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The growth of cities: Does agglomeration matter?

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THE GROWTH OF CITIES: DOES AGGLOMERATION MATTER? [a,b]

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ABSTRACT: Does agglomeration influence the growth capacity of cities? Would an excessive agglomeration diminish this capacity? In the document the factors determining the growth of Spanish cities from 1981 to 2000 are examined. From recent theoretical approaches, these determining factors are the ones that affect the productivity of the firms, the quality of life for the inhabitants and the availability of land. After developing the theoretical model, the results of the empirical analysis applied to the large cities indicate that the initial conditions of 1981 effectively influence the capacity for growth of these cities. The cities that start with higher levels of population, general economic activity, industrial activity and unemployment and lower levels of technology and surface area present lower rates of economic and demographic growth. Reproducing the analysis for sub-periods (the decades of the eighties and the nineties), it has been demonstrated that, in spite of obtaining similar results, the factors that determine the growth of cities change over time.

Key words: cities, agglomeration economies, growth
JEL Classification: R3, R14, R21, C13.

RESUMEN: ¿Puede el tamaño de una ciudad influir en su capacidad de crecimiento? ¿Podría un tamaño excesivo disminuir esta capacidad? En el presente trabajo se analizan los factores determinantes del crecimiento de las ciudades españolas entre los años 1981 y 2000. A partir de recientes aproximaciones teóricas, se considera que estos factores afectan la productividad de las empresas, la calidad de vida de los residentes y la disponibilidad de suelo. Tras desarrollar el modelo teórico, los resultados del análisis empírico aplicado a las grandes ciudades indican que las condiciones iniciales de 1981 efectivamente influyen en la capacidad de crecimiento de las mismas. Las ciudades que parten de mayores niveles de población, actividad económica, actividad industrial y paro y menores niveles de tecnología y superficie, presentan tasas de crecimiento económico y demográfico menores. Reproduciendo el análisis por subperíodos (la década de los ochenta y la década de los noventa) se ha constatado que, a pesar de obtener resultados parecidos, los factores que determinan el crecimiento de las ciudades se modifican con el tiempo.

Palabras clave: ciudades, economías de aglomeración, crecimiento
Clasificación JEL: R3, R14, R21, C13.

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1. Introduction

In recent years the processes of economic integration and the internationalisation of the economy have conferred greater importance upon the cities as axes of economic growth. In this way cities have progressively gained prominence in regional development policies and have become a key factor in the social and economic wealth of countries.

The role of cities in economic analysis originates in the work begun in the thirties and forties based on evidence that, due to changes in economic conditions, population and productive activity was progressively concentrating in large cities. Nevertheless, it was not until the eighties before more formal analyses appear, mainly applied to the United States, that studied the causes of the unequal distribution of population and economic activity in an area. Numerous contributions, outstanding among which are those of Jacobs (1969) and Lucas (1988), explain the existence of cities, which are understood as demographic and productive agglomerations in small geographical spaces from which they obtain a set of advantages[1]. According to these studies cities offer a set of conditions that increase the productivity of firm and the welfare of their inhabitants (economies of agglomeration). Nevertheless, the larger cities, in as far as they increase in size, begin to present factors that act in the opposite direction and harm the location of residential and economic activity within their areas.

In the present study we analyse the factors determining the growth of Spanish cities. The study is organised in the following manner. In the second section there will be an analysis, starting from the existing economic literature, of the way in which forces of agglomeration and disagglomeration act in such a way that cities arrive at a size at which their growth slows down and, finally, shows negative growth rates. This idea will be illustrated with data from Spanish cities. In the third section the factors identified as determining the growth of the cities, both by the theoretical contributions and by the empirical evidence, will be analysed. These determining factors are defined as the productivity of firm, the quality of life for the inhabitants and the availability of land. The fourth section, following recent studies, carries out an empirical analysis to corroborate whether the growth of Spanish cities follows the patterns mentioned. Specifically, the growth of the large cities in the period 1981-2000 is

[1] Lucas (1988) illustrates this idea by making a reference to the cities of New York and Chicago as follows 'What can people be paying Manhattan or downtown Chicago rents for, if not for being near other people', page 39.

explained in this analysis in relation to the characteristics presented by these cities in 1981. The results are presented in the fifth section and the conclusions in the final section.

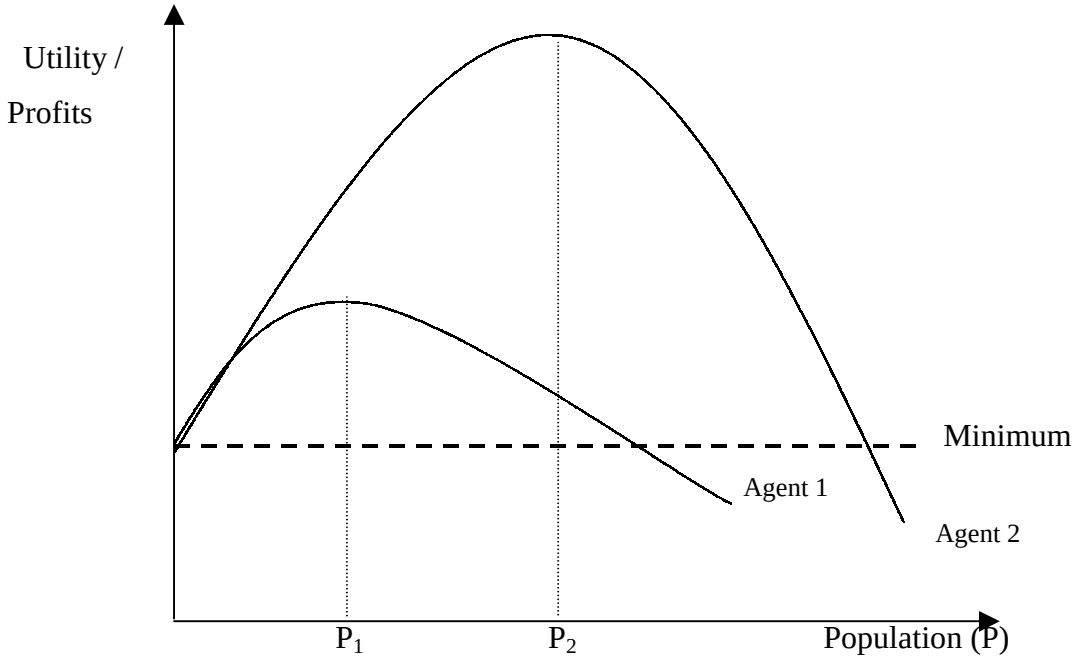
2. The growth of cities: Forces of agglomeration and congestion

