\ REGIONS + \varepsilon_{4i} \quad (4)$$

III.4 - Other Specifications: Non-agricultural and Interaction term

III.4.1 - Non-agricultural

All the equations of Items III.2 and III.3 will also be run with the substitution of NONAGR for INDGSP, the share of non-agricultural output in the states' gross state product. In this case, we are assuming that "backward and forward linkages" are not only a feature of the industrial sector, but also are strong in the service sector. We expect a positive sign for NONAGR in the linear specifications.

III.4.2 - Interaction Term

III.4.2.1 - YTC

We are going to use other specifications that include an interaction term, YTC (YTC=(1/TC)*Y). This is probably **a better representation of the Krugman-Venables model than just entering TC additively.**

Figure 3 of Chapter I implies that the coefficient of TC varies with the initial per capita income of the region. This suggests the inclusion of an interaction term YTC. When the slope of the curve in Figure 3 is positive, a decrease in transportation costs leads to the agglomeration of activities in richer regions. It would be expected, in this case, to be a positive sign for the interaction term.

On the other hand, when the slope of the curve is negative, a decrease in transportation costs is generating a more even distribution of activities among regions. Poor regions will be growing faster than rich regions, and we would expect a negative sign for the interaction term.

The coefficient of this YTC could tell us if we are observing a situation of decreasing (or increasing) disparities among the states. If YTC is positive, inequality is rising, since richer states, in the beginning of the period, with good provision of roads and railways, are growing faster. If it is negative, a decrease in the dispersion of income would be expected.

The relationship between per capita income and the growth rate of output can be expressed by the following equation:

$$GRGSP_{i,\,T\text{-}to} = aY_{io} + bYTC_{io} = (a + b\ (1/TC_{io}))Y_{io}$$

In this case, the coefficient of Y would be a function of TC. If a (the coefficient of Y in the regressions) and b (the coefficient of YTC) are positive, we would obtain a positive coefficient for

Y, which would be consistent with a rise in income dispersion. In terms of Figure 3 in Chapter I, we would be in the "core-periphery" interval, where a decrease in transportation costs is reinforcing the agglomerative advantages of the richer regions.

If, on the other hand, we observe negative coefficients for Y and YTC, equality of income will be the tendency, since richer states are now losing activities to poorer states, due to the further decrease in transportation costs.

The econometric models with YTC would be:

$$GRGSP_{i,\,T-To} = \alpha_5 + \beta_5\ Y_{io} + \Omega_5\ INDGSP_{io} + \phi_5\ (1/TC)_{io} + \sigma_5\ YTC_{io} + \Gamma_5\ DD_{io} + \varepsilon_{5i} \quad (5)$$

$$GRGSP_{i,\,T-to} = \alpha_6 + \beta_6\ Y_{io} + \Omega_6\ INDGSP_{io} + \phi_6\ (1/TC)_{io} + \sigma_6\ YTC_{io} + \Gamma_6\ DD_{io} + \Phi_6\ MAIN\ STATE + \varepsilon_{6i} \quad (6)$$

$$GRGSP_{i,\,T-to} = \alpha_7 + \beta_7\ Y_{io} + \Omega_7\ INDGSP_{io} + \phi_7\ (1/TC)_{io} + \sigma_7\ YTC_{io} + \Gamma_7\ DD_{io} + \Phi_7\ MAIN\ STATE + \chi_7\ DUMMY\ FOR\ REGIONS + \varepsilon_{7i} \quad (7)$$

$$GRGSP_{i,\,T-to} = \alpha_8 + \beta_8\ Y_{io} + \Omega_8\ INDGSP_{io} + \phi_8\ (1/TC)_{io} + \sigma_8\ YTC_{io} + \Gamma_8\ DD_{io} + \chi_8\ DUMMY\ FOR\ REGIONS + \varepsilon_{8i} \quad (8)$$

III.4.2.2 - YTCM

Due to the difficulty of imposing an expected sign for TC, another interesting alternative is to try the specifications (5) to (8), following steps 1 and 2.

Step 1: we first construct a variable TCM(t) = TC(t) - average value of TC in period t. We create the correspondent YTCM variable, where YTCM = Y * (1/TCM). Substituting TCM and YTCM for TC and YTC in the above specifications, we would expect a not significant sign for TCM. If this is true, we can proceed to Step 2.

Step 2: run the specifications dropping the variable TCM. The interpretation of the signs of YTCM is the same as the one for YTC.

The specifications with TCM and YTCM, or the ones with only YTCM, which correspond to equations (5)-(8), will be the ones that we will test empirically.

We will also create interaction terms between INDGSP and (1/TC) and between NONAGR and (1/TC).

III.4.2.3 - YTCTIME

In the models, at a high level of transportation costs, we have symmetry among regions. In our case, the expected sign of YTC would be negative. At lower levels of transportation cost, the core-periphery pattern is established and we would expect a positive sign for YTC, i.e., richer states with lower transportation costs would be growing more, benefiting from the economies of scale. With congestion (or in a completely open economy), the sign of YTC would revert to negative again at further lower levels of transportation cost. So, as time passes by, and transportation costs decrease, we would expect that the sign of YTC would change first from negative to positive and then from positive to negative.

Having this pattern in mind we generated the variable YTCTIME = YTC*YEAR.

The sign of the variable YTCTIME could help us to investigate the behaviour of manufacturing activity in time. If manufacturing activities are concentrating in the "core" regions of a country, the coefficient of YTCTIME should be positive. If transportation cost decreases further with time, and manufacturing activities disperse again, the coefficient of this variable should be negative.

III.5 - Growth rate of manufacturing output (GRIND)

An alternative approach is to use the growth rate of manufacturing output (GRIND) as the dependent variable instead of the states' income growth rate. This change could be indicative of the dispersion of manufacturing activities among the regions of a country. All the specifications will be run with this dependent variable.

$$GRIND_i = (INDUSTRIAL\ OUTPUT_{it}/INDUSTRIAL\ OUTPUT_{it-n})^n$$

where n = number of periods.

III.6 - Omitted variables

III.6.1 - Dummies

In order to control for omitted variables, we have already introduced dummies for the MAIN STATE of the country and for the outlying region in the specifications of the former section.

The usage of these specifications will allow us to test the robustness of our results, especially in a situation where we have multicollinearity among our variables.

It is important to highlight that we are going to control for the "omitted variable" problem because it can bias the coefficients of the variables of our model. We are not trying to fully explain the reasons of growth in the states of a country. Instead, we are trying to test some ideas of the New Economic Geography Literature.

III.6.2 - Omitted variables

The omitted variable problem will also be dealt with by the inclusion of other variables that can be important to explain the growth of the income of the states. Of course, the specific variables included will depend of the country (and on the availability of the data), so we will leave the complete list of these variables to the further chapters. These variables will be chosen from the Economic Growth literature.

III.7 - Test of Restrictions

After running the econometric models, we will try to select the "best" model trough imposing restrictions in our coefficients.

We will proceed in the following way:

a) we will include all regional variables in the specification with the independent variables: Y, INDGSP (or NONAGR), (1/TCM), YTCM and DD[1]. We will test if the coefficients of the regional dummies are jointly significant. If the F-test rejects the joint significance of the regional dummies, we will exclude them from the model (in the case of Brazil);

b) we will test if the coefficients of the dummy for SP and Delhi, for Brazil and India respectively, are significant. If not, we exclude the variable from the econometric model;

c) we will test if the coefficient of (1/TCM) is significant (through the F-test). If not, we will exclude this variable from the model. The reason for this test was explained in section III.4.2.2;

d) we will test if the coefficients of the interaction term YTRM and of the proxy for economies

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[1] - among our specifications, we have concluded that the one with (1/TCM) and YTCM is the best way to describe K&V(m) model.

of scale (INDGSP or NONAGR) are jointly significant and if they are individually significant. We observe also the signs of the coefficients: INDGSP (NONAGR) must have a positive coefficient, as already explained. **Only if the proxy for economies of scale and the interaction term are both jointly and individually significant, and the coefficient of the proxy for economies of scale is positive, we do not refute the model.**

e) to select the best model among the ones with different proxies for transportation cost we will use the higher R^2.

If we do not refute the model and the coefficient of the interaction term is positive, we conclude that the economy is in the agglomerative stage of K&V(m) model (phase II). If the interaction term is negative, we conclude that the economy is in the third phase of the model, where we observe convergence of income among regions.

III.8 - Applications

We are going to apply the above model to two countries - Brazil and India. The choice of these countries reflects their federation system and their size.

For Brazil, we are going to test the model for three periods: 1950-1995, the beginning of strong Brazilian industrialisation, 1950-1970, for comparative studies, and 1970-1995, a period when the market was considered integrated by the communication system in Brazil.

For India, we just have data for the period 1961-1991.

We are going to use two econometric techniques: cross-section and panel analysis (Greene (1997) and Hsiao(1986)). The cross-section analysis is the appropriate choice when we have to analyse the behaviour of several units at a specific moment of time. But in our case, the size of our samples are usually small. Because of this problem, we also use the panel specification, or precisely, the one-way fixed effect model, with time-period dummies (LSDV). In the panel analysis, although we increase the number of observations, the problems of measurement errors increase.

We are not choosing the two-way fixed effect model because we would lose too many degrees of freedom.

We are opting to control for time-period dummies, instead of region dummies, because crosssectional differences in regional performances are the primary focus of interest.

III.9 - Similarities and differences with economic growth

Our econometric models superficially resemble the models of the economic growth literature, but there are three important differences:

a) our dependent variable, as discussed, is not the per capita growth rate of output, but the growth rate of total output;

b) due to (a), the coefficient of the per capita income variable does not test for beta [better?] convergence;

c) transportation cost is not a commonly used variable in the economic growth literature. When we proxy transportation cost by the extension of roads and railways, it is true that, instead of testing for transportation cost, we could be testing a model of availability of public goods. We address this problem by using an alternative proxy for transportation cost: the average distance between the states' capitals, weighted by states' economic importance, definitively does not proxy for public goods availability.

But since we are testing the impact of some variables on the growth rate of output, there will be some similarities between the structures of the models. That is why we control our model for the differences in per capita income and why we will choose variables from the economic growth literature to test for omitted variables.

Conclusion

In this Chapter we have specified the econometric models with which we will try to observe if the data for the states of Brazil and India resembles the main ideas of the Krugman-Venables' model (K&V(m)).

"Backwards and forwards" effects were introduced through the share of industrial output (in the state total output) and through the share of non-agricultural output.

Transportation costs were introduced directly, with the variables TR or through their impact in the coefficient of per capita income, through the interaction term YTCM.

Congestion costs and differences among states were controlled by population density and per capita income, respectively.

We will also try to control the econometric model for special effects of regions and for the special effects of outlying cities.

We will try to observe if the interaction between economies of scale and transportation costs, as specified in our econometric models, is generating dispersion or concentration among the states of Brazil and India.

Chapter IV - The Case of Brazil - Cross-Section Results

Introduction

In this chapter, we are going to apply the econometric models specified in Chapter III to investigate if they are able to explain the performance of the growth rate of income of Brazilian states.

Three periods will be considered: 1950-1995, 1950-1970 and 1970-1995. 1950 was chosen to start the first period because it is a year that represents the beginning of "heavy" industrialisation in Brazil, while 1970 is a year that represents a period of greater integration of its market, through communication channels and transport links.

Two samples will be considered: a small sample that excludes the states of the North of Brazil, and the total sample (24 States). Two reasons explain this partition: the fact that we do not have information for all the six states of the North in 1950; and the outstanding performance of these states in the post-1970 period. Also, although Brazil now has 27 states, one is just the Federal District, the city of Brasilia, and was excluded from the sample.

We also combined Mato Grosso with Mato Grosso do Sul and Tocantins with Goias, since these two broader areas were political units in the beginning of our period, and separate data for them do not exist at that time.

We shall use two techniques: a cross-section for the whole period and a panel based on five-year averages. The cross-section regressions will be discussed briefly, since the available number of observations is too small to provide reliable results.

The structure of the Chapter will be the following: in Section IV.1 we will present our data; in Section IV.2, the correlation matrix will be presented; in Section IV.3 we will explore the cross-section results; and in Section IV.4, the same will be done with another proxy for transportation costs. Section IV.5 will discuss the behaviour of the industrial growth rate.

IV.1 - Data

We do not have a homogeneous source for the output of the states. For the years 1950, 1955, 1960, and 1965, we have used the estimations of the states' income from Fundação Getúlio Vargas. This institution provides this data from 1949 to 1969.

For the years 1970, 1975, 1980, and 1985, the output of the states was obtained from IBGE (Instituto Brasileiro de Geografia e Estatística).

From 1985 onwards, IPEA (Instituto Brasileiro de Pesquisa Aplicada) has been estimating the output of each state on an annual basis.

The output of the states was used to calculate the growth rate of output during the period and the per capita income.

Total population was found in the Anuário Estatístico from IBGE. Data for the years 1950, 1960, 1970, 1980, and 1991 were based on the Population Census. Data for the years 1955 and 1965 were estimated by interpolation using the annual growth rate of the decade. For 1975 and 1985 the data of IBGE is based on a sample survey (PNAD, national research by household sample). For 1990, we calculated the annual growth rate between 1985 and 1991 and used this value to find the estimated 1990 data. We used a similar procedure to find the data for 1995, since we have used the 1996 data from the Population Account (Contagem Populacional), from IBGE. Total population was used to calculate per capita income, population density, urbanisation rate and enrolment rates.

Industrial product, agricultural product and non-agricultural product were found in the same sources as total product. These data were used to calculate their shares in the states' output.

Two proxies were used for (the inverse) transportation cost: extension of the roads and railways within the state per unit area of that state (TR) and the inverse of the weighted average distance from the capital of each state to the capitals of other states (the weight being the product of each state in Brazilian total product)(PROX). For the extension of roads and railways per area we have used again Anuário Estatístico do Brazil, which provides the extension of the road and railways and the area of the states in square kilometres. The distances between each pair of states (more precisely, each pair of states' capitals) were also found in Anuário Estatístico do Brazil (AEB).

Population density was also found in AEB, or calculated from the data for population and area.

Urbanisation rate, the value of total exports and enrolment in primary and secondary schools were found also in AEB.

Urbanisation rate is the share of urban population in total population. The concept of urban population used by IBGE is very wide, including the population of cities (municipal seats), villages (vilas, district seats) and "isolated urban areas" (FIBGE, 1991).

Exportation will be measured by the value of exports in the states' output.

Our proxies for human capital are enrolment in primary and secondary education (number of total enrolment over the population of the state).

The raw data for Brazil is in Appendix 1.

IV.2 - Correlation Matrix

The analysis of the correlation matrix for the period 1950-1995 shows that the growth rate of output is not strongly correlated with any of our right-hand side variables, with the exception of population density (DD) and the dummy for the states of the Centre-West (CO) (Table IV.1). DD has a negative correlation with the income growth rate.

The right-hand side variables show strong correlation among themselves. Richer states in 1950 (Y) are also the most industrialised ones (INDGSP), the states with more non-agricultural output

(NONAGR), the more populated states and also the states with greater availability of transport(TR).

São Paulo (SP) has a high share of industrial output (in total output-INDGSP), while high shares of non-agricultural output (in total output-NONAGR) are common in all states of the Southeast (SE).

The states of the Southeast (SE) are rich in per capita terms, have good provision of transport (TR), are close to the richest markets (high correlation with PROX), and have a dense population (DD). These characteristics are very strong in São Paulo.

The states of Northeast (NE) show an opposite situation. They are poor in per capita terms, they are far from the richest markets (negative correlation with PROX) and they have bad provision of transport (TR).

Centre-West (CO) shows poor provision of transport and high-income growth rates (GRGSP).

The states of the South (S) are relatively close to the richest markets.

The variable PROX, which measures proximity to the richest markets, is positively correlated with SP and SE, and negatively correlated with NE.

The interaction terms YTR (Y*TR) and YTRM (Y*TRM)[1] reflect the characteristics of the states of SE and especially of São Paulo, which are rich and well provided with transport. They are negatively correlated with the dummy for the states of NE.

PROX has a positive correlation with TR. YTRM and YPROXM (Y*PROXM)[2] are positively correlated.

YPROXM shows a positive correlation with INDGSP, NONAGR, DD and TR. YPROXM reflects positively SP and SE and, negatively, NE.

Table IV.1 - CORRELATION MATRIX - BRAZIL -1950-1995 (18 STATES)

	grgsp	y	indgsp	nonagr	dd	tr	trm
grgsp	1.0000						
y	-0.1977	1.0000					
indgsp	-0.3535	0.6982	1.0000				
nonagr	-0.3720	0.7029	0.7562	1.0000			
dd	-0.5860	0.6545	0.6213	0.8030	1.0000		
tr	-0.3384	0.7021	0.7279	0.4616	0.4831	1.0000	
trm	-0.3384	0.7021	0.7279	0.4616	0.4831	1.0000	1.0000
ytrm	-0.1937	0.7772	0.6905	0.5563	0.4590	0.8821	0.8821
prox	0.0051	0.8462	0.5302	0.4257	0.4049	0.6305	0.6305
proxm	0.0051	0.8462	0.5302	0.4257	0.4049	0.6305	0.6305
yproxm	-0.1447	0.9284	0.6190	0.6469	0.6127	0.6871	0.6871
sp	0.0081	0.5760	0.5139	0.3450	0.1433	0.6565	0.6565
ne	-0.3523	-0.6496	-0.2727	-0.1384	-0.0842	-0.3731	-0.3731
se	-0.1826	0.6457	0.3457	0.4471	0.4932	0.5392	0.5392
s	0.0483	0.2493	0.2749	-0.0389	-0.1642	0.2387	0.2387
co	0.7448	-0.1163	-0.3495	-0.3251	-0.3237	-0.4028	-0.4028

[1] TRM = TR - mean value of TR
[2] PROXM = PROX - mean value of PROX

	ytrm	prox	proxm	yproxm	sp	ne	se
ytrm	1.0000						
prox	0.6810	1.0000					
proxm	0.6810	1.0000	1.0000				
yproxm	0.8523	0.8900	0.8900	1.0000			
sp	0.8938	0.5241	0.5241	0.6928	1.0000		
ne	-0.3489	-0.8076	-0.8076	-0.5678	-0.2425	1.0000	
se	0.5955	0.8070	0.8070	0.7666	0.4537	-0.5345	1.0000
s	0.0266	0.2131	0.2131	0.0202	-0.1085	-0.4472	-0.2390
co	-0.2643	-0.0354	-0.0354	-0.1348	-0.0857	-0.3536	-0.1890

	s	co
s	1.0000	
co	-0.1581	1.0000

Table VI.2 shows the correlation matrix for 1950-1970. The growth rate of income (GRGSP) is positively correlated with CO (states of Centre-West) and negatively correlated with NE (states of Northeast).

Per capita income (Y), INDGSP (share of industry), NONAGR (share of non-agricultural output) and DD (population density) show similar patterns from the previous samples.

TR (transport availability), PROX (proximity to markets), YTRM (Y*TRM) and YPROXM (Y*PROXM) are positively correlated, reflecting the low transportation costs of SE (Southeast) and SP (São Paulo) and the high transportation costs of the NE (Northeast).

Table IV.2 - CORRELATION MATRIX - BRAZIL -1950-1970 (18 STATES)

	grgsp	grind	y	indgsp	nonagr	dd	tr
grgsp	1.0000						
grind	0.6249	1.0000					
y	0.2170	0.0522	1.0000				
indgsp	0.0315	-0.3228	0.6982	1.0000			
nonagr	0.0440	-0.2114	0.7029	0.7562	1.0000		
dd	-0.2784	-0.4281	0.6545	0.6213	0.8030	1.0000	
tr	-0.1090	-0.1326	0.7021	0.7279	0.4616	0.4831	1.0000
ytrm	0.0881	0.0552	0.7772	0.6905	0.5563	0.4590	0.8821
prox	0.3280	0.3078	0.8462	0.5302	0.4257	0.4049	0.6305
yproxm	0.2180	0.1533	0.9284	0.6190	0.6469	0.6127	0.6871
sp	0.1874	0.1940	0.5760	0.5139	0.3450	0.1433	0.6565
ne	-0.5803	-0.4170	-0.6496	-0.2727	-0.1384	-0.0842	-0.3731
se	0.0109	0.1429	0.6457	0.3457	0.4471	0.4932	0.5392
s	0.2307	0.0290	0.2493	0.2749	-0.0389	-0.1642	0.2387
co	0.6353	0.4400	-0.1163	-0.3495	-0.3251	-0.3237	-0.4028

	ytrm	prox	yproxm	sp	ne	se	s
ytrm	1.0000						
prox	0.6810	1.0000					
yproxm	0.8523	0.8900	1.0000				
sp	0.8938	0.5241	0.6928	1.0000			
ne	-0.3489	-0.8076	-0.5678	-0.2425	1.0000		
se	0.5955	0.8070	0.7666	0.4537	-0.5345	1.0000	
s	0.0266	0.2131	0.0202	-0.1085	-0.4472	-0.2390	1.0000
co	-0.2643	-0.0354	-0.1348	-0.0857	-0.3536	-0.1890	-0.1581

	co
co	1.0000

For the small sample of the period 1970-1995 (Table IV.3), the growth rate of output (GRGSP) is strongly (negatively) correlated with the richest states (Y), the more industrialised ones (INDGSP), the states that provide high amounts of services (NONAGR), with the most populated states (DD) and are better provided with transport (TR).

These results are different from the same 18-State sample of the period 1950-1995, where only DD was negatively correlated with the income growth rate.

Again, excluding the North, the region of the Centre-West shows the best performance in Brazil.

The same pattern applies: richer states in 1970 are the more industrialised areas and the ones with a higher share of non-agricultural output. Richer states in 1970 were the ones with more roads and railways and the more populated states.

The highly industrialised states are close to the richest market (PROX) and also are the states that provide a high amount of services, as can be inferred by the correlation of INDGSP and NONAGR with PROX.

TR is positively correlated with PROX, as expected. TR is positively correlated with all interaction terms, including YPROXM (Y*PROXM).

The states with a high provision of transport are São Paulo (SP) and the states of the South (S), while the states of the Centre-West (CO) are badly provided with them.

YPROXM is positively correlated with YTRM. The states of the Northeast(NE) are the furthest from the richer markets, while the states of SE (Southeast) and S (South) are the closest ones, showing a similar picture from 1950.

The interaction terms - YTRM and YPROXM - are all positively correlated. The richest states, closer to the rich markets and better provided with transport, are in the SE (specially São Paulo) and the poorer ones, without good provision of transport and further from the markets, are in the NE (Northeast).

The SE (Southeast) (specially São Paulo) is positively correlated with Y (per capita income), DD (population density), INDGSP (share of industry) and NONAGR (share of non-agricultural output).

NE is negatively correlated with Y.

The states of the Centre-West, that have shown a good performance in terms of growth, are not characterised by having significant amounts of industries and services.

YPROXM resembles the behaviour of this variable in the first sample, negatively reflecting the states of NE, and positively the states of SE, SP, and the rich and industrialised states. It is also positively correlated with TR, DD and NONAGR.

Table IV-3 - CORRELATION MATRIX - BRAZIL - 1970-1995 (18 STATES)

	grgsp	y	indgsp	nonagr	dd	tr	trm
grgsp	1.0000						
y	-0.5226	1.0000					
indgsp	-0.5451	0.7732	1.0000				
nonagr	-0.6569	0.6722	0.7712	1.0000			
dd	-0.6944	0.6343	0.4871	0.7262	1.0000		
tr	-0.5444	0.6254	0.7248	0.6327	0.5272	1.0000	
trm	-0.5444	0.6254	0.7248	0.6327	0.5272	1.0000	1.0000
ytrm	-0.5836	0.8706	0.8188	0.6675	0.5958	0.8524	0.8524
prox	-0.3378	0.8542	0.6868	0.5669	0.4877	0.5692	0.5692
proxm	-0.3378	0.8542	0.6868	0.5669	0.4877	0.5692	0.5692
yproxm	-0.4411	0.9248	0.7579	0.6619	0.6090	0.5853	0.5853
ne	0.0117	-0.6567	-0.3129	-0.1834	-0.1852	-0.3296	-0.3296
se	-0.3205	0.6549	0.4973	0.6358	0.5258	0.3597	0.3597
s	-0.1606	0.2251	0.2001	-0.0947	-0.0949	0.5067	0.5067
co	0.5959	-0.0884	-0.3974	-0.4370	-0.2883	-0.5523	-0.5523
sp	-0.1819	0.6794	0.6624	0.4316	0.1750	0.3985	0.3985

	ytrm	prox	proxm	yproxm	ne	se	s
ytrm	1.0000						
prox	0.7348	1.0000					
proxm	0.7348	1.0000	1.0000				
yproxm	0.8794	0.8821	0.8822	1.0000			
ne	-0.4116	-0.7940	-0.7940	-0.5465	1.0000		
se	0.5234	0.7893	0.7893	0.7414	-0.5345	1.0000	
s	0.3125	0.2571	0.2571	0.0299	-0.4472	-0.2390	1.0000
co	-0.4081	-0.0857	-0.0857	-0.1468	-0.3536	-0.1890	-0.1581
sp	0.7301	0.5647	0.5647	0.8065	-0.2425	0.4537	-0.1085

	co	sp
co	1.0000	
sp	-0.0857	1.0000

For the period 1970-1995, using the whole sample, the results of the correlation matrix are in Table IV.4. The income growth rate is correlated with the dummy for the states of the North (N). In accordance with this evidence, income growth rate (GRGSP) is negatively correlated with population density (DD) and with provision of transport (TR), since the states of the North (N) are poorly provided with this kind of infrastructure and are one of the emptiest spaces in Brazil. Income growth rate is negatively correlated with PROX, which represents the proximity to markets. This is another characteristic that seems to be related with the performance of the states of the North, since they are located far from the richest markets in Brazil.

The richest states (Y) are the most industrialised ones (INDGSP). While São Paulo (SP) shows high correlation with INDGSP, high presence of both industry and services (NONAGR) is a feature of the whole Southeast (SE). Industry and services are also concentrated in dense states, which are well provided by transport.

Comparing Table IV.4 with Table IV.1, it is interesting to observe that good provisions of transport, high population density and production of services are not only characteristics of the richest states in 1970.

Population density is correlated with good provision of transport (TR) and with the states of the Southeast (SE).

As expected, TR is positively correlated with PROX. Good provision of transport is a feature of the SE and of S (South), while North (N), as has already been said, does not have high extensions of roads and railways.

The states that are closer from the richest markets (high PROX) are in the Southeast (especially SP) and the South. The furthest ones are the states of the North and Northeast. The interaction terms - YTRM and YPROXM - are positively correlated.

YTRM represents the states of the Southeast (SE), especially São Paulo, and it is negatively correlated with N (North). The same occurs with YTRM, which is also reflecting the states of the South.

YPROXM reflects the proximity of the richest markets, being positively correlated with Y, INDGSP, NONAGR, DD, TR and with the other interaction term.

Table IV-4 - CORRELATION MATRIX - BRAZIL - 1970-1995 (24 STATES)

	grgsp	y	indgsp	nonagr	dd	tr	trm
grgsp	1.0000						
y	-0.2064	1.0000					
indgsp	-0.3908	0.5635	1.0000				
nonagr	-0.3716	0.6162	0.7651	1.0000			
dd	-0.5836	0.5642	0.3049	0.6028	1.0000		
tr	-0.6552	0.4429	0.3793	0.4574	0.6248	1.0000	
trm	-0.6552	0.4429	0.3793	0.4574	0.6248	1.0000	1.0000
ytrm	-0.6206	0.7270	0.4321	0.5103	0.6868	0.8758	0.8758
prox	-0.4907	0.7134	0.4153	0.4726	0.5862	0.7025	0.7025
proxm	-0.4907	0.7134	0.4153	0.4726	0.5862	0.7025	0.7025
yproxm	-0.4774	0.8178	0.4466	0.5446	0.6694	0.6628	0.6628
n	0.6831	0.0200	-0.0547	-0.0803	-0.3962	-0.6704	-0.6704
ne	-0.3004	-0.5869	-0.1529	-0.1046	0.0251	0.0811	0.0811
se	-0.3275	0.6173	0.3187	0.5470	0.5687	0.4309	0.4309
s	-0.2255	0.2118	0.1357	-0.0617	0.0015	0.5132	0.5132
co	0.1675	-0.0892	-0.2385	-0.3547	-0.1917	-0.2868	-0.2868
sp	-0.1704	0.6612	0.4234	0.3767	0.2072	0.3743	0.3743

	ytrm	prox	proxm	yproxm	n	ne	se
ytrm	1.0000						
prox	0.8298	1.0000					
proxm	0.8298	1.0000	1.0000				
yproxm	0.9128	0.8980	0.8980	1.0000			
n	-0.5372	-0.5042	-0.5042	-0.3942	1.0000		
ne	-0.1084	-0.3871	-0.3871	-0.2722	-0.4472	1.0000	
se	0.5909	0.7879	0.7879	0.7589	-0.2582	-0.3464	1.0000
s	0.3652	0.3264	0.3264	0.1128	-0.2182	-0.2928	-0.1690
co	-0.2022	0.0150	0.0150	-0.0640	-0.1741	-0.2335	-0.1348
sp	0.6772	0.5442	0.5442	0.7820	-0.1204	-0.1615	0.4663

	s	co	sp
s	1.0000		
co	-0.1140	1.0000	
sp	-0.0788	-0.0629	1.0000

IV.3 - Cross Section Results (WITH TR)

As we have mentioned in the Introduction, we are not going to discuss deeply the cross-section results, since the number of observations in our samples is small, which can bias our estimated coefficients.