The theoretical contributions study the evolution of cities as attractors of population and economic activity departing from the balance of two forces. On the one hand, those of agglomeration, that contain a set of factors that attract economic activity and/or population and, on the other hand, those of congestion (or disagglomeration) that act in the opposite direction. This idea is used by Henderson (1974) when explaining the tension that arises between the economies that favour geographical concentration and the diseconomies caused by the displacement of agents (firms and/or workers) to other areas. The effect of this tension can be represented by an inverted U-formed curve that relates the size of the city and the utility/profit obtained by the representative inhabitant/firm. As shown in Graph 1, initially the utility to the economic agents increases with the size of the population of the cities. Nevertheless, the maximum level of utility is reached at different points, depending on the characteristics of those agents. So Agent 1 reaches maximum utility when the city has a population of P_1 and from that moment on, if the city continues to grow, the utility of that agent will diminish until it arrives at a minimum at which the agent may consider leaving the city and relocating in a city of smaller size.

On the other hand Agent 2 achieves maximum utility at a higher population level P_2 and therefore arrives at a minimum utility in a city of greater size. By way of example, this divergence occurs between economic sectors. Some manufacturing activities may arrive at maximum utility in cities with a volume of population lower than those at which service activities such as the financial sector would arrive[2].

[2] The work of Van Den Berg (1982) puts forward a descriptive model of the cycle of economic growth. Departing from this model there is an initial growth of cities, called the urbanisation process, connected to the stage of industrialisation; in time a saturation arises that provokes sharp growth in the urban periphery, activated by increases in the cost of land. This appears as a suburbanisation process, with the consequent decline in population and certain productive activities.

Graph 1: The growth of cities



Since the nineties these primary approaches have been expanded and improved in the work of other authors who, within the framework of what is called the New Economic Geography, ask questions about the reasons for the agglomeration of economic activity in an area. Outstanding among these are the studies of Fujita, Krugman and Venables (2000), who in numerous contributions attempt to improve previous theoretical propositions, correct the analytical limitations of previous models and include space in their analysis. In fact the predictions of these models note that cities, in time and after periods of high growth, may experience reductions in this growth after a maximum size at which growth will become negative.

At this point, it would seem interesting to ask whether these predictions are true in the case of Spain and whether, therefore, after a period of high growth some big cities have experienced a period of more moderate growth and whether there is a proportion of these that have arrived at, and even passed, their maximum size. These cities would present negative growth rates.

Recently, some authors such as Alonso (1999) and Vázquez Barquero (1999) have studied the dynamics of the Spanish urban structure and have found that the process of urban growth in Spain since the second half of the eighties has followed the patterns pointed to. And therefore

it has had the same experience as cities in more industrialised European countries. Since the seventies a modernisation and restructuring process has taken place in the urban system in Spain that has resulted in an increase in the concentration of productive activity in the big cities. In parallel, the cities have developed in demographic terms as a result of migration that has occurred from the less developed towards the more dynamic regions. As can be seen in Table 1, the Spanish population concentrated in urban areas (those with a population over 20,000 inhabitants) has gone up from 71% in 1960 to 81% in the middle of the seventies, at the end of the period of economic development. Nevertheless, since the second half of the eighties a continuous period of expelling productive activity and population from cities of larger size began. Consequently cities of more than 500,000 inhabitants represent a much lower percentage of the population than in the middle of the seventies.

The demographic growth of Spanish cities has in fact changed significantly in the last twenty years. In some of these cities, the rate of population growth has reached high levels while other cities have experienced considerable loss of population. This very uneven demographic evolution among Spanish cities has changed the distribution of the population by size significantly. Table 1 shows how the six cities of more than 500,000 inhabitants have gone from containing 18.9% of the total national population in the year 1975 to 17.2% currently. On the other hand, the cities with a population between 100,000 and 500,000 inhabitants have gone from being 21.5% of the total national population to 23.1% currently. This evidence indicates a loss of population in the big cities in favour of smaller-sized cities. At the same time, the almost 7,000 smallest centres of population with up to 5,000 inhabitants, that represent 86% of the total of Spanish cities, continue to lose population and only represented 7.5% of the total population in the year 2000.

Table 1: Evolution of city population

	1965		1975		1995		2000	
Inhabitants	Number	%	Number	%	Number	%	Number	%
≤ 2,000	4,440,868	14.5	3,346,110	9.3	3,092,179	7.6	3,053,067	7.5
2,001-5,000	4,406,789	14.4	3,655,189	10.1	3,170,048	7.8	3,134,288	7.7
5,01-20,000	7,781,913	25.4	7,452,905	20.7	8,131,522	20.1	8,138,661	20.1
20,001-50,000	3,027,992	9.9	4,289,796	11.9	5,195,443	12.8	5,609,225	13.9
50,001-100,000	2,442,326	8.0	2,732,561	7.6	4,093,177	10.1	4,241,165	10.5
100,001-500,000	4,160,188	13.6	7,730,613	21.5	9,510,170	23.5	9,368,333	23.1
> 500,000	4,322,860	14.1	6,805,533	18.9	7,267,516	18.0	6,955,052	17.2
TOTAL	30,582,936	100	36,012,707	100	40,460,055	100	40,499,791	100

Source: National Institute of Statistics (INE)

It is important to point out that the urban dynamic may differ among cities. That is to say that cities may coincide in the same economy in which the factors of location of economic and residential activity act to attract firms and population and, also, cities in which urban saturation causes a loss of population and/or firms. As a general rule, the latter type concerns cities of greater relative size. A more detailed analysis of the 56 large Spanish cities (with more than 100,000 inhabitants), shows that very different behaviour exists among them. As shown in Table 2, the demographic dynamics between 1981 and 2000 differ to a considerable degree among these cities. Whilst the national average shows an accumulative annual demographic growth rate of 0.4%, the three large cities with the highest growth rate - Fuenlabrada, Marbella and Móstoles - show much higher growth rates of 6.4%, 4% and 1.6% respectively. On the other hand, the cities with the least growth have experienced negative rates located around 1%. It should also be pointed out that the six Spanish cities with a current population above 500,000 inhabitants present, in all cases, growth rates that are below the national average. More precisely, the annual growth rates of Madrid, Barcelona and Valencia, the three biggest Spanish cities, are negative.

Table 2: Evolution of demography, economic activity and density of the cities (1981-2000)

	Δ Population (1981-00)	Δ Economic activity (1981-00)	Density of population (1981)
5 top cities			
Fuenlabrada	6.4	17.9	2,002.5
Marbella	4.0	1.3	518.7
Móstoles	1.6	4.5	3,333.9
Albacete	1.5	0.4	93.7
Murcia	1.3	1.6	321.2
5 bottom cities			
Bilbao	-1.0	-2.7	10,563.8
L'Hospitalet del Llobregat	-1.0	0.1	21,076.7
Barakaldo	-0.9	-1.0	4,090.2
Sta Coloma de Gramanet	-0.9	-0.2	20,087.6
Barcelona	-0.9	-2.6	17,883.9
Cities average > 100.000inhab.	0.7	-1.1	1,177.5

Source: National Institute of Statistics (INE) and *Spanish Commercial Atlas*

The figures for growth in economic activity are measured by the market share of the city, compiled by Banesto and later by 'La Caixa' in the Commercial Atlas of Spain. This data is obtained from an index that combines various variables of the productive activity of a city and that could be considered a good approximation of the GDP of a city. It should be pointed out that this is the only information available at a local level for cities in Spain in the period

being analysed. The growth in economic activity corroborates the differential behaviour of Spanish cities. The five cities in which the population shows the highest growth rates increase their market share at well above the average rate and, therefore, the economic activity located in them. In the same way the cities with the greatest demographic decreases show increases in economic activity well below the average for the cities as a whole. Finally, it is interesting to see how the cities that lose most population and activity present, in 1981, a population density well above average. This fact, as is mentioned later, indicates that available land is also a determining element in the growth of cities.

3. Determining factors in the growth of cities

Cities increase in size because they are more attractive to the economic agents. So firms prefer to locate in a city the characteristics of which permit them to achieve higher levels of productivity. Similarly, people value residence in a city if the quality of life it offers is good. Finally, the land available in a city is also a determining element in the capacity of the city for growth, given that a greater area means greater possibilities for locating new productive or residential activities at a lower cost. The following presents, firstly, the factors that attract firms to the city, and afterwards the factors attracting residents, and finally the elements that determine the availability of land, and therefore its price.

3.1 Attraction factors for firms

There are a set of factors that explain the concentration of enterprises in urban agglomerations. Firms prefer to be located in urban areas because the characteristics of these areas increase their productivity. The reasons that explain this greater productivity are very diverse and, depending on the economic sector, may influence location with more or less forcefulness. Firstly, the improvement experienced in means of transport has been transformed into lower costs and this allows the location of productive activity at a greater distance from markets, for example, of raw materials. A second factor that explains the concentration of production in cities is the proximity of a market that is larger when the city is larger. According to this idea, already introduced by Krugman (1991), the city means a great concentration of consumers, a fact that makes it more attractive than other locations.

A third factor that makes cities the best alternative for location for firms and that contributes towards the concentration of economic activity is the external economies. Generically, it is understood that external economies are an element that exists in the environment of the production unit which affects the various business parameters - location, productivity[3] and efficiency - through various channels. Marshall (1890) is the first author who distinguishes between economies that depend on the general development of the economy, which he defines as external economies, and internal economies that depend on the internal resources of firms, on their organisation and on the efficiency of their management. To summarise, Marshall (1890) classifies external economies into three categories. Firstly the existence of a complete and specialised labour market that makes an abundant workforce with a good level of training available. In this area, more recent studies have analysed cities as areas with a greater concentration of human capital, a key element in explaining economic growth (Glaeser *et al.*, 1995 and Simon 1998). The second type of external economy consists of the availability of suppliers that allow the firms to obtain the inputs they require that are produced with a high degree of skill. Finally, the third type of external economy is the ease of transmission of information between the economic agents in the area that implies a greater capacity to exchange information about specialised knowledge, intensely and at the least cost, for the firms located in the same city. Various empirical studies have shown the relation between the existence of cities and greater transfer of information using the concentration of patents (as an indicator of innovation) and, specifically, of knowledge (Audretsch and Feldman (1996), Jaffe et al. (1993)).

The use of new technologies is presented as an alternative to the interchange of information in traditional ways and permits communication between firms and agents located in different geographical areas. In recent years a debate has opened up about whether technological external economies - concerned with the distribution of knowledge - develop more efficiently in the same geographical area or, on the contrary, these technologies allow the distribution of information without the need for physical proximity (Antonelli, 1999 and Cohendet *et al*. 1999). If the second hypothesis is correct, part of the justification for economic concentration would no longer make sense and cities, as the traditional points of distribution of knowledge,

[3] Since the seventies a series of studies has appeared, mainly applied to the United States, that examine the determinants of greater productivity, with special emphasis on external economies, of firms located in big cities. Of note among these are those of Kawashima (1975), Sveikaukas (1975) and Ciccone and Hall (1996). In all cases the external economies related to urban agglomerations exert a positive influence on productivity.

would lose this function. Confronted with this possibility, authors such as Audretsch (1998), Gaspar and Glaeser (1998) and Maskell and Malmberg (1999) argue theoretically and empirically that certain contacts between agents make sense only if they take place face-to-face. Therefore the concentration of economic activity in certain geographical areas continues have a clear justification from the point of view of the transmission of informal knowledge between entrepreneurial agents in the area.

3.2 Attraction factors for population

From the point of view of quality of life, the reasons that explain why the population has traditionally preferred to live in cities of greater size have been the advantages that these agglomerations offer as a place of residence. Recently, theoretical and empirical work has appeared that analyses these factors and their modifications in the last few years (Glaeser (1998) and Glaeser *et al*. (2001)). According to these, living in cities means a saving on transport costs resulting from travel from the home to work. Secondly, cities offer a wide range of consumer goods and services that can be supplied by firms or the public sector as the size of the market is sufficiently great. This diversity appears as a greater supply of consumer goods and leisure activities (theatres, cinemas, music and sport). A third reason, of a more sociological nature, is concerned with the younger section of the population and consists of the greater ease of social relations that larger-sized cities offer. Also, the younger population have the opportunity to enter into a higher level of human capital, that may mean a higher salary, through the ease of access to information present in big cities.