In this Chapter we are going to discuss only the following cross-section specifications:

$GRGSP_{i,\ T-to} = \alpha_1 + \beta_1 Y_{io} + \Omega_1 INDGSP_{io} + \phi_1 (1/TC)_{io} + \Gamma_1 DD_{io} + \varepsilon_{1i}$ (1)

$GRGSP_{i,\ T-to} = \alpha_2 + \beta_2 Y_{io} + \Omega_2 INDGSP_{io} + \phi_2 (1/TC)_{io} + \Gamma_2 DD_{io} + \Phi_2 MAIN\ STATE_{io} + \varepsilon_{2i}$ (2)

$GRGSP_{i,\ T-to} = \alpha_3 + \beta_3 Y_{io} + \Omega_3 INDGSP_{io} + \phi_3 (1/TC)_{io} + \Gamma_3 DD_{io} + \Phi_3 MAIN\ STATE + \chi_3\ DUMMY\ FOR\ REGIONS + \varepsilon_{3i}$ (3)

$GRGSP_{i,\ T-to} = \alpha_4 + \beta_4 Y_{io} + \Omega_4 INDGSP_{io} + \phi_4 (1/TC)_{io} + \Gamma_4 DD_{io} + \chi_4 DUMMY\ FOR\ REGIONS + \varepsilon_{4i}$ (4)

$GRGSP_{i,\ T-to} = \alpha_5 + \beta_5 Y_{io} + \Omega_5 INDGSP_{io} + \Lambda_5 YTRM_{io} + \Gamma_5 DD_{io} + \varepsilon_{5i}$ (5)

$GRGSP_{i,\ T-to} = \alpha_{6io} + \beta_6 Y_{io} + \Omega_6 INDGSP_{io} + \Lambda_6 YTRM_{io} + \Gamma_6 DD_{io} + \Phi_6 MAIN\ STATE + \varepsilon_{6i}$ (6)

$GRGSP_{i,\ T-to} = \alpha_7 + \beta_7 Y_{io} + \Omega_7 INDGSP_{io} + \Lambda_7 YTRM_{io} + \Gamma_7 DD_{io} + \Phi_7 MAIN\ STATE + \chi_7 DUMMY\ FOR\ REGIONS + \varepsilon_{7i}$ (7)

$GRGSP_{i,\ T-to} = \alpha_8 + \beta_8 Y_{io} + \Omega_8\ INDGSP_{io} + \Lambda_8 YTRM_{io} + \Gamma_8 DD_{io} +$

χ_8DUMMY FOR REGIONS + ε_{8i} (8)

where (o) stands for the value of the variable in the beginning of the period.

These econometric models will also be run with NONAGR (the share of industrial and service output taken together in state's output) in the place of INDGSP and two proxies will be used for the inverse of TC: the availability of roads and rail per area, TR; and the inverse of the weighted average of the distances among the states, PROX (in the following section).

Two interaction terms will be used: YTRM (Y*TRM) and YPROXM (Y*PROXM). Usually the coefficients of TRM (TR - mean value of TR) and of PROXM (PROXM - mean value of PROX) are not significant, and so they are dropped from the specifications with the interaction term. When TRM or PROXM is significant, the results with these variables will be reported.

In the case of Brazil, the MAIN STATE is the State of São Paulo (SP), while the region that is not well explained by our models is the Centre-West (CO), when we are excluding the observations from the states of the North. When we are studying the full sample of 24 states, North (N) is the region not well explained by the econometric models.

As discussed in the previous chapter, Krugman and Venables's theory suggests a positive coefficient for INDGSP, a negative one for measurement of agglomeration (DD) and a coefficient of YTRM that is likely to be statistically significant but could be of either sign.

We will only consider the significant coefficients and the coefficients that show t-statistics greater than one.

IV.3.1 - 1950-1995 (18 States)

a) INDGSP

Table IV.5 shows the cross-section results for the 18 states in the period 1950-1995. Specifications (1)-(4) show the results without interaction terms. It can be seen that few variables are significant: DD, the proxy for population density, has a negative coefficient, implying that congestion effects have harmed growth. Based on Table IV.1, it can be inferred that these effects were particularly strong for the states of SE. The states of Centre-West, CO, show a strong performance in terms of growth that is not explained by our independent variables.

Observing the coefficients with t-statistics at least greater than one, we can find further inferences.

Rich states grew more (without controlling for CO).

The other coefficients are highly insignificant.

Specifications (5)-(8) show a similar picture to the one discussed above. The few variables that are significant are DD (population density) and CO (Centre-West).

Including the dummies, DD remains negative and significant, reflecting congestion effects.

The dummy for the Centre-West states (CO) is positive and significant.

The interaction term, YTRM, is positive (with a t-statistic greater than one (+1.30)), if there is a control for both SP and CO. Observe that the specifications with CO are the ones with smaller MSE and higher R^2.

Observing the whole set of equations of Table VI.5 the conclusions that can be reached are:

a) acting against agglomeration, congestion effects were taking place, as shown by the negative and significant sign of DD;

b) CO had a very good performance in its growth rate, not explained by our model.

Table IV.5 - INDGSP & TR - BRAZIL - 1950-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,958	(1.530)	0,905	(1.320)	0,332	(0.610)	0,330	(0.660)	0,872	(1.100)	0,894	(1.070)	0,113	(0.220)	0,203	(0.400)
INDGSP	-0,001	(-0.020)	-0,003	(-0.050)	0,014	(0.300)	0,014	(0.310)	-0,020	(-0.470)	-0,021	(-0.430)	0,011	(0.310)	0,009	(0.220)
TR	-3,865	(-0.960)	-4,192	(-0.930)	-0,253	(-0.070)	-0,269	(-0.080)								
YTRM									-0,988	(-0.420)	-2,439	(-0.410)	3,309	(1.300)	0,570	(0.400)
DD	-0.036***	(-2.930)	-0.034**	(-2.180)	-0.026**	(-2.380)	-0.026***	(-2.890)	-0.035**	(-2.470)	-0.032**	(-2.200)	-0.029***	(-3.370)	-0.024**	(-2.730)
SP			0,321	(0.280)	-0,014	(-0.020)					0,961	(0.330)	-1.738*	(-1.790)		
CO					2.087**	(2.400)	2.086**	(2.510)					2.314**	(2.680)	2.156**	(2.620)
R2	0,469		0,470		0,719		0,719		0,427		0,431		0,735		0,721	
MSE	0,926		0,963		0,732		0,701		0,962		0,998		0,712		0,698	

* All standard errors were corrected for heteroscedasticity.

Table IV.6 - NONAGR & TR - BRAZIL - 1950-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,905	(1.640)	0,874	(1.420)	0,120	(0.190)	0,079	(0.130)	0,773	(1.090)	0,797	(1.050)	-0,096	(-0.160)	0,069	(0.120)
NONAGR	7.41 E-03	(0.240)	5.82 E-03	(0.160)	0,036	(1.000)	0,032	(1.040)	0,015	(0.360)	0,013	(0.320)	0,038	(1.180)	0,030	(0.960)
TR	-3,806	(-1.160)	-4,108	(-1.020)	1,540	(0.580)	0,907	(0.380)								
YTRM									-1,448	(-0.600)	-2,515	(-0.470)	4.690*	(1.920)	0,575	(0.390)
DD	-0.038**	(-2.140)	-0.037	(-1.540)	-0.036**	(-2.160)	-0.033**	(-2.810)	-0.042*	(-1.810)	-0,039	(-1.750)	-0.041**	(-2.610)	-0.032**	(-2.410)
SP			0,238	(0.190)	-0,432	(-0.490)					0,713	(0.300)	-2.598*	(-2.060)		
CO					2.324***	(3.590)	2.282***	(3.490)					2.490***	(3.920)	2.237***	(3.500)
R^2	0,471		0,472		0,755		0,751		0,428		0,431		0,779		0,752	
MSE	0,925		0,962		0,684		0,659		0,961		0,998		0,649		0,659	

* All standard errors were corrected for heteroscedasticity.

b) NONAGR

Table IV.6 displays the specifications where NONAGR was substituted for INDGSP. The intention behind these specifications is to test if economies of scale in the service sector as well as in the industrial sector were relevant to economic growth.

Equations (1)-(4) do not include interaction terms. Again only DD and CO were usually significant, reinforcing the negative effect of congestion and highlighting the extraordinary performance of the states of the Centre-West.

Richer states seem to have grown quicker than poorer ones, showing t-statistics greater than one when we are not controlling for CO.

Equations (5)-(8) include the interaction term YTRM. Similarly to those results in the previous Table, the coefficient of YTRM is positive and significant (+1.92), controlling for SP and CO.

The coefficient of per capita income is never significant. It shows t-statistics higher than one when CO is not included.

IV.3.2 - 1950-1970 (18 states)

a) INDGSP

The cross-section results for the first sub-period (1950-1970), with INDGSP, are in Table IV.7.

Equations (1)-(4) do not include the interaction term. Similarly to the results for the whole period, they suggest that congestion effects were generating dispersion of economic activity, since DD (population density) is always negative and significant. CO (Centre-West) is positive and significant.

Per capita income (Y) is positive and significant in all specifications, implying that there was a movement of economic activity towards richer states.

Controlling for CO, INDGSP (the share of industry) shows t-statistics higher than one and a positive coefficient, suggesting that activities have concentrated in the most industrialised states.

TR (availability of transports) shows high t-statistics and a negative coefficient when we do not control for CO, suggesting that the states that grew more did not have a good provision of transport.

Equations (5)-(8) include the interaction term.

Per capita income is positive and significant (or has a high t-statistic in (7)), DD is negative and significant and CO is positive and significant.

SP (São Paulo)(positive) shows one t-statistic greater than one (7).

INDGSP (positive) shows t-statistics higher than one when we control for the special effects of CO. INDGSP shows positive coefficients, implying that there was a concentration of economic activity towards more industrialised states.

Equations (6a) and (7a) include the demeaned variable TRM. The importance of congestion effects and of the dummies is confirmed. These equations imply that there was a movement of economic activity towards richer states (since Y is positive and significant), that this was reinforced by lower transportation cost (since YTRM is positive and significant), and that economies of scale in the industrial sector were spurring growth (since INDGSP is positive and shows a high t-statistic or is significant).

In the period 1950-1970, there is evidence that economies of scale in the industrial sector were generating concentration, as predicted by the model. Considering the significant coefficients of the interaction term in (6a) and (7a), a decrease in transportation cost would be reinforcing this concentration of activities. These results resemble the "core" phase of the K&V(m) model.

It is important to remember that the theoretical models showed three phases for the distribution of income, while transportation costs decreased. In phase one, high transportation costs would create an equality of income between regions; in phase two, decrease in transportation costs would benefit richer regions, creating a concentration in income (YTRM would be positive). Finally, very small transportation costs (or congestion effects) would generate convergence of total income (YTRM would be negative).

In our sample, the coefficient of YTRM is positive (in (6a) and (7a)), showing evidence of a concentration of activity taking place in the country, *due to the economic forces described* by NEG models.

Figures IV.1, IV.2 and IV.3 (displayed in this Chapter) can also help us to understand the meaning of the combinations of the coefficients of Y and YTRM. The total coefficient of Y can be expressed as (a + bTRM)Y[3], since YTRM=Y*TRM. A significant

[3] a is the coefficient of Y and b the coefficient of YTRM.

coefficient for YTRM means that the coefficient of Y changes with the level of transport.

Figure IV.1 graphs the case corresponding to the results of this sample: positive coefficient for Y; positive coefficient for YTRM. At the mean value of TR (TRM), the estimated coefficient of Y is positive. At all levels of transportation cost, agglomeration effects are taking place.

Since we are controlling for YTRM, we can interpret the sign of the Y coefficient as an indicator of how other factors (like differences in taste or in costs, as suggested in Chapter I) are affecting the dispersion (or convergence) of TOTAL income. The economic factors directly related to NEG models would be controlled by the variable YTRM.

Figure IV.1 - POSITIVE Y & POSITIVE YTRM

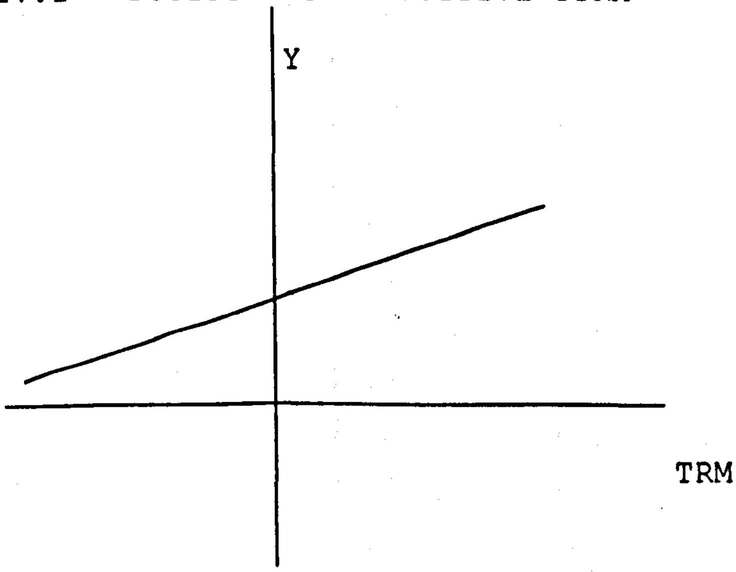


Table IV.7 - INDGSP & TR - BRAZIL - 1950-1970 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	2,270***	(3.089)	2,275**	(2.805)	1,597**	(2.407)	1,534**	(2.388)	2,191**	(2.156)	2,215*	(2.061)	1,198	(1.748)	1,324*	(2.071)
INDGSP	0,069	(0.998)	0,069	(0.926)	0,089	(1.321)	0,086	(1.328)	0,027	(0.505)	0,027	(0.464)	0,069	(1.545)	0,065	(1.360)
TR	-9,500	(-1.651)	-9,472	(-1.431)	-4,817	(-0.744)	-5,288	(-0.939)								
TRM																
YTRM									-3,216	(-1.074)	-4,810	(-0.659)	2,677	(0.736)	-1,200	(-0.619)
DD	-0,051***	(-3.266)	-0,051**	(-2.460)	-0,041**	(-2.699)	-0,039***	(-2.975)	-0,051**	(-2.600)	-0,048**	(-2.372)	-0,043***	(-3.636)	-0,037**	(-2.697)
SP			-0,028	(-0.016)	-0,423	(-0.343)					1,055	(0.299)	-2,461	(-1.731)	2,791***	(3.905)
CO					2,467***	(2.925)	2,444***	(3.106)					3,015***	(3.853)		
R2	0,509		0,051		0,687		0,685		0,398		0,400		0,663		0,650	
MSE	1,245		1,296		1,082		1,038		1,379		1,432		1,121		1,095	

* All standard errors were corrected for heteroscedasticity.

Table IV.7 - INDGSP & TR - BRAZIL - 1950-1970 (18 states)

dependent variable: GRGSP - cross-section results

	6a	t	7a	t
Y	1,682*	(1.954)	0,803*	(1.855)
INDGSP	0.107	(1.446)	0,137*	(1.925)
TR				
TRM	23,498**	(-2.699)	-21,056**	(-2.575)
YTRM	21,088**	(2.198)	25,274***	(3.866)
DD	0,074***	(-4.672)	-0,067***	(-4.767)
SP	-8,866**	(-2.343)	-11,064***	(-3.984)
CO			2,769***	(3.594)
R2	1.204		0.832	
MSE				

* All standard errors were corrected for heteroscedasticity.

Table IV.8 - NONAGR & TR - BRAZIL - 1950-1970 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	2,059***	(2.872)	2,114**	(2.726)	1,146	(1.552)	1,023	(1.429)	1,959**	(2.209)	1,956*	(2.017)	0,761	(1.032)	1,048	(1.442)
NONAGR	0,052	(1.180)	0,054	(1.012)	0,093**	(2.420)	0,083**	(2.402)	0,066	(1.183)	0,066	(1.089)	0,099**	(2.601)	0,085**	(2.361)
TR	-6,769	(-1.468)	-6,227	(-1.019)	1,023	(0.243)	-0,865	(-0.217)								
TRM																
YTRM									-3,236	(-1.192)	-3,090	(-0.436)	6,558*	(2.132)	-0,621	(-0.315)
DD	-0,061***	(-2.970)	-0,064*	(-2.118)	-0,063**	(-2.863)	-0,055***	(-3.456)	-0,069**	(-2.577)	-0,069**	(-2.228)	-0,072***	(-3.152)	-0,056***	(-3.135)
SP			-0,428	(-0.226)	-1,287	(-1.006)					-0,098	(-0.027)	-4,531**	(-2.533)		
CO					2,983***	(5.154)	2,859***	(5.049)					3,335***	(6.764)	2,894***	(6.287)
R2	0,524		0,526		0,764		0,749		0,473		0,473		0,793		0,750	
MSE	1,226		1,274		0,938		0,926		1,290		1,343		0,879		0,925	

* All standard errors were corrected for heteroscedasticity.

** TRM is significant in (6a);

b) NONAGR

The results with NONAGR are in Table IV.8.

They are similar to the results for INDGSP.

Equations (1)-(4) do not include the interaction term. They show positive and significant coefficients for per capita income, without controlling for CO. Controlling for CO, per capita income shows high t-statistics.

Controlling for CO, NONAGR shows significant positive coefficients, suggesting that economies of scale in the industrial and service sectors taken together were generating concentration of economic activity. The coefficients of NONAGR still show high t-statistics without controlling for CO.

DD is negative and significant, reinforcing the importance of congestion effects to weaken the concentration of activities among the states.

CO is positive and significant, and TR, without controlling for CO, shows negative coefficients, with t-statistics higher than one.

Equations (5)-(8) include the interaction term. The results for Y, NONAGR, DD and CO are similar to the ones in the initial equations. In specification (5), the interaction term shows a t-statistic higher than one, and in Equation (7), YTRM is significant (+2.13).

In contrast to the results for the whole period, there is evidence that economies of scale INDGSP and NONAGR) were generating economic growth, as predicted by the model. The significant coefficient of YTRM (Equation (7)), shows that a decrease in transportation cost would reinforce this concentration.

The importance of CO and DD is common to both samples.

IV.3.3 - 1970-1995 (18 States)

a) INDGSP

Table IV.9 shows the results with INDGSP for the period 1970-1995, excluding the performance of the North. There is a decrease in the number of significant variables found in this exercise.

In the specifications without interaction terms - (1)-(4) - the hypothesis that "backwards and forwards linkages" have benefited growth is refuted, since the coefficients of INDGSP (share of industry) are negative (and statistically not significant).

There is a smaller number of significant coefficients for DD (population density), but it still seems that negative congestion effects are deterring growth.

SP (São Paulo) does not show significant coefficients. The region that shows a positive and significant coefficient is CO.

When controlling for CO, TR (extension or roads and railways) shows positive coefficients, with t-statistics higher than one.

In the specifications with YTRM (Y*TRM) - (5)-(8) - we do not observe any support for the hypothesis that economies of scale spur growth (INDGSP is not significant). Congestion effects have a negative (but not always significant) effect on growth.

Table IV.9 - INDGSP & TR - BRAZIL - 1970-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,130	(0.315)	0,029	(0.054)	-0,422	(-1.035)	-0,266	(-0.784)	0,262	(0.487)	0,160	(0.302)	-0,444	(-0.967)	-0,437	(-0.940)
INDGSP	-0,036	(-0.801)	-0,044	(-1.020)	-0,014	(-0.374)	-3.55 E-03	(-0.091)	-0,033	(-0.858)	-0,037	(-0.915)	-5.28 E-03	(-0.156)	-1.39 E-03	(-0.040)
TR	-0,739	(-0.426)	-0,622	(-0.351)	1,365	(1.059)	1,132	(1.038)								
YTRM									-0,646	(-0.559)	-1,059	(-0.720)	0,485	(0.439)	0,749	(0.802)
DD	-0.015**	(-2.547)	-0,013	(-1.635)	-0,009	(-1.482)	-0.011**	(-2.255)	-0.015**	(-2.761)	-0,011	(-1.384)	-9.18 E-03	(-1.550)	-0.011**	(-2.376)
SP			0,791	(0.557)	1,108	(1.104)					1,481	(0.805)	0,668	(0.640)		
CO					2.010*	(1.839)	1.939*	(1.895)					1,915	(1.568)	2,028	(1.668)
R2	0,551		0,560		0,709		0,690		0,558		0,586		0,697		0,691	
MSE	0,900		0,927		0,788		0,778		0,893		0,899		0,805		0,777	

* All standard errors were corrected for heteroscedasticity.

Table IV.10 - NONAGR & TR - BRAZIL - 1970-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,032	(0.109)	-0,063	(-0.135)	-0,456	(-1.270)	-0,275	(-1.134)	0,232	(0.458)	0,118	(0.242)	-0,453	(-1.030)	-0,451	(-1.012)
NONAGR	-0,028	(-0.687)	-0,032	(-0.717)	-8.13 E-03	(-0.264)	-3.01 E-03	(-0.101)	-0,029	(-0.761)	-0,036	(-0.813)	-3.04 E-03	(-0.095)	1.55 E-03	(0.052)
TR	-1,085	(-0.685)	-1,073	(-0.638)	1,231	(1.122)	1,102	(1.203)								
YTRM									-0,868	(-0.781)	-1,342	(-0.993)	0,448	(0.426)	0,751	(0.810)
DD	-0.011**	(-2.614)	-0,010	(-1.202)	-7.86 E-03	(-1.402)	-0.011***	(-3.149)	-0.012**	(-2.511)	-6.97 E-0	(-0.899)	-8.79 E-03	(-1.624)	-0.011***	(-3.302)
SP			0,599	(0.424)	1,038	(1.029)					1,603	(0.989)	0,666	(0.629)		
CO					2.036*	(1.885)	1.940*	(1.961)					1,922	(1.579)	2,057	(1.703)
R2	0,548		0,554		0,707		0,690		0,562		0,595		0,696		0,691	
MSE	0,903		0,934		0,790		0,778		0,889		0,890		0,805		0,777	

* All standard errors were corrected for heteroscedasticity.

b) NONAGR

Table IV.10 shows the results with NONAGR (share of industrial and service sectors in state's output) instead of INDGSP. The results are very similar to Table IV.9.

Congestion effects are usually negatively affecting growth.

The dummies are seldom significant, but it seems that SP has a good economic performance as well as the states of CO.

Controlling for CO, TR shows positive coefficients, with t-statistics higher than one.

Conclusion for the 18-state Sample

The exercises with INDGSP and TR do not show support for the hypothesis that economies of scale in the industrial service spur growth, since the coefficient of INDGSP is highly insignificant or negative. The exception was the period 1950-1970, where INDGSP shows a positive (and once significant) coefficient, if controlling for CO. Congestion effects, by their turn, are negatively affecting growth. The impact of lower transportation cost for the coefficient of per capita income could be perceived for the first sub-period, when YTRM showed some significant coefficients. In 1950-1970, a decrease in transportation cost was generating concentration of economic activity. There is some evidence (based on t-statistics at least higher than one) that there was a concentration of economic activity in richer states in the whole period (without CO), especially influenced by the performance of per capita income in the first sub-period.

For the 18-State samples, the exercises with NONAGR and TR usually deny the importance of economies of scale in the service and industrial sector taken together to explain the distribution of activity. The exception again occurs in the period 1950-1970, where NONAGR shows significant coefficients controlling for the special effects of CO.

IV.3.4 - 1970-1995 (24 States)

a) INDGSP

Table IV.11 shows the cross-section results for the 24 states in the period 1970-1995.

Specifications (1)-(4) do not include interaction terms. Rejecting the hypothesis of NEG models, the coefficient of INDGSP is negative and significant, showing no signs that economies of scale are important for growth.

Similarly to our findings in the first sample, congestion effects are negatively affecting growth.

Per capita income is usually positive (positive and significant in (1)), implying concentration of economic activity. Having transport seems to be harming growth, since TR is negative and significant (without controlling for N).

The good performance in terms of growth of the states of the North is not explained by our dependent variables.

The second set of equations (5)-(8) includes the interaction term YTRM (Y*TRM). Again, it is clear that "backward and forward linkages", proxied by INDGSP, are harmful for growth.

With the inclusion of the interaction term, the coefficients of DD are not always significant and the coefficients of N are never significant.

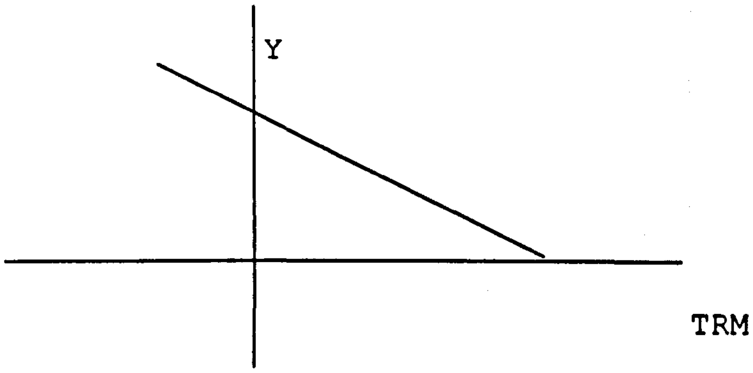
Richest states in per capita terms grew more (the coefficients are significant in (5) and (6)). So, other economic factors were encouraging a concentration of economic activity among the states of Brazil.

YTRM is negative and negative and significant when not controlling for N. Equations (6a) and (7a), which include the variable TRM, show significant coefficients for Y and YTRM. This is a different result from the one we have observed in the sample for the period 1950-1995.

The combination of a negative coefficient for YTRM and a positive coefficient for Y is portrayed in Figure IV.2. At the mean level of TR, having transport is positive for growth. But when transport infrastructure increases, this positive effect weakens, leading to a dispersion of economic activity, due to the interaction of transport costs, pecuniary externalities and economies of scale.

This pattern corresponds to phase III of the K&V(m) model, only *considering the effect of transportation cost, since the hypothesis of a* *positive influence of "backward and forward" linkages was denied.*

Figure IV.2 - POSITIVE Y & NEGATIVE YTRM



On the other hand, the cross-sections results with INDGSP showed strong evidence against K&V(m) model: economies of scale in the industrial service were harmful for the growth rate of income.

Although negative congestion effects are present, the significance of the variable DD is usually lost with the introduction of the interaction terms. This may reflect the high correlation between the interaction term and the states of North, which are the ones which showed an outstanding performance in terms of growth.

Table IV.11 - INDGSP & TR - BRAZIL - 1970-1995 (24 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0.790*	(1.797)	0,956	(1.320)	0,465	(0.736)	0,428	(1.220)	1.438***	(2.759)	1.277**	(2.310)	0,900	(1.524)	0,986	(1.670)
INDGSP	-0.054**	(-2.534)	-0.054**	(-2.513)	-0.057**	(-2.593)	-0.057**	(-2.642)	-0.063***	(-3.131)	-0.065***	(-3.088)	-0.062***	(-2.812)	-0.061***	(-2.815)
TR	-4.106**	(-2.435)	-3.787*	(-1.901)	-0,820	(-0.502)	-0,841	(-0.537)								
TRM																
DD	-0.022***	(-2.967)	-0.024*	(-1.999)	-0.018*	(-1.780)	-0.018***	(-2.903)	-0.019***	(-2.945)	-0,013	(-1.130)	-0,012	(-1.170)	-0.017**	(-2.695)
SP			-1,207	(-0.547)	-0,235	(-0.124)					2,144	(0.824)	1,759	(0.734)		
N					2.085*	(1.829)	2.112*	(1.977)					1,103	(1.212)	1,230	(1.369)
R2	0,590		0,597		0,674		0,673		0,683		0,698		0,716		0,707	
MSE	1,458		1,485		1,375		1,337		1,281		1,286		1,282		1,267	

* All standard errors were corrected for heteroscedasticity.

Table IV.14 - INDGSP & TR – BRAZIL - 1970-1995 (24 states)

dependent variable: GRGSP - cross-section results

	6a	t	7a	t
Y	1.858***	(2.911)	1.492**	(2.156)
INDGSP	-0.090***	(-3.774)	-0.087***	(-3.519)
TR				
TRM	8.421**	(2.178)	8.315**	(2.185)
YTRM	-7.421**	(-2.682)	-6.449**	(-2.224)
DD	-8.61 E-03	(-0.705)	-7.83 E-03	(-0.707)
SP	5.665*	(1.757)	5.254	(1.702)
N			1.050	(1.242)
R2	0.765		0.782	
MSE	1.160		1.159	

* All standard errors were corrected for heteroscedasticity.

Table IV.12 - NONAGR & TR - BRAZIL - 1970-1995 (24 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,526	(1.507)	0,693	(1.125)	0,223	(0.412)	0,192	(0.658)	1.223**	(2.354)	1.069*	(1.937)	0,621	(1.100)	0,703	(1.245)
NONAGR	-0,018	(-0.416)	-0,017	(-0.380)	-0,035	(-0.725)	-0,035	(-0.768)	-0,040	(-0.952)	-0,045	(-1.037)	-0,046	(-0.995)	-0,042	(-0.945)
TR	-4.746**	(-2.429)	-4.421**	(-2.199)	-1,357	(-0.796)	-1,371	(-0.816)								
YTRM									-2.770**	(-2.522)	-3.338**	(-2.478)	-2,136	(-1.543)	-1,590	(-1.354)
DD	-0.018**	(-2.416)	-0.020*	(-1.734)	-0,013	(-1.224)	-0.013*	(-1.926)	-0.014**	(-2.233)	-7.44 E-0	(-0.727)	-6.26 E-03	(-0.668)	-0.011*	(-1.758)
SP			-1,229	(-0.579)	-0,196	(-0.108)					2,235	(1.074)	1,779	(0.986)		
N					2.152*	(1.861)	2.176*	(1.971)					1,377	(1.528)	1,496	(1.648)
R2	0,525		0,532		0,610		0,610		0,603		0,618		0,647		0,637	
MSE	1,570		1,601		1,504		1,462		1,435		1,445		1,430		1,409	

* All standard errors were corrected for heteroscedasticity.

b) NONAGR

There is also no evidence in favour of the model's hypothesis about the importance of economies of scale in the analysis with NONAGR.

In the first set of equations (1)-(4), in Table IV.12, externalities in the industrial and service sectors (NONAGR) do not have impact on the dispersion of activities.

Richest states grew more (but the coefficient is not significant) and having transport is harmful for growth, in specifications (1) and (2).

Clearly, these equations do not explain the positive growth of the states of the North.

DD is negative and usually significant.

In equations (5)-(8), with the interaction term YTRM, the results are similar to the ones in Table IV.11. NONAGR is not significant, the dummy for the outlying state lost significance and DD shows smaller number of significant coefficients.

Richest states grew more, at mean values of TR, and the sign of YTRM is negative. Y and YTRM are significant when not controlling for CO. Again, this means that increasing TR is less positive to the economic growth of the richer states, although the overall result (positive Y) is a concentration of activities among the states of the country.

São Paulo (SP) has a positive but not significant coefficient.

The results with NONAGR just confirm the results for INDGSP.

IV.4 - Cross Section Results (WITH PROX)

In this section, we repeat the exercise of Section IV.3, in order to test if we obtain the same results while changing the proxy for transportation costs. Since we do not have an adequate proxy for transportation costs, it is advisable to proceed in this way.

The proxy that we will use in this section is a weighted average of the distances between the capital of state i and the capital of all other states (j) in the country. The weight is the share of state j's output in Brazilian total output. In effect this is the average distance of the capital of the state to the capitals of other states, weighted by economic activity. Then distance to SP will be relatively heavily weighted, whilst distance to the states of N and NE will be only lightly weighted. We calculate PROX as equal to (1/average distance).