These factors, that attract population to the cities of greater size, indirectly favour firm. Workers with a high level of training may be prepared to receive a lower real salary (discounting the greater economic cost of living in a big city, mainly of housing) as they value the non-pecuniary advantages they obtain from the city. Studies have been made along these lines on the relation between the size of cities, the human capital of its inhabitants and salaries paid by firms. Among these, the work of Glaeser and Maré (2001), shows empirically that the salary received by workers in a big city is higher than that received by those employed in a smaller city. These better incomes are attributed to the greater productivity of firms and the greater volume of human capital that workers may acquire in the city. However, once the real salary (that includes the higher cost of living in the city) and the personal

characteristics of the workers are considered, the differences in salaries among the cities gets smaller.

3.3 The availability of land

As was mentioned in the second section, when the size of a city grows continuously it can get to a point at which diseconomies of agglomeration appear. These are understood to be a set of factors that make the city a less attractive location. In general these factors appear as higher levels of pollution, congestion and greater social problems. Also of importance is the increase in the price of land due to the limitations on supply that occur when there is excessive occupation. This increase in the price of land results in more expensive housing and industrial land.

Because of the intensification of these diseconomies of agglomeration, in recent years the big cities have experienced an increase in the trend towards a loss of population and productive activity, and especially manufacturing activities with a greater land use. There are some empirical studies, mainly applied to the US economy, that have studied the diminishing population and productive activity in big cities (Brennan and Hill, (1999) and Glaeser and Khan, (2001)). Among the reasons that explain the phenomenon the price of land, and therefore of business buildings and housing, is of some importance. The smaller the area of the city, the greater is this increase in prices. As a result competition appears between the potential uses that the land may have, converting it into a scarce good and therefore of great value. Intuitively, compared to a city A with an area double that of city B, the first can locate double the activity and population of the second at an identical price of land. However, it must be pointed out that urban policies may vary between cities (green areas, industrial estates, residential districts, etc.) and therefore the availability and the price of land for economic and residential activities depends not only on the area of the city but also on the urban policies that regulate it.

4. The empirical analysis

The factors explaining the growth of cities have been presented in the previous sections. This section presents an empirical analysis of the determinants of growth in large Spanish cities.

The approach used is such that the rate of growth of the cities is a function of their initial characteristics. The variables that measure these characteristics are the three groups of variables dealt with in sections 3.1, 3.2, and 3.3 (the productivity of enterprise, the quality of life of residents and the availability of land). Recently, a series of studies has appeared that, setting out from a model of the growth of cities, examine the factors that influence their greater or lesser population growth. Outstanding amongst these are the studies of Glaeser *et al*. (1995), Eaton and Zvi (1997), Beeson *et al*. (2001) and Glaeser and Shapiro (2001). The model that is estimated in the current work is based on those used in the contributions of Glaeser *et al*. (1992), Glaeser *et al*. (1995), Glaeser (2000), and Glaeser and Shapiro (2001)[4]. The model is developed more extensively in the Annexe.

In the theoretical model the cities are treated as open and sharing common assets of labour and capital. These two factors are considered to be completely mobile. Due to this, their distribution in space reflects a situation of equilibrium in which the return on capital and the utility obtained by workers are equal in all the cities. These assumptions are not totally decisive for the empirical study, but are useful because they allow an interpretation of the results obtained. In the theoretical framework it is considered that the size of a city *i* at the moment *t* (N_{it}) in demographic terms depends on three factors: the characteristics that influence the productivity of firm, (a_{it}), the characteristics that influence the quality of life of the residents (q_{it}) and the availability of building land where new economic or residential activity can be located (t_{it}).

$$\log N_{it} = \alpha_0 + \alpha_1 \log a_{it} + \alpha_2 \log q_{it} + \alpha_3 \log t_{it}$$

In relation to these characteristics, that make a city more or less attractive, the capacity for growth of each city will be different. To go on to an equation for the determinants of growth of a city it is assumed that the evolution of the three factors depends on the characteristics that they present in the initial year.

$$\log a_{it} - \log a_{i0} = X'_{i0}.\Psi + \eta_i$$

[4] A limitation of this approach compared to these studies is that it assumes that the inhabitants live and work in the same city. This assumption could be valid in the United States where the city usually covers a metropolitan area that is clearly defined statistically and which is the equivalent of a local labour market where the inhabitants live and work. In the case of Spain, no specific delimitation of all the metropolitan areas exists anywhere in the territory, and therefore it is not possible to deal with the cities in groups. See Viladecans (2001) for a more detailed analysis of this problem.

$$\log q_{it} - \log q_{i0} = X_{i0}^{'}.\Omega + \mu_i$$

Therefore, as is shown by the above two expressions, increases in the level of productivity and the quality of life of a city depend on a set of variables X_i that may influence it. As can be seen, it is initially difficult to distinguish which of these variables influence productivity, which influence the quality of life and which influence both factors simultaneously. Some of these variables are shown in the empirical development of the model and the reasons for which they may influence one or another factor are explained. The variables that influence the available land in the city are considered to be of a different nature and, as such, they are dealt with separately.

$$\log t_{it} - \log t_{i0} = Y_{i0}^{'}.\Theta + \rho_i$$

Therefore the growth of a city depends on a set of variables that explain the evolution of productivity, the quality of life and the availability of land:

$$\log N_{it} - \log N_{i0} = B^{''} + k.\left[X_{i0}^{'}.(\Psi + \Omega) + Y_{i0}^{'}.\Theta\right] + \upsilon_i$$

Where B'' is a constant and k is a parameter that brings in the importance of the economies of agglomeration and disagglomeration (see Annexe). A high parameter k indicates that the economies of agglomeration are greater. On the other hand, a low parameter k indicates a greater presence of diseconomies of agglomeration. Therefore the effect of initial conditions on the growth of the cities depends on the influence of the economies and diseconomies of agglomeration.

The estimation of the growth of Spanish cities by OLS controlled for heteroscedasticity was carried out from an analysis of 56 large Spanish cities between 1981 and 2000. The dependent variable of the specification will therefore be the rate of growth of the population. This demographic growth will be explained through a set of variables of the characteristics of these cities in the year 1981. The data used for the econometric estimations come from two statistical sources. Firstly they come from the Census and later estimations of population compiled by the INE (National Statistics Institute) that provide the data for population, percentage of the population by level of education, percentage of the population unemployed

and the percentage of industrial employment. Secondly, they come from the Commercial Atlas of Spain that provides a battery of data on a local scale. The data for economic activity shares, telephone lines and surface area come from this second source.

In the first estimation, the explaining variables include the population (Population 1981), the surface area of the city (Area) (as a variable that brings in the greater or lesser availability of building land) and the variable that indicates the level of economic activity per inhabitant of the city (Economic activity/inhabitant 1981). It is to be expected that the coefficients estimated for the population and the economic activity will be negative, given that with starting situations in which the cities have high levels of population and productive activity, problems of congestion could appear that will be transformed into a lower growth rate of the city. Nevertheless, for the area of the city an estimated positive coefficient is expected that would indicate that the more land there is available, the greater is the capacity of the cities for growth.

New variables will be included in a second estimation that, from different directions, could influence the growth of cities. These are industrial employment (% Industry1981), the technological level (Telephones/inhab.1981), human capital (% Higher education1981) and unemployment (% Unemployment1981). Industrial employment is measured as a percentage of total employment and attempts to bring in the idea that cities with a greater presence of manufacturing activities at the initial moment present lower growth given that this type of activity relocates more easily (higher intensity of use of urban land, more ease of transport and less proximity to the consumer market). In this case, industrial employment is a variable directly related to the productivity of firm. However, it is also indirectly related to the quality of life of the city given that the residents could associate a high volume of industry with higher levels of pollution and, therefore, less attractiveness of the city as a place of residence.

Following the work of Gaspar and Glaeser (1998), it is possible to approximate the technological level of a city through the number of telephone lines per inhabitant and it is expected that this variable will positively influence the growth of cities. So it is assumed that cities that in 1981 show a higher ratio of telephones *per capita* will transfer this characteristic into a greater technological development that should be transformed into greater growth. A higher technological level favours the productivity of firm and, complimentarily, is also

related to a higher standard of living, and therefore could be considered an attraction of the city as a place of residence.

The initial level of human capital accumulated in a city - measured as a percentage of the population with higher education - and following the same approach, should positively influence urban growth. Finally, the level of unemployment is included, which brings in mismatches in the labour market, lower levels of skills in the workforce (decisive factors in the productivity of enterprise) and possible social conflict (an element of considerable importance in the quality of life of the residents in a city). The sign of the variable should be negative, indicating a lower level of growth in cities that start with higher levels of unemployment.

In the third and last estimation four dummy geographical variables are added that classify the cities into four groups in relation to whether they belong to the various axes of Spanish economic growth that have developed since the second half of the eighties. The first group consists of the cities located in the Mediterranean Arc and the Axis of the Ebro (Mediterranean) axes of economic growth. A second group selects the cities in the area of Madrid, including the capital (Madrid). A third group is made up of the cities of the Balaeric and Canary Islands (recent examples of economic growth connected to tourism) (Islands). The fourth group is made up of the cities located in the north of Spain characterised, generally, as belonging to regions of lower economic growth in the last twenty years (North). The rest of cities locates in other areas will be the control group in the econometric estimation.

5. Results

The results of the estimation by OLS is shown in Table 3, which includes the results of the estimations of the determinants of growth of the population in cities in Spain in relation to their initial conditions. The first column shows the regression for demographic growth in relation to the initial population, area of the city, and economic activity. The results confirm very clearly that the cities of greater size, more economic activity and smaller area grow more slowly. In the second column the variables that widen the initial conditions are added. The results, with the expected sign, are that: the importance of industry (with a negative sign;

cities with greater initial development in the industrial sector grow more slowly), technological level (with a positive sign) and unemployment (with a negative sign; a higher level of unemployment is transformed into less capacity for growth in the cities) are significant and have the expected sign.

Table.3: Estimation of population growth (1981-2000)

Variable	(1)	(2)	(3)
C	2.718	6.075	4.844
	(2.050)**	(2.992)***	(2.136)**
Population 1981	-0.001	-0.010	-0.017
	(-3.419)***	(-4.603)***	(-4.899)***
Area1981	0.095	0.075	0.077
	(7.356)***	(6.088)***	(6.697)***
Economic activity1981	-0.115	-0.099	-0.051
	(-1.872)*	(-0.819)	(-0.362)
% Industry 1981	--.--	-0.098	-0.093
		(-2.348)***	(-2.235)**
Phone lines /inhab.1981	--.--	0.191	0.151
		(2.229)**	(1.876)*
% Higher education 1981 .	--.--	-0.229	-0.180
		(-1.243)	(-0.930)
% Unempoloyment1981	---.--	-0.149	-0.084
		(-1.969)*	(-0.926)
Mediterranean	--.--	--.--	0.157
			(0.412)
Madrid	--.--	--.--	0.083
			(1.143)
Islands	--.--	--.--	-0.008
			(0.242)
North	--.--	--.--	-0.006
			(-0.229)
R^2	0.45	0.55	0.52
F	15.96***	10.44***	6.38***
N observations	56	56	56

The figures in parentheses are the t-Student tests values. (***) Significant at the 0.01 per cent level; (**) 0.05; (*) 0.10.

Finally, the result for level of human capital is that it is not significant. This result is contradictory to the majority of studies (Glaeser *et al*., 1995 and Glaeser and Shapiro, 2001). The final column includes the geographical dummies in the estimation that, in no case, are significant. This result indicates that belonging to a determined geographical area that is more or less dynamic does not influence the demographic behaviour of the cities.

After this first estimation, it must be taken into account that the database provides information for cities and not for metropolitan areas (a delimitation that would allow a single area of production and residence to be considered). Therefore it may occur that economic activity is located in the city but the workers employed in it may reside in cities in the surrounding area to benefit from, for example, lower land prices. It should be pointed out that

Glaeser *et al*., (1995) and Glaeser and Shapiro (2001) have the same problem and first carry out the analysis for the cities and, secondly, for the metropolitan areas to see whether the results are similar. In Spain it is impossible to find a statistical delimitation for the metropolitan areas. To correct this fact, a second specification is developed in which instead of measuring the demographic growth of the cities the growth of economic activity located in the cities is measured. It is considered that, in this way, it is plausible that the city concentrates productive activity but that the workers live in another city in the surrounding area having experienced what is called the suburbanisation process. In this second specification the dependent variable is the rate of growth of the economic activity of the cities. The explaining variables are the same.