So TR measures internal infrastructure, while PROX captures the proximity of the state from markets.

IV.4.1 - 1950-1995 (18 States)

a) INDGSP

Table IV.13 shows the cross section results with PROX, as the proxy for transportation costs, and INDGSP (share of industry), as the proxy for external economies of scale.

Specifications (1)-(4) do not include the interaction term. The results are similar to the ones shown in Table IV.5, with the previous proxies for transportation costs.

There is no evidence in support of the hypothesis that economies of scale inside the industrial sector are beneficial for growth, since the coefficients of INDGSP are not significant. Congestion effects (DD - population density) are also showing a negative and significant coefficient.

As in the previous results, CO (Centre-West) is the outlier region that showed a positive income growth rate.

Specifications (5)-(8) include the interaction term - YPROXM = (Y*PROXM). PROXM is generated by subtracting the mean value of PROX from this variable.

Similarly to Table IV.5, the coefficients of INDGSP are not significant. DD is negative, showing again the bad effects of congestion for growth. CO shows a significant positive coefficient.

YPROXM is positive, controlling for CO (it shows t-statistics at least higher than one in the best fitted equations, (7) and (8)).

Table IV.13 - INDGSP & PROX - BRAZIL - 1950-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,346	(0.327)	0,416	(0.329)	-0,090	(-0.128)	-0,093	(-0.153)	0,262	(0.230)	-6.28 E-04	(0.000)	-0,704	(-1.051)	-0,433	(-0.780)
INDGSP	-0,027	(-0.713)	-0,024	(-0.595)	0,014	(0.415)	0,014	(0.473)	-0,026	(-0.634)	-5.25 E-03	(-0.106)	0,040	(1.185)	0,019	(0.607)
PROX	52144	(0.456)	51110	(0.418)	57897	(0.696)	57940	(0.732)								
YPROX									42389	(0.519)	96589	(0.767)	125257	(1.501)	69546	(1.519)
DD	-0.032**	(-2.228)	-0.033*	(-1.783)	-0.023**	(-2.221)	-0.023***	(-3.104)	-0.034***	(-2.977)	-0.041***	(-2.863)	-0.033***	(-3.188)	-0.026***	(-3.698)
SP			-0,270	(-0.296)	-0,011	(-0.017)					-1,307	(-0.947)	-1,343	(-1.245)		
CO					2.117**	(2.297)	2.118**	(2.401)					2.186**	(2.311)	2.182**	(2.474)
R2	0,429		0,431		0,732		0,732		0,429		0,451		0,769		0,746	
MSE	0.960		0,998		0,716		0,685		0,960		0,980		0,664		0,667	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.14 - NONAGR & PROX - BRAZIL - 1950-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	-0,055	(-0.061)	0,123	(0.106)	-0,451	(-0.554)	-0,486	(-0.719)	-0,025	(-0.028)	-0,227	(-0.231)	-0,643	(-1.115)	-0,517	(-0.867)
NONAGR	0,019	(0.548)	0,022	(0.570)	0,040	(1.395)	0,039	(1.456)	0,013	(0.357)	0,023	(0.605)	0,038	(1.471)	0,032	(1.137)
PROX	72899	(0.620)	72458	(0.569)	92232	(1.042)	92401	(1.104)								
YPROX									49402	(0.576)	114063	(1.091)	113501	(1.634)	69259	(1.346)
DD	-0.039*	(-1.781)	-0,042	(-1.540)	-0.032**	(-2.226)	-0.031***	(-3.010)	-0.040*	(-1.911)	-0.050*	(-2.022)	-0.040**	(-2.848)	-0.033***	(-3.184)
SP			-0,640	(-0.579)	-0,120	(-0.172)					-1,672	(-1.384)	-1,159	(-1.273)		
CO					2.202***	(3.253)	2.212***	(3.438)					2.160***	(3.214)	2.222***	(3.356)
R2	0,428		0,438		0,779		0,778		0,424		0,469		0,798		0,776	
MSE	0,961		0,992		0,650		0,623		0,965		0,964		0,621		0,626	

* All coefficients standard errors were corrected for heteroscedasticity.

b) NONAGR

The results of Table IV.14, with NONAGR (share of service and industrial income taken together) and PROX are: NONAGR is positive (showing high t-statistics when controlling for CO) and DD is negative and significant. CO is the region not explained by the independent variables.

In specifications (5)-(8), with the interaction term YPROXM, we found usually positive coefficients for the interaction term.

IV.4.3 - 1950-1970 (18 States)

a) INDGSP

Table IV.15 shows the results with INDGSP.

Equations (1)-(4) do not include the interaction term.

The negative influence of congestion effects (DD is negative) and the higher growth of CO are the only consistent significant results.

Per capita income shows positive coefficients when we control for SP.

INDGSP shows t-statistics higher than one and positive coefficients when controlling for CO.

Equations (5)-(8) include the interaction term. INDGSP is positive and significant in (7), while also showing a t-statistic higher than one in Equation (8), suggesting the existence of concentration effects of economies of scale in the industrial sector, as expected by the model.

DD and CO show the same significant coefficients.

The interaction term has a t-statistic higher than one in specification (7), controlling for the special effects of SP and CO. The coefficient is positive, suggesting an increase in the coefficient of per capita income with lower transportation costs.

Table IV.15 - INDGSP & PROX - BRAZIL - 1950-1970 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	1,298	(0.946)	1,662	(1.036)	0,979	(1.097)	0,697	(0.833)	1,311	(1.010)	0,685	(0.392)	-0,272	(-0.237)	0,367	(0.484)
INDGSP	1,61 E-03**	(0.031)	0,020	(0.380)	0,071	(1.673)	0,058	(1.557)	2,58 E-03	(0.046)	0,052	(0.690)	0,113*	(2.082)	0,063	(1.518)
PROX	50691	(0.295)	45300	(0.243)	54457	(0.404)	58628	(0.472)								
YPROXM									32192	(0.315)	161305	(0.801)	200297	(1.234)	69079	(0.915)
DD	-0,045**	(-2.281)	-0,052**	(-2.231)	-0,038***	(-2.971)	-0,032**	(-2.672)	-0,047**	(-2.526)	-0,064**	(-2.506)	-0,052**	(-2.621)	-0,035**	(-2.556)
SP			-1,407	(-1.161)	-1,058	(-1.356)					-3,114	(-1.161)	-3,162	(-1.421)		
CO					2,857***	(3.519)	2,900***	(3.585)					2,974***	(3.428)	2,964***	(3.772)
R2	0,361		0,384		0,664		0,651		0,359		0,423		0,724		0,658	
MSE	1,420		1,451		1,120		1,093		1,422		1,405		1,015		1,082	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.16 - NONAGR & PROX - BRAZIL - 1950-1970 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,452	(0.335)	0,940	(0.601)	0,175	(0.144)	-0,137	(-0.121)	0,910	(0.888)	0,518	(0.430)	-0,035	(-0.044)	0,244	0,281
NONAGR	0,071	(1.272)	0,080	(1.359)	0,103***	(3.096)	0,099**	(2.799)	0,061	(1.073)	0,079	(1.436)	0,100***	(3.450)	0,086**	2,444
PROX	115859	(0.619)	114646	(0.559)	141022	(0.900)	142523	(0.987)								
YPROXM									38220	(0.361)	163438	(1.092)	162691	(1.559)	65119	(0.928)
DD	-0,063**	(-2.387)	-0,073**	(-2.355)	-0,059***	(-3.287)	-0,053***	(-3.919)	-0,065**	(-2.393)	-0,084**	(-2.721)	-0,071***	(-3.261)	-0,056***	(-3.466)
SP			-1,758	(-1.403)	-1,064	(-1.170)					-3,238	(-1.735)	-2,555	(-1.672)		
CO					2,937***	(7.419)	3,024***	(7.574)					2,873***	(7.778)	3,010***	(7.169)
R2	0,449		0,488		0,798		0,784		0,429		0,516		0,814		0,761	
MSE	1,319		1,323		0,868		0,860		1,342		1,287		0,833		0,905	

* All coefficients standard errors were corrected for heteroscedasticity.

b) NONAGR

The results for NONAGR are in Table IV.16.

NONAGR is positive and significant, controlling for CO, suggesting that there was a concentration of activities in the less agricultural states.

Two coefficients of the interaction term (Equations (6) and (7)), show t-statistics higher than one. Their coefficient is positive, reinforcing the suggestion that a decrease in transportation cost was generating a concentration of activities.

DD and CO are both significant.

IV.4.3 - 1970-1995 (18 States)

a) INDGSP

Table IV.17 shows the specifications with INDGSP and PROX.

Equations (1)-(4) do not include the interaction term.

Controlling for CO, per capita income shows a negative coefficient with high t-statistics (it is significant in (3)).

DD (population density) is usually negative and significant, suggesting the importance of congestion effects.

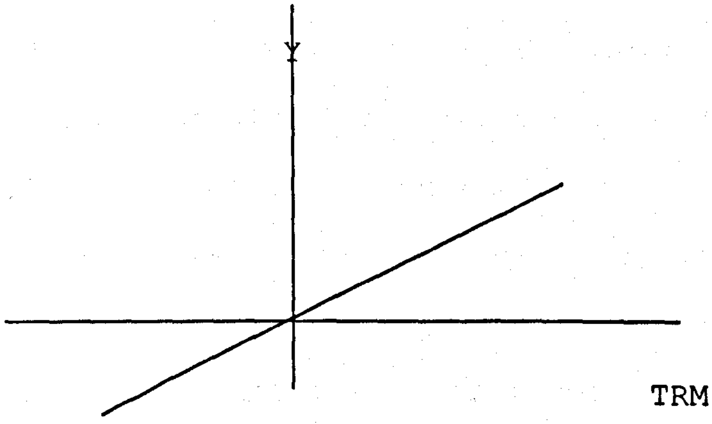
INDGSP (share of industrial output in each state's total output) shows t-statistics higher than one and a negative coefficient, when not controlling for CO.

Controlling for any dummy, PROX shows t-statistics higher than one and a positive coefficient.

The dummies, although showing high t-statistics, are seldom significant.

Equations (5)-(6) include the interaction term. The results are similar to Equations (1)-(4) for the common variables. The interaction term, controlling for CO, is positive, with a high t-statistic in (7) and significant (+1.99) in (8). Since per capita income is negative and significant in these equations, we have evidence that in the period 1970-1995, although poor states grew more, this advantage of the poor states declined when transportation cost decreased. This process is portrayed in Figure IV.3.

Figure IV.3 - NEGATIVE Y & POSITIVE YPROXM



We may have two interpretations for this picture. Either we consider it as not resembling any phase of our model, or we consider that it resembles phase II. In phase II, we were expecting positive coefficients both for Y and for the interaction term. A decline in transportation cost would increase the (negative) coefficient of per capita income, generating concentration of economic activity. We may interpret the negative sign of Y not as a failure of the NEG model, but as the influence of other factors not discussed in the model. What is really happening in reality depends on the relative importance of the determinants of the coefficient of per capita income, which are the coefficient of Y and the product of the coefficient of b and the value of proximity, since (Y = (a + b (PROXM)).

Table IV.17 - INDGSP & PROX - BRAZIL - 1970-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	-0,127	(-0.220)	-0,296	(-0.450)	-0.671**	(-2.371)	-0,482	(-1.371)	-0,208	(-0.334)	-0,233	(-0.355)	-0.642**	(-2.251)	-0.608**	(-2.189)
INDGSP	-0,048	(-1.045)	-0,057	(-1.184)	-9.14 E-03	(-0.293)	7.23 -04	(0.024)	-0,052	(-1.108)	-0,048	(-0.980)	1.82 E-03	(0.061)	-2.89 E-03	(-0.091)
PROX	84415	(0.911)	94694	(1.086)	100206	(1.613)	88945	(1.239)								
YPROX									36864	(0.953)	48822	(0.906)	57334	(1.423)	42112*	(1.985)
DD	-0.015**	(-2.526)	-0,012	(-1.620)	-7.34 E-03*	(-2.073)	-0.010**	(-2.652)	-0.016***	(-3.287)	-0.018**	(-2.784)	-0.013**	(-2.305)	-0.011***	(-3.856)
SP			1,083	(0.887)	1.180*	(1.922)					-0,662	(-0.479)	-0,841	(-0.614)		
CO					1,717	(1.568)	1,696	(1.636)					1,759	(1.597)	1,747	(1.666)
R2	0,572		0,589		0,730		0,709		0,581		0,584		0,731		0,726	
MSE	0,879		0,896		0,759		0,754		0,870		0,902		0,758		0,732	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.18 - NONAGR & PROX - BRAZIL - 1970-1995 (18 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	-0,279	(-0.617)	-0,428	(-0.711)	-0.693**	(-2.737)	-0,469	(-1.575)	-0,350	(-0.648)	-0,372	(-0.665)	-0.628**	(-2.585)	-0.611**	(-2.590)
NONAGR	-0,038	(-0.858)	-0,043	(-0.907)	-8.96 E-03	(-0.283)	-3.20 E-03	(-0.107)	-0,040	(-0.856)	-0,036	(-0.752)	-1.63 E-03	(-0.054)	-4.54 E-03	(-0.147)
PROX	81123	(0.892)	88134	(0.987)	99858	(1.618)	89326	(1.242)								
YPROX									33040	(0.866)	50295	(1.030)	56773	(1.438)	42110*	(2.031)
DD	-0.011**	(-2.300)	-8.23 E-03	(-1.073)	-6.34 E-03	(-1.660)	-9.81 E-03**	(-2.732)	-0.012**	(-2.807)	-0.014**	(-2.382)	-0.013**	(-2.340)	-0.011***	(-4.394)
SP			0,801	(0.638)	1.164*	(2.062)					-0,935	(-0.770)	-0,797	(-0.583)		
CO					1,729	(1.595)	1,659	(1.651)					1,728	(1.599)	1,736	(1.687)
R2	0,557		0,567		0,731		0,709		0,561		0,567		0,731		0,726	
MSE	0,894		0,920		0,758		0,754		0,890		0,920		0,758		0,732	

* All coefficients standard errors were corrected for heteroscedasticity.

b) NONAGR

The following observations apply for the specifications with NONAGR (Table IV.18) and for its comparison with Table IV.10:

a) congestion effects are harming growth in both samples;

b) controlling for CO, PROX is positive (and TR is positive), meaning that having transport infrastructure is positive for growth;

c) NONAGR has not significant coefficients;

d) SP and CO are positive;

e) while Y is negative and significant in (3), (7) and (8), it was never significant with TR;

f) YPROXM is positive in (6) and (7) and significant in (8).

The usage of a different proxy for transportation costs confirmed some of our previous cross-section results for the states of Brazil. Signs that economies of scale were important for growth are weak and concentrated in the period 1950-1970. Congestion effects have harmed growth in all samples.

With PROX, we could find a pattern for the interaction between per capita income and the interaction term for the 18-state samples of the period 1970-1995. The states would also be in phase II of the K&V(m) model.

IV.4.4 - 1970-1995 (24 States)

a) INDGSP

The results in Table IV.19, without the interaction terms, with INDGSP and PROX, are also similar to the ones in Table IV.11.

The coefficient of INDGSP is negative and significant, refuting the hypothesis that economies of scale were important for growth. Congestion effects were harmful for growth (the coefficients of DD were negative and usually significant). N is the outlier region in the full sample.