Table 4: Estimation of economic activity growth (1981-2000)

Variable	(1)	(2)	(3)
C	11.574	15.707	14.846
	(8.035)***	(7.216)***	(6.433)***
Population 1981	-0.003	-0.016	-0.016
	(-3.722)***	(-4.590)***	(-4.934)***
Area1981	0.099	0.075	0.086
	(6.208)***	(5.242)***	(6.392)***
Economic activity1981	-0.931	-0.936	-0.966
	(-6.659)***	(-7.353)***	(-6.564)***
% Industry 1981	--.--	-0.130	-0.140
		(-2.891)***	(-2.951)***
Phone lines/inhab1981	--.--	0.181	0.147
		(1.897)*	(1.632)
% Higher education 1981.	--.--	-0.336	-0.144
		(-1.617)	(-0.687)
% Unemployment 1981	---.--	-0.245	-0.177
		(-3.058)***	(-1.839)*
Mediterranean	--.--	--.--	0.942
			(2.321)**
Madrid	--.--	--.--	0.061
			(0.834)
Islands	--.--	--.--	0.033
			(0.735)
North	--.--	--.--	0.138
			(0.415)
R^2	0.83	0.87	0.87
F	89.87***	53.27***	33.31***
N observations	56	56	56

The figures in parentheses are the t-Student tests values. (***) Significant at the 0.01 per cent level; (**) 0.05; (*) 0.10.

The results are presented in Table 4 in three columns. In the first column, in which only the initial values for population, the area of the city and the economic activity are included, all the variables are significant and have the expected sign. Similarly, their explicative strength is well above that of the previous specification given that the coefficient R^2 is situated at 83%. In the second estimation, that includes the rest of the initial conditions, industrial

employment, telephone lines *per capita* and unemployment are significant. Therefore economic activity grows less in those cities that in the year 1981 showed a greater proportion of industrial employment, a higher level of unemployment and a smaller proportion of telephone lines. Finally, the inclusion of geographical dummies in the third estimation improves the previous estimations given that the variable for the cities of the Mediterranean Arc is significant. This result indicates that these cities have a greater capacity for economic growth than the rest.

The results of this second specification confirm the influence of the initial characteristics of cities on their growth in terms of economic activity. Similarly, the comparison of the coefficients obtained for both specifications concludes that the cities expel more economic activity than population. More specifically, those cities that start with higher levels of economic activity, with a higher proportion of industrial activity and a higher level of unemployment are those that expel the most economic activity. Finally it is interesting to analyse whether the results obtained in order to explain the growth of cities (through the population as well as economic activity) in the period 1981-2000, are maintained for both decades if they are analysed separately. The possibility is therefore considered that some of the explaining factors for the dynamics of the cities could have had a strong influence in the eighties coinciding, in part, with an economic, and especially industrial, recession, to reduce this influence in more recent years. To highlight this possibility, both specifications are estimated again but for the period 1981-1991 and, secondly, for the period 1991-2000. In the first case the initial year in which the explaining variables are taken is 1981 and the dependent variables are the rate of growth of the population and the economic activity between 1981 and 1991. In the second case, the dependent variables are calculated between 1991 and 2000 and the initial year is 1991. These estimations for sub-periods, that must allow the coefficients of the explaining variables to vary, will show whether the patterns of growth of the cities change over time.

Table 5 shows the results of the estimations referring to population growth in cities in the eighties and the nineties. In spite of the fact that, in general terms, the results coincide between both decades and, in turn, are similar to the results previously obtained for the whole of the period 1981-2000, some aspects must be pointed out that indicate that the patterns of demographic growth of the cities has varied between the two decades.

Table 5: Estimation of population growth for periods

	(1991-81)		(2000-1991)	
C	1.174	0.890	3.835	2.261
	(1.976)*	(1.471)	(2.960)***	(1.506)
Population	-0.009	-0.012	-0.004	-0.051
	(-3.648)***	(-3.870)***	(-4.982)***	(-4.922)***
Area	0.016	0.014	0.005	0.056
	(2.436)***	(3.046)***	(10.273)***	(10.086)***
Economic activity	-0.064	-0.048	0.076	0.154
	(-2.293)**	(-1.681)	(1.769)*	(2.445)***
% Industry	-0.028	-0.035	-0.048	-0.021
	(-2.359)**	(-2.654)***	(-2.505)***	(-1.000)
Phone lines/inhab.	0.051	0.037	0.245	0.198
	(1.388)	(1.076)	(2.992)***	(2.416)**
% Higher education	-0.026	-0.035	-0.243	-0.217
	(-1.375)	(-0.565)	(-2.876)***	(-2.303)**
% Unemployment	-0.056	-0.022	-0.064	-0.026
	(-2.076)**	(-1.875)*	(-1.536)	(-0.549)
Mediterranean	--.--	0.011	--.--	-0.008
		(0.689)		(-0.433)
Madrid	--.--	0.033	--.--	0.050
		(1.196)		(1.694)
Islands	--.--	-0.022	--.--	0.047
		(-0.960)		(2.446)***
North	--.--	-0.001	--.--	-0.014
		(-0.116)		(-0.783)
R^2	0.47	0.51	0.65	0.65
F	6.240***	5.110***	13.092***	10.131***
N observations	56	56	56	56

The figures in parentheses are the t-Student tests values. (***) Significant at the 0.01 per cent level; (**) 0.05; (*) 0.10.

With regard to the population variable, it can be observed that in the last decade the effect of population in the initial year is smaller. This fact could indicate that since the nineties there is already a volume of smaller-sized cities that may be losing population. The initial area variable obtains higher coefficients in one of the estimations for the last decade and, therefore, it seems that the effect of crowding the land could have become more serious in recent years. In the same way, the variable that brings in the effects of technology is significant in the last decade, indicating that the influence of technology on population growth in cities has increased in recent years. The coefficients of the variable economic activity vary considerably. While in the first decade this variable negatively influences population growth, in the last decade the sign becomes positive. The variable for the importance of industry is significant and negative (as occurs with the period as a whole), but it is not significant in one of the estimations for the last decade. This fact could show the effect of the industrial crisis in the eighties. This result is reproduced in the variable of unemployment. The human capital variable is not significant in the first ten years and becomes so in the last ten, though obtaining the opposite sign to that expected. As regards the dummy variables, it is shown that cities located in the Islands experience greater demographic growth.

The estimations that analyse the growth of economic activity for the two decades also confirm a variation in the patterns of growth of the cities between the two periods (Table 6).