Without the interaction term - Equations (1)-(4) - richer countries in per capita terms grew more (not controlling for N), although the coefficient is only significant in Equation (1). The combination of a negative coefficient for TR (in Table IV.11) and a negative for PROX (Table IV.19) seems to reflect the positive growth of the states of the N. As a result, the coefficients of TR and PROX decrease when the equations are controlled by the respective dummy. The coefficients of TR and PROX also reflect conditions and performance of SE and S.

Controlling for the interaction terms, in both Tables, SP has a much higher coefficient (and becomes positive), while N decreases.

With the interaction terms we also find similar results. The interaction term - YPROXM - is negative, in (5), and negative and significant in Equation (6). The combination of this sign with the positive sign of Y in these specifications implies that the coefficient of per capita income becomes (positively) smaller as transportation cost decreases.

Table IV.6, with YTRM, showed the same result: although rich states were benefiting from the decrease in transportation costs, the negative sign of YTRM indicated that this effect was decreasing.

Table IV.19 - INDGSP & PROX - BRAZIL - 1970-1995 (24 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	1.260*	(1.909)	1,428432	(1.601)	0,4691	(0.455)	0,4196	(0.624)	1,5472	(1.671)	1,5238	(1.672)	0,6646	(0.604)	0,6281	(0.594)
INDGSP	-0.066***	(-2.843)	-0.065***	(-3.055)	-0.059**	(-2.635)	-0.060**	(-2.652)	-0.070***	(-3.051)	-0.074***	(-3.169)	-0.063**	(-2.502)	-0.061**	(-2.558)
PROX	-221198**	(-2.076)	-203162**	(-2.198)	-11946	(-0.093)	-11466	(-0.096)								
YPROX									-86587	(-1.682)	-130215*	(-1.976)	-41647	(-0.495)	-21985	(-0.340)
DD	-0.027***	(-3.735)	-0.029***	(-3.024)	-0.019*	(-1.725)	-0.019**	(-2.679)	-0.024***	(-4.806)	-0,0158447	(-1.425)	-0.015*	(-1.808)	-0.018***	(-3.239)
SP			-1,501	(-0.684)	-0,297	(-0.148)					2,973	(1.062)	1,123	(0.585)		
N					2,252	(1.499)	2.297*	(1.875)					1,967	(1.387)	2,069	(1.510)
R2	0,581		0,592		0,671		0,671		0,589		0,606		0,677		0,675	
MSE	1,474		1,494		1,380		1,342		1,460		1,468		1,368		1,334	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.20 - NONAGR & PROX - BRAZIL - 1970-1995 (24 states)
dependent variable: GRGSP - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,986	(1.585)	1,179	(1.348)	0,145	(0.165)	0,099	(0.183)	1,239	(1.356)	1,228	(1.345)	0,257	(0.291)	0,247	(0.289)
NONAGR	-0,034	(-0.828)	-0,031	(-0.741)	-0,039	(-0.844)	-0,040	(-0.896)	-0,036	(-0.914)	-0,043	(-1.088)	-0,041	(-0.913)	-0,040	(-0.916)
PROX	-234559*	(-1.869)	-213170*	(-1.976)	4201	(0.035)	4677	(0.042)								
YPROX									-87748	(-1.500)	-123682*	(-1.763)	-18689	(-0.269)	-12406	(-0.213)
DD	-0.023**	(-2.559)	-0.026**	(-2.309)	-0,014	(-1.178)	-0.013*	(-1.771)	-0.020***	(-3.070)	-0,013	(-1.241)	-0,012	(-1.546)	-0.013**	(-2.230)
SP			-1,723	(-0.740)	-0,276	(-0.141)					2,414	(0.951)	0,363	(0.255)		
N					2.579*	(1.866)	2.622**	(2.233)					2.407*	(1.930)	2.436*	(1.991)
R2	0,485		0,499		0,603		0,603		0,482		0,493		0,604		0,604	
MSE	1,634		1,656		1,516		1,474		1,638		1,665		1,514		1,472	

* All coefficients standard errors were corrected for heteroscedasticity.

b) NONAGR

NONAGR has insignificant coefficients in Table IV.20 that shows the results with PROX. DD is usually negative and significant.

Without the interaction term, per capita income is positive in equations (1) and (2). With the interaction term, it is positive in (5) and (6). All these specifications do not control for N.

YPROXM shows a negative (5) and a negative and significant (6) coefficient. A positive sign of Y and a negative coefficient for YPROXM implies that as transportation cost decreases, the higher growth of the richer states decreases. This result is completely compatible with the one in Table IV.12.

Conclusion

Tables IV.21 and IV.22 help us to draw some conclusions related to the cross-section exercises. In these tables, (>) or (<) indicate positive or negative coefficients with t-statistics greater than one. (<*) or (>*) indicate significant coefficients.

Using TR, there was a concentration of economic activity towards richer states in the sub-period

1950-1970 (Y is positive and usually significant, in Tables IV.7 and IV.8), which still affects the results for the whole period 1950-1995, where per capita income shows a positive coefficient (with t-statistics higher than one) when we do not control for the Centre-West (CO)(Tables IV.5 and IV.6, Equations (1), (2), (5), (6)).

The concentration of economic activity in richer states was clear for the larger sample of the period 1970-1995.(Tables IV.11 and IV.12 , Equations (1), (2), (5), (6), (7), (8); Tables IV.19 and IV.20, Equations (1), (2), (5) and (7)).

For the whole period, with TR (and for the second sub-period), economies of scale in the industrial sector (INDGSP) do not have importance for the distribution of economic activity, refuting the hypothesis of the model(Tables IV.5 and IV.9).

With PROX we even found that INDGSP was harmful for economic growth in the second sub-period (Table IV.17, Equations (1), (2) and (5)).

There is weak support for this hypothesis in the period 1950-1970, when we control the results for CO, where the t-statistics of INDGSP are at least greater than one.(Table IV.7 and IV.15, Equations (3,4,7,8)). In Table IV.5, Equations (6a) and (7a), shows positive and positive and significant coefficients, respectively, for INDGSP.

In the 24-State sample of the period 1970-1995, it is clear that economies of scale in the industrial sector were negative for growth.

Economies of scale in the industrial and service sector taken together were generating concentration of economic activity in the first sub-period (1950-1970), where NONAGR is significant controlling for CO (Tables IV.8 and IV.16, Equations (3), (4),(7) and (8)). For the whole period, 1950-1995, with PROX, Equations (3), (4), (7) and (8), which control for CO, show evidence of positive effects of NONAGR on growth. For the two samples of 1970-1995, they were not important for explaining economic growth.

Both TR and PROX do not show significant statistics, for the 18-state samples. Coefficients with high t-statistics indicate negative impact of TR, for the periods 1950-1995 and 1950-1970, and positive impact of TR in the period 1970-1995 and for PROX, in all samples).

In the sample that includes the North (N), the coefficients of TR and PROX are negative and significant (without controlling for N) (Tables IV.11, IV.12, IV.19, IV.20, Equations (1) and (2)).

TRM shows positive and significant coefficients for the equations that control for SP in the sub-period 1950-1970 and in the 24-State sample of 1970-1995.

For the 18-State samples, YTRM provides us with significant information for the first sub-period, where the equation with the demeaned variable TRM shows positive and significant coefficients for the interaction term (Table IV.6, Equations (6a) and (7a)). YPROXM shows (t-statistics higher than one and two significant coefficients) evidence that in the second sub-period (1970-1995) its coefficient was positive (Table IV.17, Equations (7) and (8), and IV.18, Equations (6), (7) and (8)) , which reflects in the positive coefficient for the whole period 1950-1995 (controlling for CO) (Table IV.13, (7) and (8) and Table IV.14, (6), (7), and (8)).

For the 24-State sample, without controlling for N, the interaction term is negative (and sometimes significant).

The SP dummy is rarely significant, while the regional dummy CO is important in the empirical exercise for the whole period and for the first sub-period. The regional dummies are usually less important for the samples of the period 1970-1995.

Important elements exploited by NEG models were present in the economics of Brazil. NEG models show three phases for the path of the economy: in the first one, high transportation costs help an equal division of income to prevail; in the second one, decrease in these costs leads to concentration of activities in the richest states; finally, a further decrease in transportation costs and congestion effects would reintroduce symmetry into the economy.

The hypothesis that "backwards and forwards" linkages were important for the distribution of activity has only stronger support in the period 1950-1970 (Tables IV.21 and IV.22). For the whole period, with PROX, NONAGR is positive controlling for CO, providing some weak evidence that economies of scale outside the agricultural sector was generating concentration, in accordance with K&V(m) model (Table IV.13). The samples for the 1970-1995 strongly refute this hypothesis.

For the whole period - 1950-1995 - we cannot infer any clear pattern for the behaviour of the states of Brazil, but we can suggest that there is evidence (especially with PROX) that lower concentration costs would be generating concentration of activity (observing the coefficient of the interaction term), resembling phase II of the K&V(m) model.

In the first sub-period (1950-1970) we found more evidence in accordance to NEG's model. INDGSP is positive (Tables IV.7 and IV.15, Equations (3), (4), (7) and (8)) and NONAGR is positive or positive and significant (Tables IV.8 and IV.16), highlighting the importance of economies of scale in generating growth. The significant YTRM (Table IV.7, Equations (6a) and (7a) and IV.8, Equation (7)) and the coefficients of YPROXM (Table IV.15, Equation (7) and IV.16, Equations (6) and (7))indicate that a decrease in transportation cost was also generating concentration. Since per capita income shows a positive (and significant with TR) coefficient, there is evidence of strong concentration occurring in this period (the states of Brazil would be in phase II of the K&V(m) model).

In the period 1970-1995, per capita income starts to show a negative coefficient (Table IV.9, Equation (3), Table IV.10, Equations (3), (4), (7) and (8), Tables IV.17 and IV.18, Equations (3), (4), (7), (8)), suggesting dispersion of economic activity towards poorer states. The impact of a change in transportation cost in this process is to increase the negative coefficient of per capita income, enhancing concentration of economic activity (Tables IV.17 and IV.18, Equations (7) and (8). INDGSP and NONAGR usually show insignificant coefficients, denying the importance of "backwards and forwards" linkages.

In the 24-State sample of the period 1970-1995, we can observe evidence that there was a concentration of economic activity in richer states (in almost all equations Y is positive or positive and significant). The coefficients of the interaction terms show that a decrease in transportation cost counteracts this process (the coefficients are almost always negative or negative and significant). The effect of transportation cost resembles phase III of the model.

Table IV.21 - SUMMARY OF CROSS-SECTION RESULTS (TR)

1950-1995 (18 STATES)	<	>	<*	>*	number of equations
Y*	0	4	0	0	8
INDGSP	0	0	0	0	8
NONAGR	0	0	0	0	8
TR	2	0	0	0	8
DD	1	0	14	0	16
SP	0	0	2	0	8
CO	0	0	0	8	8
Y**	0	4	0	0	8
YTRM	0	0	0	1	8

1950-1970 (18 states)	**<**	**>**	**<***	**>***	**number of equations *** **
Y*	0	2	0	6	8
INDGSP	0	5	0	1	10
NONAGR	0	4	0	4	8
TR	4	0	0	0	8
DD	0	0	18	0	18
SP	2	0	2	0	10
CO	0	0	0	9	9
Y**	0	3	0	7	10
TRM	0	0	2	0	2
YTRM*****	0	2	0	3	10
1970-1995 (18 STATES)	**<**	**>**	**<***	**>***	**number of equations**
Y*	3	0	0	0	8
INDGSP	1	0	0	0	8
NONAGR	0	0	0	0	8
TR	2	2	0	2	8
DD	6	0	8	0	16
SP	0	2	0	0	8
CO	0	4	0	4	8
Y**	1	0	0	0	8
YTRM	0	0	0	0	8
1970-1995 (24 STATES)	**<**	**>**	**<***	**>***	**number of equations *** **
Y*	0	4	0	1	8
INDGSP	0	0	10	0	10
NONAGR	0	0	0	0	8
TR	0	0	4	0	8
DD	4	0	12	0	18
SP	0	2	0	1	10
N	0	5	0	4	9
Y**	0	4	0	6	10
TRM	0	0	0	2	2
YTRM*****	4	0	6	0	10

* coefficient of Y in the specifications without the interaction term;

** coefficient of Y in the specifications with the interaction term;

*** includes the equations with TRM;

**** includes the coefficients of Y in the equations with TRM.

Table IV.22 - SUMMARY OF CROSS-SECTION RESULTS (PROX)

1950-1995 (18STATES)	<	>	<*	>*	number of equations
Y*	0	0	0	0	8
INDGSP	0	1	0	0	8
NONAGR	0	4	-	0	8
DD	10	0	16	0	16
PROX	0	1	0	0	8
SP	3	0	0	0	8
CO	0	0	0	8	8
Y**	1	0	0	0	8
YPROXM	0	3	0	0	8
1950-1970 (18 states)	<	>	<*	>*	number of equations
Y*	0	2	0	0	8
INDGSP	0	3	0	1	8
NONAGR	0	4	0	4	8
DD	10	0	16	0	16
PROX	0	0	4	0	8
SP	8	0	0	0	8
CO	0	0	0	8	8
Y**	1	0	0	0	8
YTRM	0	3	0	0	8
1970-1995 (18 STATES)	<	>	<*	>*	number of equations
Y*	2	0	2	0	8
INDGSP	4	0	0	0	8
NONAGR	0	0	0	0	8
DD	3	0	13	0	16
PROX	0	4	0	0	8
SP	0	0	0	2	8
CO	0	8	0	0	8
Y**	0	0	4	0	8
YPROXM	0	0	0	2	8

1970-1995 (24 STATES)	<	>	<*	>*	number of equations
Y*	0	7	0	1	8
INDGSP	0	0	8	0	8
NONAGR	0	0	0	0	8
DD	3	0	13	0	16
PROX	0	0	4	0	8
SP	0	1	0	0	8
N	0	3	0	5	8
Y**	0	4	0	0	8
YTRM	2	0	2	0	8

* coefficient of Y in the specifications without the interaction term;

** coefficient of Y in the specifications with the interaction term;

*** includes the equations with TRM;

**** includes the coefficients of Y in the equations with TRM.

IV.5 - Cross-Section Results with the Growth Rate of Industrial Output (GRIND)

We repeat the cross-section specifications here, replacing the growth rate of total income for the growth rate of industrial income (GRIND).

IV.5.1 - 1950-1995 (18 States)

The results for the whole period are in Table IV.23 and IV.25 (with INDGSP) and in Table IV.26 and IV.27(with NONAGR) .

Congestion effects are negatively influencing the industrial growth rate, helping to generate a dispersion of industrial activity, as in the results with GRGSP.

The dummies are not as important as they were in the previous exercises with GRGSP.

Economies of scale in the industrial sector (INDGSP) show significant negative coefficients.

The transportation cost's proxy fits better with GRIND. The t-statistics of PROX are higher than one, with INDGSP, and higher than one with NONAGR and controlling for CO. The coefficients of the interaction term (YPROXM) are positive and significant when controlling for CO.

With NONAGR and TR, we could only observe some significant negative impact of transport availability on industrial growth (1t and 5at-8at) and a positive and significant coefficient for the interaction term - YTRM - in specification (5at).