Table 6: Estimation of economic activity growth for periods

	(1991-81)		(2000-1991)	
C	21.275	24.085	10.002	9.935
	(5.226)***	(6.484)***	(6.701)***	(5.255)***
Population	-0.005	-0.035	-0.053	-0.064
	(-1.912)*	(-1.514)	(-4.584)***	(-5.119)***
Area	0.026	0.045	0.060	0.0.64
	(0.694)	(1.230)	(6.794)***	(7.617)***
Economic Activity	-1.118	-1.445	-0.614	-0.574
	(-4.630)***	(-5.086)***	(-13.394)***	(-7.817)***
% Industry	-0.307	-0.399	-0.031	-0.016
	(-3.341)***	(-3.726)***	(-1.448)	(-0.664)
Phone lines/inhab.	0.284	0.336	0.142	0.124
	(1.296)	(1.796)	(1.538)	(1.351)
% Higher education	-0.736	-0.373	-0.188	-0.095
	(-1.655)	(-0.802)	(-1.755)	(-0.765)
% unemployment	-0.457	-0.473	-0.111	-0.052
	(-2.706)***	(-2.734)***	(-2.379)**	(-0.949)
Mediterranean	--.--	0.249	--.--	0.029
		(3.366)***		(1.155)
Madrid	--.--	-0.138	--.--	0.061
		(-1.073)		(1.908)*
Islands	--.--	0.025	--.--	0.065
		(0.296)		(2.129)***
North	--.--	0.120	--.--	-0.020
		(1.421)		(-0.895)
R^2	0.73	0.76	0.83	0.86
F	18.981***	13.967***	39.778***	31.076***
N observations	56	56	56	56

The figures in parentheses are the t-Student tests values. (***) Significant at the 0.01 per cent level; (**) 0.05; (*) 0.10.

In this case there is a notable increase in the coefficient of the population variable in the nineties. This means that in populations of a greater size economic activity grows less. This fact indicates that the loss of activity could have sharpened in recent years. Similarly, as occurs in the analysis of population growth, the area increases its negative effect on the growth of economic activity in the cities. In one of the estimations for the most recent years, unemployment ceases to be significant as a variable that influences the growth of economic activity located in the cities. Finally, with regard to the dummy variables, it can be seen that the cities in the areas of Madrid and the Islands experience higher growth in economic activity.

6. Conclusions

In the present study the factors determining the growth of cities have been analysed departing from a theoretical approach and an empirical estimation applied to the growth of large Spanish cities between the years 1981 and 2000. With regard to the theoretical approach, it is considered that the growth of a city depends on three factors: 1) the level of productivity that firms can achieve; 2) the quality of life in the city that makes it attractive to the residents; and 3) the availability of land that allows new residents and firms to locate in the area. These three factors are influenced by a set of characteristics of the cities that make them more or less attractive (external economies and the supply of goods and services, among others).

After developing the theoretical model, the empirical analysis applied to the large Spanish cities considers that the rate of growth of the population depends on the initial level, in this case 1981, that these characteristics present. The initial characteristics considered are population, the area of the city, economic activity, the importance of industry, the education of the population, the level of technology and unemployment. Dummy variables are introduced that bring in the location of the cities on the various axes of growth that there have been in the Spanish economy since the middle of the eighties. The results of the analysis indicate that, in the majority of cases, these initial conditions effectively influence the capacity for growth of Spanish cities. More precisely, the cities that start with higher levels of population, economic activity, industrial activity and unemployment and lower levels of technology and surface area present lower rates of demographic growth.

This first analysis referring to the growth of cities in demographic terms is complemented with a second specification in which the growth of the cities is measured on the basis of growth of economic activity. In this way a possible problem in the database that contemplates cities and not metropolitan areas is corrected. Because of this the database does not cover an integrated economic area and excludes the possibility of the existence of a large city surrounded by other smaller-sized cities that may attract economic activity and population. Therefore the possibility that increases in economic activity and population may behave differently is considered. The results of this second specification confirm the influence of the explaining variables at the initial moment on the growth of the economic activity located in the city. Cities with greater population, economic activity, industrial activity and unemployment and a smaller surface area experience greater losses of economic activity.

Finally, repeating the analysis for sub-periods (the decades of the eighties and the nineties), it has been demonstrated that, in spite of obtaining similar results, the factors that determine the growth of cities change over time. This result coincides with the majority of similar studies. The differences are mainly concerned with a smaller influence of variables referring to the importance of industry and the level of unemployment on the growth of cities. Apart from this, in recent years, a limited availability of surface area considerably accentuates its negative effect on the growth of cities.

Annexe: A model of city growth

The model that provides the basis for the empirical work carried out in Section 4 is presented in this Annexe. This approach is based on previous work by Glaeser (1992), Glaeser *et al*. (1995) and Glaeser *et al*. (2001). Some small differences in respect to these previous studies consist in considering the existence of economies of agglomeration in production (and not only in consumption) and in endogenizing the process of forming the price of urban land (thereby including an additional type of diseconomy of agglomeration). This said, the empirical specification derived is very similar to that presented by the authors mentioned.

In the model cities are treated as open and sharing common resources of labour and capital. These two factors are considered to be totally mobile. Due to this their distribution in space reflects an equilibrium situation in which the returns from capital and the utility obtained by the workers are the same in all the cities. These assumptions are not totally decisive for the empirical work, but are useful because they allow an interpretation of the results obtained. The various parts necessary for building the base (i.e. the functions of production, utility, the labour market and the land market) are presented below.

Production

Due to the assumptions of the perfect mobility of capital and labour, the differences in urban growth cannot be due to differences in the rate of saving or exogenous resources of the labour factor. The production of the city, therefore, can be expressed simply as:

$$A_{it}.L_{it}^{\sigma}.S_{it}^{\gamma} \qquad (1)$$

Where A_{it} is the level of productivity of the city i in the year t, L_{it} and S_{it} are the resources (endogenous) of the labour and land factors of the city i in the period t. With the object of simplifying the development of the model, it is supposed that the quantity of land per worker is the same in all the cities; that is $S_{it}/L_{it}=s_t$. Although this supposition is rather restrictive, it is totally innocuous as regards the objectives of the study. It is also supposed that the productivity of the city depends on the number of workers in it; that is: $A_{it}=a_{it}.L_{it}^{\alpha}$.The parameter α reflects the importance of the economies of agglomeration in production. Taking these considerations into account the expression (1) is transformed into:

$$a_{it}.L_{it}^{(\sigma+\gamma+\alpha)}.s_t^{\gamma} \qquad (2)$$

Utility

The utility of a worker residing in the city is equal to:

$$U_{it} = \frac{W_{it}.Q_{it}}{P_{it}} \qquad (3)$$

Where W_{it} is the salary, P_{it} is the level of prices in the city, and Q_{it} is an index of the quality of life that brings in all the attractions that the city has for individuals (e.g. climate, public services). It is supposed that the index of the quality of life is also related to the size of the city; that is $Q_{it}=q_{it}.L_{it}^{-\beta}$. This specification is that used by Glaeser *et al*. (1995) and presupposes that the quality of life diminishes as the size of the city increases. Nevertheless, some positive effects on the quality of life can also be expected from the size of the city, as was later recognised in Glaeser *et al*. (2001), for which reason it is the empirical analysis that should provide information about the sign and the intensity of this effect.