Table IV.23 - INDGSP & TR - BRAZIL - 1950-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	1,477	(1.689)	1,320	(1.408)	0,981	(0.955)	1,093	(1.119)	1,240	(1.270)	1,263	(1.248)	0,759	(0.775)	0,798	(0.864)
INDGSP	-0.155*	(-2.101)	-0.161*	(-2.045)	-0.151*	(-1.927)	-0.146*	(-1.972)	-0.177***	(-2.977)	-0.178**	(-2.788)	-0.157**	(-2.626)	-0.158**	(-2.627)
TR	-2,568	(-0.466)	-3,539	(-0.562)	-1,210	(-0.176)	-0,371	(-0.061)								
YTRM									0,407	(0.154)	-1,085	(-0.166)	2,626	(0.485)	1,437	(0.618)
DD	-0.042**	(-2.641)	-0.038*	(-1.888)	-0,033	(-1.657)	-0.036*	(-2.105)	-0.041**	(-2.332)	-0.038*	(1.844)	-0.036*	(-2.016)	-0.336*	(-2.047)
SP			0,952	(0.653)	0,754	(0.610)					0,988	(0.302)	-0,755	(-0.312)		
CO					1,234	(1.604)	1,275	(1.719)					1.494*	(2.091)	1.426**	(2.164)
									0,681		0,683					
									1,153		1,197					
R2	0,689		0,696		0,730		0,725						0,732		0,731	
MSE	1,139		1,173		1,155		1,114						1,150		1,103	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.24 - NONAGR & TR - BRAZIL - 1950-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t	7a	t
Y	1.490*	(1.862)	1,358	(1.554)	0,962	(0.997)	1,025	(1.105)	1,078	(1.034)	1,129	(1.042)	0,429	(0.434)	0,495	(0.536)	0,451	(0.670)
NONAGR	-0,050	(-0.927)	-0,056	(-0.954)	-0,041	(-0.636)	-0,036	(-0.628)	-0,035	(-0.513)	-0,039	(-0.556)	-0,020	(-0.287)	-0,023	(-0.344)	-0,051	(-0.901)
TR/TRM(7a	-7.981*	(-1.849)	-9,260	(-1.700)	-6,290	(-1.070)	-5,328	(-1.120)									-19.274*	(-1.883)
YTRM									-2,370	(-0.718)	-4,693	(-0.824)	0,958	(0.148)	-0,070	(-0.259)	20.938*	(1.867)
DD	-0,039	(-1.530)	-0,033	(-1.022)	-0,033	(-1.047)	-0,037	(-1.453)	-0,046	(-1.332)	-0,041	(-1.167)	-0,042	(-1.269)	-0,038	(-1.257)	-0,048	(-1.632)
SP			1,009	(0.577)	0,657	(0.402)					1,552	(0.626)	-1,045	(-0.317)			-7,849	(1.749)
CO					1,222	(1.266)	1,285	(1.410)					1.953**	(2.252)	1.851**	(2.392)	1,329	(1.162)
R2	0,591		0,598		0,628		0,625		0,506		0,511		0,594		0,592		0,710	
MSE	1,307		1,349		1,355		1,302		1,436		1,488		1,416		1,359		1,254	

* All coefficients standard errors were corrected for heteroscedasticity.

* TRM was significant in (5a) and (6a), while YTRM was not.

Table IV.25 - INDGSP & PROX - BRAZIL - 1950-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,168	(0.161)	0,030	(0.026)	-0,295	(-0.325)	-0,108	(-0.127)	-0,033	(-0.031)	-0,354	(-0.296)	-0,826	(-0.929)	-0,498	(-0.668)
INDGSP	-0,170***	(-4.006)	-0,177***	(-3.805)	-0,152***	(-3.051)	-0,144***	(-3.209)	-0,165***	(-3.631)	-0,140**	(-2.518)	-0,110*	(-1.836)	-0,135**	(-2.812)
PROX	165599	(1.462)	167642	(1.473)	172004	(1.754)	1692441	(1.684)								
YPROX									128404	(1.727)	194717	(1.540)	213928*	(1.887)	146575**	(2.612)
DD	-0,034**	(-2.329)	-0,031	(-1.630)	-0,025	(-1.580)	-0,028**	(-2.415)	-0,042***	(-3.106)	-0,051**	(-2.504)	-0,045**	(-2.358)	-0,036***	(-3.062)
SP			0,533	(0.547)	0,700	(0.814)					-1,600	(-0.935)	-1,623	(-0.960)		
CO					1,361	(1.560)	1,332	(1.624)					1,465	(1.740)	1,460*	(1.902)
R2	0,721		0,724		0,772		0,767		0,717		0,730		0,785		0,772	
MSE	1,079		1,118		1,062		1,026		1,087		1,105		1,030		1,016	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.26 - NONAGR & PROX - BRAZIL - 1950-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	-0,598	(-0.495)	-0,328	(-0.225)	-0,840	(-0.687)	-0,988	(-0.879)	-1,037	(-1.173)	-1,487	(-1.426)	-1,849**	(-2.521)	-1,492**	(-2.170)
NONAGR	-0,024	(-0.383)	-0,019	(-0.281)	-3,85 E-03	(-0.057)	-6,02 E-0	(-0.095)	-0,037	(-0.617)	-0,016	(-0.274)	-2,26 E-03	(-0.041)	-0,020	(-0.327)
PROX	163049	(0.988)	162379	(0.913)	180028	(1.111)	180742	(1.185)								
YPROX									160237	(1.516)	304039**	(2.141)	303549**	(2.397)	178626*	(2.060
DD	-0,041	(-1.310)	-0,046	(-1.234)	-0,037	(-1.296)	-0,034	(-1.476)	-0,045	(-1.367)	-0,066*	(-1.874)	-0,058*	(-2.000)	-0,038	(-1.508)
SP			-0,971	(-0.620)	-0,506	(-0.435)					-3,719*	(-1.854)	-3,271*	(-1.848)		
CO					1,965**	(2.007)	2,001**	(2.363)					1,882**	(2.182)	2,058**	(2.279)
R2	0,522		0,531		0,636		0,634		0,544		0,630		0,727		0,661	
MSE	1,412		1,456		1,339		1,287		1,380		1,293		1,160		1,238	

* All coefficients standard errors were corrected for heteroscedasticity.

IV.5.2 - 1950-1970 (18 States)

The results for the first sub-period are in Tables IV.27-IV.30.

With TR and INDGSP, Y shows some positive and significant coefficients.

The coefficient of INDGSP is always negative and it usually shows high t-statistics (and some significant coefficients), while we have found positive coefficients, for this period when explaining the growth rate of total income.

There are less significant coefficients of NONAGR and less significant coefficients for CO.

DD reveals significant signs of congestion effects.

As in the previous sample, proximity explains better the behaviour of GRIND. PROX shows high t-statistics, being usually significant with INDGSP. YPROXM is positive and usually significant. In the exercises with GRGSP, the coefficients had the same signs, but were not significant.

Table IV.27 - INDGSP & TR - BRAZIL - 1950-1970 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	2.608**	(2.511)	2.354*	(2.095)	2,055	(1.653)	2.259*	(1.845)	2.173*	(1.863)	2.180*	(1.791)	1,668	(1.387)	1,742	(1.565)
INDGSP	-0,123	(-1.519)	-0,132	(-1.484)	-0,123	(-1.343)	-0,115	(-1.377)	-0.152**	(-2.180)	-0.152*	(-2.067)	-0,131	(-1.723)	-0.134*	(-1.796)
TR	-1,868	(-0.292)	-3,437	(-0.425)	-1,387	(-0.145)	0,131	(0.017)								
YTRM									1,851	(0.631)	1,377	(0.179)	5,150	(0.689)	2,853	(1.052)
DD	-0.550**	(-2.809)	-0.048*	(-1.790)	-0,043	(-1.631)	-0.049**	(-2.219)	-0.052**	(-2.501)	-0.051*	(-1.840)	-0.048*	(-2.078)	-0.045**	(-2.187)
SP			1,539	(0.640)	1,364	(0.596)					0,314	(0.070)	-1,458	(-0.362)		
CO					1,086	(0.947)	1,160	(1.046)					1,519	(1.560)	1.386*	(1.837)
R2	0,490		0,505		0,526		0,515		0,495		0,495		0,537		0,534	
MSE	1,609		1,651		1,686		4,634		1,601		1,666		1,667		1,602	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.28 - NONAGR & TR - BRAZIL - 1950-1970 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	2.284**	(2.115)	2.156*	(1.802)	1,676	(1.400)	1,730	(1.535)	1,833	(1.405)	1,829	(1.349)	1,032	(0.956)	1,226	(1.143)
NONAGR	8.38 E-03	(0.125)	1.78 E-03	(0.025)	0,021	(0.293)	0,025015	(0.395)	0,01712	(0.220)	0,0173593	(0.209)	0,03911	(0.533)	0,0298601	(0.426)
TR	-5,636257	(-1.127)	-6,883	(-0.980)	-3,292	(-0.405)	-2,474	(-0.405)								
YTRM									-0,887	(-0.270)	-0,735	(-0.120)	5,702	(0.881)	0,855	(0.291)
DD	-0.067**	(-2.354)	-0,061	(-1.579)	-0,060	(-1.612)	-0.064**	(-2.156)	-0.071*	(-2.032)	-0.071*	(-1.778)	-0.073*	(-2.011)	-0.063*	(-1.837)
SP			0,984	(0.400)	0,558	(0.247)					-0,102	(-0.031)	-3,060	(-0.914)		
CO					1,477	(1.177)	1,531	(1.282)					2.225*	(2.004)	1.927**	(2.150)
R2	0,422		0,428		0,464		0,462		0,382		0,382		0,470		0,458	
MSE	1,713		1,775		1,794		1,720		1,772		1,845		1,783		1,727	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.29 - INDGSP & PROX - BRAZIL - 1950-1970 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,777	(0.622)	0,469	(0.359)	0,173	(0.146)	0,531	(0.439)	0,506	(0.396)	0,173	(0.116)	-0,268	(-0.190)	0,071	(0.063)
INDGSP	-0,131**	(-2.316)	-0,146**	(-2.141)	-0,124	(-1.568)	-0,107	(-1.591)	-0,124*	(-2.069)	-0,098	(-1.165)	-0,070	(-0.726)	-0,096	(-1.398)
PROX	247973	(1.698)	252528*	(1.759)	256510*	(1.935)	251222*	(1.835)								
YPROX									189432**	(2.300)	258184	(1.630)	276157*	(1.768)	206426**	(2.795)
DD	-0,043**	(-2.696)	-0,037	(-1.692)	-0,031	(-1.534)	-0,038**	(-2.507)	-0,056***	(-3.422)	-0,064**	(-2.255)	-0,059*	(-2.120)	-0,050***	(-3.236)
SP			1,189	(0.804)	1,341	(0.973)					-1,658	(-0.622)	-1,680	(-0.639)		
CO					1,242	(1.713)	1,187	(1.601)					1,371*	(1.809)	1,365*	(2.011)
R2	0,561		0,571		0,604		0,591		0,552		0,563		0,603		0,591	
MSE	1,494		1,537		1,542		1,500		1,509		1,551		1,545		1,500	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.30 - NONAGR & PROX - BRAZIL - 1950-1970 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	-0,569	(-0.372)	-0,438	(-0.257)	-0,951	(-0.667)	-0,952	(-0.680)	-0,571	(-0.445)	-1,028	(-0.651)	-1,379	(-1.034)	-1,014	(-0.961)
NONAGR	0,044	(0.651)	0,046	(0.636)	0,062	(0.954)	0,062	(1.040)	0,019	(0.287)	0,041	(0.618)	0,054	(0.932)	0,036	(0.627)
PROX	303752	(1.496)	303428	(1.414)	321090	(1.592)	321098	(1.657)								
YPROX									218388*	(2.023)	364295**	(2.307)	363822**	(2.509)	236259**	(2.545)
DD	-0,065**	(-2.363)	-0,067*	(-2.085)	-0,058*	(-2.079)	-0,058**	(-2.540)	-0,072**	(-2.268)	-0,094**	(-2.830)	-0,085**	(-2.698)	-0,065**	(-2.349)
SP			-0,470	(-0.313)	-5,04 E-03	(-0.004)					-3,773*	(-1.795)	-3,340	(-1.741)		
CO					1,967***	(2.928)	1,967***	(3.001)					1,820**	(2.673)	2,000***	(3.242)
R2	0,481		0,483		0,569		0,569		0,467		0,540		0,614		0,558	
MSE	1,623		1,687		1,608		1,539		1,646		1,591		1,522		1,560	

* All coefficients standard errors were corrected for heteroscedasticity.

IV.5.3 - 1970-1995 (18 States)

The results for the second sub-period are in Tables IV.31-IV.34.

There is a decrease in the number of significant coefficients for per capita income, when controlling for INDGSP, and an increase, when controlling for NONAGR.

INDGSP is consistently negative and significant, while the number of significant negative coefficients for NONAGR increases (with PROX).

Population density is only important with INDGSP, and the dummies are no longer significant.

Once more, the interaction terms (YPROXM) show positive and usually significant coefficients. In the exercises with GRGSP, they were positive but usually not significant.

Table IV.31 - INDGSP & TR - BRAZIL - 1970-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,530	(0.865)	0,348	(0.405)	0,122	(0.120)	0,345	(0.472)	0,599	(0.809)	0,459	(0.553)	0,209	(0.192)	0,227	(0.206)
INDGSP	-0.170**	(-2.532)	-0.185**	(-2.618)	-0.170**	(-2.349)	-0.155*	(-2.124)	-0.174***	(-3.045)	-0.180***	(-2.981)	-0.167**	(-2.754)	-0.157**	(-2.438)
TR	-0,812	(-0.280)	-0,601	(-0.190)	0,394	(0.105)	0,061	(0.020)								
YTRM									-0,342	(-0.218)	-0,907	(-0.468)	-0,268	(-0.112)	0,399	(0.182)
DD	-0.022**	(-2.184)	-0,019	(-1.348)	-0,016	(-1.092)	-0.020*	(-1.827)	-0.022**	(-2.379)	-0,017	(-1.172)	-0,016	(-1.084)	-0.020*	(-1.771)
SP			1,427	(0.557)	1,586	(0.598)					2,026	(0.724)	1,690	(0.685)		
CO					1,007	(0.725)	0,904	(0.745)					0,791	(0.518)	1,077	(0.632)
R2	0,645		0,653		0,663		0,653		0,644		0,658		0,663		0,654	
MSE	1,556		1,601		1,649		1,602		1,559		1,590		1,649		1,599	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.32 - NONAGR & TR - BRAZIL - 1970-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	5.52 E-03	(0.011)	-0,045	(-0.058)	-0,319	(-0.355)	-0.210698	(-0.377)	0,379	(0.527)	0,227	(0.292)	-0,069	(-0.066)	-0.063	(-0.060)
NONAGR	-0,100	(-1.412)	-0,102	(-1.335)	-0,086	(-1.138)	-0,083	(-1.162)	-0.10741	(-1.665)	-0.116	(-1.668)	-0,099	(1.343)	-0,087	(-1.260)
TR	-2,910	(-1.099)	-2,904	(-1.047)	1,296	(-0.383)	-1,373	(-0.444)								
YTRM									-1,782	(-1.247)	-2,415	(-1.581)	-1,487	(-0.672)	-0,735	(-0.345)
DD	-8.23 E-03	(-1.023)	-7.33 E-0	(-0.524)	-6.08 E-0	(-0.429)	-7.88 E-03	(-0.966)	-8.70 E-0	(-1.023)	-2.60 E-03	(-0.200)	-3.54 E-0	(-0.272)	-8.10 E-03	(-0.933)
SP			0,317	(0.139)	0,623	(0.268)					2,139	(0.940)	1,654	(0.762)		
CO					1,420	(1.067)	1,363	(1.166)					0,996	(0.660)	1,331	(0.830)
R2	0,573		0,573		0,593		0,591		0,576		0,591		0,598		0,590	
MSE	1,706		1,775		1,811		1,737		1,701		1,738		1,7994		1,7404	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.33 - INDGSP & PROX - BRAZIL - 1970-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	-0,242	(-0.383)	-0,576	(-0.830)	-0,791	(-1.494)	-0,440	(-0.768)	-0,288	-0,392	-0,399	(-0.565)	-0,652	(-1.278)	-0,527	(-0.889)
INDGSP	-0.188***	(-4.222)	-0.207***	(-4.508)	-0.180***	(-4.773)	-0.161***	(-3.957)	-0.197***	(-4.040)	-0.182***	(-4.103)	-0.151***	(-4.120)	-0.168***	(-3.441)
PROX	255030*	(2.105)	275387**	(2.745)	278549**	(2.996)	257556**	(2.238)								
YPROX																
DD									89487*	(1.807)	142950*	(1.760)	148221*	(1.890)	92627**	(2.216)
SP	-0.020**	(-2.442)	-0,015	(-1.441)	-0,012	(-1.311)	-0.017**	(-2.156)	-0.023***	(-3.048)	-0.031*	(-2.076)	-0.028*	(-1.829)	-0.021**	(-2.748)
CO			2,144	(1.319)	2,200	(1.516)					-2,961	(-0.933)	-3,071	(-0.924)		
					0,985	(0.822)	0,946	(0.826)					1,089	(0.896)	1,045	(0.903)
R2	0,709		0,727		0,739		0,720		0,699		0,715		0,730		0,713	
MSE	1,409		1,420		1,449		1,438		1,432		1,452		1,476		1,456	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.34 - NONAGR & PROX - BRAZIL - 1970-1995 (18 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	-0.895*	(-1.786)	-1,0587	(-1.476)	-1.352**	(-2.854)	-1.105***	(-3.110)	-0,8599175	(-1.249)	-0,9602407	(-1.439)	-1.245**	(-2.735)	-1.154**	(-2.468)
NONAGR	-0.126*	(-1.954)	-0.131*	(-1.944)	-0,0940002	(-1.430)	-0,088	(-1.383)	-0.129*	(-1.946)	-0,112	(-1.656)	-0,074	(-1.174)	-0,089	(-1.468)
PROX	238181*	(1.847)	245868*	(1.964)	258835**	(2.246)	247256*	(2.038)								
YPROX									72253	(1.532)	152217*	(2.049)	159411*	(2.065)	82499**	(2.261)
DD	-5.95 E-03	(-0.725)	-3.36 E-0	(-0.265)	-1.27 E-03	(-0.112)	-5.09 E-0	(-0.661)	-8.65 E-03	(-0.949)	-0,021	(-1.222)	-0,020	(-1.083)	-7.84 E-03	(-0.949)
SP			0,879	(0.467)	1,280	(0.817)					-4,333	(-1.250)	-4,180	(-1.116)		
CO					1,913	(1.487)	1,836	(1.510)					1,919	(1.482)	1,962	(1.643)
R2	0,5995		0,603		0,656		0,649		0,579		0,614		0,667		0,635	
MSE	1,6522		1,713		1,666		1,610		1,694		1,689		1,638		1,642	

* All coefficients standard errors were corrected for heteroscedasticity.

IV.5.4 - 1970-1995 (24 States)

With PROX, agricultural states showed the better results in terms of the industrial growth rate (NONAGR and INDGSP are negative and significant). Congestion effects are important with INDGSP. The interaction term shows one positive (7p) and one positive and significant (8p) coefficient, implying concentration of industrial activity due to lower transportation cost.

The main difference between the two exercises is the increase in the amount of significant negative coefficients for NONAGR, the existence of some negative coefficients for Y and the positive coefficient for the interaction term.

With TR, specifications (1at and 5at) show the existence of concentration of industrial activity in richer states and less industrialised ones. TR has a negative impact on growth and YTRM helps dispersion of industrial activity. Congestion effects were also dispersing industrial activity.

Table IV.35 - INDGSP & TR - BRAZIL - 1970-1995 (24 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	2.209**	(2.059)	1,137	(1.265)	0,458	(0.539)	0,752	(1.336)	1.681**	(2.217)	1.442*	(1.730)	0,552	(0.633)	0,662	(0.798)
INDGSP	-0.222***	(-6.251)	-0.222***	(-6.078)	-0.227***	(-7.115)	-0.226***	(-7.246)	-0.232***	(-6.755)	-0.234***	(-6.653)	-0.227***	(-7.170)	-0.225***	(-7.251)
TR	-3.807*	(-1.809)	-3,946	(-1.559)	0,154	(0.064)	0,316	(0.145)								
YTRM									-1.899*	(-1.727)	-2,687	(-1.561)	-0,402	(-0.251)	0,288	(0.250)
DD	-0.027**	(-2.587)	-0.026*	(-1.716)	-0,018	(-1.388)	-0.022**	(-2.287)	-0.027***	(-2.823)	-0,019	(-1.145)	-0,017	(-1.171)	-0.025**	(-2.486)
SP			0,527	(0.200)	1,870	(0.817)					3,176	(0.902)	2,264	(0.776)		
N					2.882**	(2.269)	2.667**	(2.379)					2.611**	(2.626)	2.775**	(2.626)
R2	0,765		0,765		0,815		0,809		0,770		0,780		0,815		0,810	
MSE	1,898		1,949		1,781		1,755		1,878		1,884		1,778		1,753	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.36 - NONAGR & TR - BRAZIL - 1970-1995 (24 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	0,666	(1.107)	0,566	(0.652)	-0,275	(-0.344)	0,126	(0.217)	1,338	(1.470)	1,033	(1.107)	-0,156	(-0.167)	-8.83 E-03	(-0.010)
NONAGR	-0.226**	(-2.354)	-0.226**	(-2.294)	-0.257**	(-2.646)	-0.253**	(-2.684)	-0.249**	(-2.636)	-0.260**	(-2.636)	-0.262***	(-2.759)	-0.254***	(-2.826)
TR	-5.929**	(-2.058)	-6.124**	(-2.140)	-0,654	(-0.206)	-0,464	(-0.145)								
YTRM									-2,761	(-1.641)	-3.884**	(-2.181)	-0,692	(-0.398)	0,292	(0.165)
DD	1.53 E-04	(0.013)	1.60 E-03	(0.100)	0,015	(0.897)	8.78 E-03	(0.720)	1.15 E-03	(0.101)	0,014	(0.892)	0,017	(1.089)	8.04 E-03	(0.706)
SP			0,738	(0.277)	3.842**	(1.067)					4.423*	(1.783)	3,211	(1.416)		
N						(2.400)	3.524**	(2.403)					3.655***	(2.850)	3.869***	(2.917)
R2	0,583		0,584		0,668		0,659		0,580		0,601		0,669		0,659	
MSE	2,526		2,593		2,382		2,349		2,535		2,540		2,378		0,348	

* All coefficients standard errors were corrected for heteroscedasticity.

Table IV.37 - INDGSP & PROX - BRAZIL - 1970-1995 (24 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	1,480*	(1.759)	1,501151	(1.368)	-0,216	(-0.244)	0,112	(0.151)	1,544	(1.370)	1,527	(1.343)	-0,053	(-0.053)	-0,123	(-0.013)
INDGSP	-0,234***	(-5.815)	0,234***	(-5.798)	-0,224***	(-6.714)	-0,223***	(-6.964)	-0,236***	(-5.521)	-0,239***	(-5.335)	-0,219***	(-5.845)	-0,221***	(-6.514)
PROX	-129556	(-0.928)	-127234	(-0.913)	214974*	(1.728)	211791	(1.576)								
YPROX									-39039	(-0.642)	-70537	(-0.721)	92325	(0.919)	70338	(1.290)
DD	-0,034***	(-3.396)	-0,035**	(-2.553)	-0,017	(-1.526)	-0,021**	(-2.409)	-0,034***	(-4.024)	-0,028	(-1.531)	-0,027*	(-1.774)	-0,024***	(-3.215)
SP			-0,193	(-0.072)	1,963	(1.145)					2,147	(0.492)	-1,256	(-0.343)		
CO					4,031***	(3.576)	3,738***	(3.294)					3,617***	(3.206)	3,503***	(3.315)
R2	0,744		0,744		0,831		0,825		0,740		0,743		0,825		0,824	
MSE	1,978		2,032		1,702		1,682		1,995		2,037		1,733		1,688	

* All coefficients standard errors were corrected for heteroscedasticity.

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Table IV.38 - NONAGR & PROX - BRAZIL - 1970-1995 (24 states)
dependent variable: GRIND - cross-section results

	1	t	2	t	3	t	4	t	5	t	6	t	7	t	8	t
Y	1,021	(1.056)	1,072	(0.867)	-1,151	(-1.570)	-0,714	(-1.157)	1,049	(0.806)	1,038	(0.792)	-1,020	(-1.247)	-0,964	(-1.216)
NONAGR	-0,243***	(-2.674)	-0,242**	(-2.569)	-0,259***	(-2.853)	-0.254***	(-2.880)	-0,242**	(-2.685)	-0,249**	(-2.569)	-0,245**	(-2.629)	-0,251***	(-2.870)
PROX	-199554	(-0.963)	-193914	(-0.930)	273238*	(1.754)	268653	(1.696)								
YPROX									-54226	(-0.680)	-88340	(-0.704)	134267	(1.569)	98655**	(1.944)
DD	-9,50 E-03	(-0.662)	-0,010	(-0.557)	0,016	(1.050)	9.90 E-03	(0.855)	-9,25 E-03	(-0.768)	-2,38 E-03	(-0.103)	-3,62 E-04	(-0.020)	5,33 E-03	(0.515)
SP			-0,454	(-0.139)	2,656	(1.249)					2,292	(0.443)	-2,057	(-0.561)		
CO					5,543***	(4.787)	5.132***	(4.126)					5,105***	(5.399)	4,943***	(4.869)
R2	0,530		0,530		0,694		0,683		0,517		0,520		0,689		0,687	
MSE	2,6819		2,7544		2,2885		2,2614		2,720		2,784		2,306		2,250	

* All coefficients standard errors were corrected for heteroscedasticity.

IV.6 - Test of *Restrictions*

In Section III.7 we have explained that, at the end of each chapter, we would try to select the "best" model, for each dependent variable, by testing the null hypothesis that:

a) the coefficients of the (all) regional dummies are not jointly significant;

b) the coefficient of SP is not significant;

c) the coefficient of (1/TCM) is not significant;

d) the coefficients of the proxy for economies of scale and for the interaction term are not individually and jointly significant.

For not refusing the model, the coefficient of the proxy for economies of scale should be positive.

Our test of restrictions would not only help us to specify the best econometric model, but also would select only the equations (through items (d) and (e)) that do not refute the theoretical model.

Since we use different proxies for transportation cost, for each dependent variable and for each proxy for economies of scale we would end up with two best specifications: one with YTRM and one with YPROXM. The choice between them was done trough the highest R^2.

Along this chapter, we try to collect information from all specifications and we use the different proxies for transportation cost as a further source of information, since they measure different things. Our strongest conclusions were based on the equations with the smaller MSE. In this section, the approach is different, since we are trying to chose the best specification that do not refute the K&V(m). Another difference is that in the rest of the Chapter, the regional dummies were selected through a stepwise procedure. In this section, all of them stay in the specification if the hypothesis that they are not jointly significant is refuted.

Finally, if the interaction term was positive, we concluded that the economy was in the "core-periphery" phase (phase II). If negative, the economy was in phase III. The results are in Appendix 6.

For the cross-section results, using GR, only the specifications for the period 1950-1970 do not refute the model (the hypothesis that the coefficients of the proxy for economies of scale and for the interaction term are equal to zero was refuted).

With INDGSP, the highest R^2 occurs in the specification with the proxy TR for transportation costs. All regional dummies are jointly significant (NE, SE and CO). SP and TRM are also significant. The coefficient of INDGSP is positive and the same occurs with the coefficient of the interaction term (Equation 3, Appendix 6).

With NONAGR, the best model is the one that uses the proxy PROX. SP and PROXM are not significant in this specifications. NONAGR and YPROXM show positive and significant coefficients.

Both results indicate a tendency for agglomeration of economic activities due to the interaction of economies of scale and lower transportation costs, corresponding to phase II of the model.

Table IV.39 - Best Equations - F test - cross-section - 1950-1970

dependent variable: GR – Brazil

variables	Eq. 3	Eq. 4
	coef t	coef t
Y	0.413 (0.22)	-2.934 (-2.50)
indgsp	0.152 (2.10)	
nonagr		0.106 (3.65)
dd	-0.067 (-1.43)	-0.034 (-2.901)
trm	-22.29 (-3.08)	
ytrm	25.82 (3.76)	
yproxm		250393 (2.83)
Sp	-11.18 (-2.30)	
Ne	-0.243 (-0.11)	-2.554 (-3.57)
se	0.45 (0.27)	-2.107 (-1.90)
co	2.689 (1.72)	1.643 (2.94)

With GRIND, all specifications deny the model.

Conclusion

The cross-section results provide us with a few significant coefficients, especially for the 18-States samples.

Special effects of the Centre-West states (CO) were not explained by our empirical model, while congestion effects were helping to generate a dispersion of economic activity.

Observing the coefficients with t-statistics higher than one and the significant ones, we could arrive at other conclusions. Patterns were found especially observing the performance of CO.

In the first sub-period (1950-1970), the behaviour of the Brazilian states was resembling the second phase of the K&V(m)model. "Backwards and forwards" linkages were generating concentration of economic activities in richer and industrialised states, enhanced by a decrease in transportation costs. For this period, the test of restriction also supports the model and reaches the same conclusion about the phase where the economy would be.

In the second sub-period (1970-1995), although a decrease in transportation cost was favouring richer states, there was a dispersion of activity towards the poor and agricultural states, which still resembles the second phase of the model, since other factors can be impacting on the coefficient of per capita income. For the whole period, there is evidence of concentration of activities due to lower transportation costs. Only NONAGR gave weak support for the importance of "backward and forward" linkages.

The behaviour of the 24-State sample is different. Richer states grew more, although lower transportation cost reduced this effect. We suspect that the presence of the Northern states is influencing these results.

The hypothesis that external economies of scale are important for the distribution of total income is refuted, except in the period 1950-1970.

The pattern of the industrial growth rate for all 18-State samples resembles the 1970-1995 period of the analyses with GRGSP. There was a dispersion of per capita income towards less industrialised and poorer states.

A decrease in transportation cost, on the other hand, was making the coefficient of per capita income less negative, acting in the direction of concentration of industrial activity. Higher industrial growth rates were also associated with higher proximity to richer markets. Congestion effects have also helped the dispersion of industrial activity, while special effects of the CO were not captured by our model.

The 24-State sample highlights the importance of the special effects of the Northern states. It seems that there was a dispersion of industrial activity towards poor and agricultural states. Controlling for INDGSP, congestion effects are important and higher industrial growth rates are associated with high transportation cost. On the other hand, controlling for NONAGR and N, higher industrial growth rates were associated with low transportation cost, and a closer proximity to richer markets was decreasing the advantage of the poor states.

The test of restriction denies all the specifications with GRIND as the dependent variable.