The level of prices P_{it} is represented by an index composed of the price of land (R_{it}) and the price of the rest of consumer goods, and that is considered to be equal for all the cities. Substituting this expression in (3) and taking logarithms, obtains:

$$\log U_{it} = \log W_{it} + \log Q_{it} - \theta.\log P_t - (1-\theta).\log R_{it} \qquad (4)$$

If it is supposed that the labour factor is completely mobile, its spatial distribution will then be in equilibrium if the utility that a worker can obtain is the same whichever city they reside in. That is, for the two cities *i* and *j* it is true that: $\log U_{it}$-$\log U_{jt}$=0. Therefore from (4) it can be obtained that:

$$\underbrace{(\log Q_{it} - \log Q_{jt})}_{\text{quality of life advantage}} = \underbrace{(\log W_{jt} - \log W_{it})}_{\text{salary disadvantage}} - \underbrace{(1-\theta).(\log R_{jt} - \log R_{it})}_{\text{price of land disadcantage}} \qquad (5)$$

Expression (5) indicates that in equilibrium the advantages (relative) of residing in a city (derived from a good quality of life) are exactly balanced by a combination of lower (relatively) nominal salaries and/or (relatively) higher land prices.

Labour market

Given that the labour market of a city is assumed to be in equilibrium, the salary of a new worker arriving in the city should be equal to the marginal productivity of labour. That is:

$$W_{it} = (\sigma + \gamma + \alpha).a_{it}.L_{it}^{(\sigma+\gamma+\alpha-1)} \qquad (6)$$

Land market

The market for land should also be in equilibrium. Demand for land is divided into residential demand and productive demand. In both cases it is supposed that the consumption of land per worker is constant, s_t being the consumption of productive land per worker and c_t the consumption of residential land per worker. It is considered that the supply of land depends on the quantity of building land available in the city (t_{it}) and its price (R_{it}). In this way the equilibrium of the land market can be expressed as:

$$(s_t + c_t).L_{it} = t_{it}.R_{it}^{\xi} \qquad (7)$$

Finding the value of R_{it} in (7) obtains:

$$R_{it} = (s_t + c_t)^{(1/\xi)}.L_{it}^{(1/\xi)}.t_{it}^{-(1/\xi)} \quad (8)$$

This simple specification tells us that the price of land will increase with the number of workers that there are in the city and with an increasing intensity of the use of land for industrial and residential purposes, and that it will decrease when an increasing quantity of building land is available in the city.

The size of the cities

Substituting the expressions for salary (6) and land prices (8) in the function for utility (4) obtains:

$$\log U_{it} = B_t + (\sigma + \gamma + \alpha - \beta - \varepsilon - 1).\log L_{it} + \log a_{it} + \log q_{it} + \varepsilon.\log t_{it} \quad (9)$$

$$\text{where } \log B_t = \log(\sigma + \gamma + \alpha) - \varepsilon.\log(s_t + c_t) - \log P_t$$

and where $\varepsilon=1/\xi$. . Assuming that now there is spatial equilibrium and that, therefore, workers must obtain the same utility in all of the cities ($\log U_{it}=\log U_t$) and also that the population of a city is equal to a constant proportion of its workforce ($N_{it}=z.L_{it}$; see Glaeser et al., 2001), obtains:

$$\log N_{it} = B_t + \kappa.[\log a_{it} + \log q_{it} + \varepsilon.\log t_{it}] \quad (10)$$

where $\kappa=(1/(1+\beta+\varepsilon-\sigma-\gamma-\alpha))$, and

$$B_t = (1/\kappa).(\log(\sigma + \gamma + \alpha) + (\sigma + \gamma + \alpha - \beta - \varepsilon - 1).\log z - \varepsilon.\log(s_t + c_t) - \log P_t - \log U_t)$$

Expression (10) indicates that the size of the city is positively correlated to its productivity (a_{it}), its quality of life (q_{it}) and the quantity of existing building land (t_{it}). The impact of these factors on the size of the city is modified by the size of the multiplier $\kappa=(1/(1+\beta+\varepsilon-\sigma-\gamma-\alpha))$ Observe that this multiplier diminishes when the parameters associated with diseconomies of agglomeration increase (β y ε) and increases when the parameters associated with economies of agglomeration increase (σ, γ y α).

The growth of cities

Expression (10) is used with the object of specifying a function of the determinants of the growth of cities. To do this, following Glaeser *et al*. (1995), it is assumed that each city has a set of K initial characteristics, written as $X_{i0}^{1},...,\ X_{i0}^{k},...,X_{i0}^{K}$, that determine the future development of productivity (a_{it}) and the quality of life (q_{it}). The vector that includes these characteristics is denominated X_{io} and the vectors of the parameters are denominated Ψ and Ω. We can then write:

$$\log a_{it} - \log a_{i0} = X_{i0}^{'}.\Psi + \eta_i \qquad (11a)$$

$$\log q_{it} - \log q_{i0} = X_{i0}^{'}.\Omega + \mu_i \qquad (11b)$$

η_i and μ being terms for error with the usual properties. It can also be considered that the rate of growth in the quantity of building land is related to the value of a vector of variables Y_{io} at the beginning of the period (e.g. the area of the municipality):

$$\log t_{it} - \log t_{i0} = Y_{i0}^{'}.\Theta + \rho_i \qquad (11c)$$

being Θ a vector of parameters and ρ_i the term for error. Subtracting $\log N_{io}$ in (10) and substituting (11) obtains the equation of the determinants of growth of cities:

$$\log N_{it} - \log N_{i0} = B^{''} + \left(\frac{1}{1+\beta+\varepsilon-\sigma-\gamma-\alpha}\right)\left[X_{i0}^{'}.(\Psi+\Omega) + Y_{i0}^{'}.\Theta\right] + \upsilon_i \qquad (12)$$

being υ_i the term for error. The equation (12) tells us that the rate of growth of a city will be related to the values of the variables included in the vectors X_{io} and Y_{io} . However, the specification does not consider that it is possible to determine whether a specific variable influences the growth of the population through its effects on productivity and the quality of life. The specification does presuppose, nevertheless, that it is possible to distinguish between the effects on the supply of building land in the city and the effects on productivity and the quality of life.

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