

ESTUDIOS SOBRE LA ECONOMÍA ESPAÑOLA

**Does Public Spending Give Rise to Growth in
Spain's Regional Per Capita Income?**

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EEE 115

October 2001



<http://www.fedea.es/hojas/publicado.html>

ISSN 1696-6384

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**Does Public Spending Give Rise to Growth in Spain's Regional Per Capita
Income?**

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ABSTRACT

A model for explaining regional per capita income has been constructed in this paper. Two types of variable have been used: territorial and non-territorial. One of the non-territorial variables that has been introduced in the model, for the purpose of checking Aschauer's hypothesis, is public capital stock. This capital stock has also been broken down into its different components in order to determine which of them has a major impact on economic growth.

Spatial Econometric techniques have been used in this paper because of the existence of spatial dependence in regional per capita income.

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0. INTRODUCTION

During the last decade many region-based studies have been carried out, owing to the importance of space when explaining certain economic aspects. In the case of Spain, due to the public sector's recent decentralization, it is very important to understand the spatial factors of economic growth in order to determine how this has affected different territories.

Most of the models that deal with economic growth employ the neoclassical production function in order to determine the impact of each production factor on income growth. This paper leaves out this neoclassical function and tries to construct an explanatory model on the basis of two types of variable: "territorial" and "non-territorial". As is well known, most of the regions with a strong growth in income are located close together. Therefore distance may play an important role in explaining certain economic processes that cause economic growth. Spatial econometric techniques have been used in order to take into account this phenomenon, which is known as spatial dependence.

Therefore, the aim of this paper is to establish those factors that have a positive effect on economic growth. One of the factors included in the model is public capital stock, for the purpose of checking whether Aschauer's (1989c)¹ proposal for the Spanish economy is true.

The paper has been structured in four parts. The first part contains an explanation of the theory on which the model is based, in the second part the need to use spatial econometric techniques has been briefly justified, in the third part the model is tested and in the final part the article's main conclusions have been discussed.

1. THEORY

In order to identify those processes that lead to economic growth, a distinction has been made between events that only occur in places with a high concentration of resources (territorial variables) and those events that occur in the same location, irrespective of the concentration of resources (non-territorial variables).

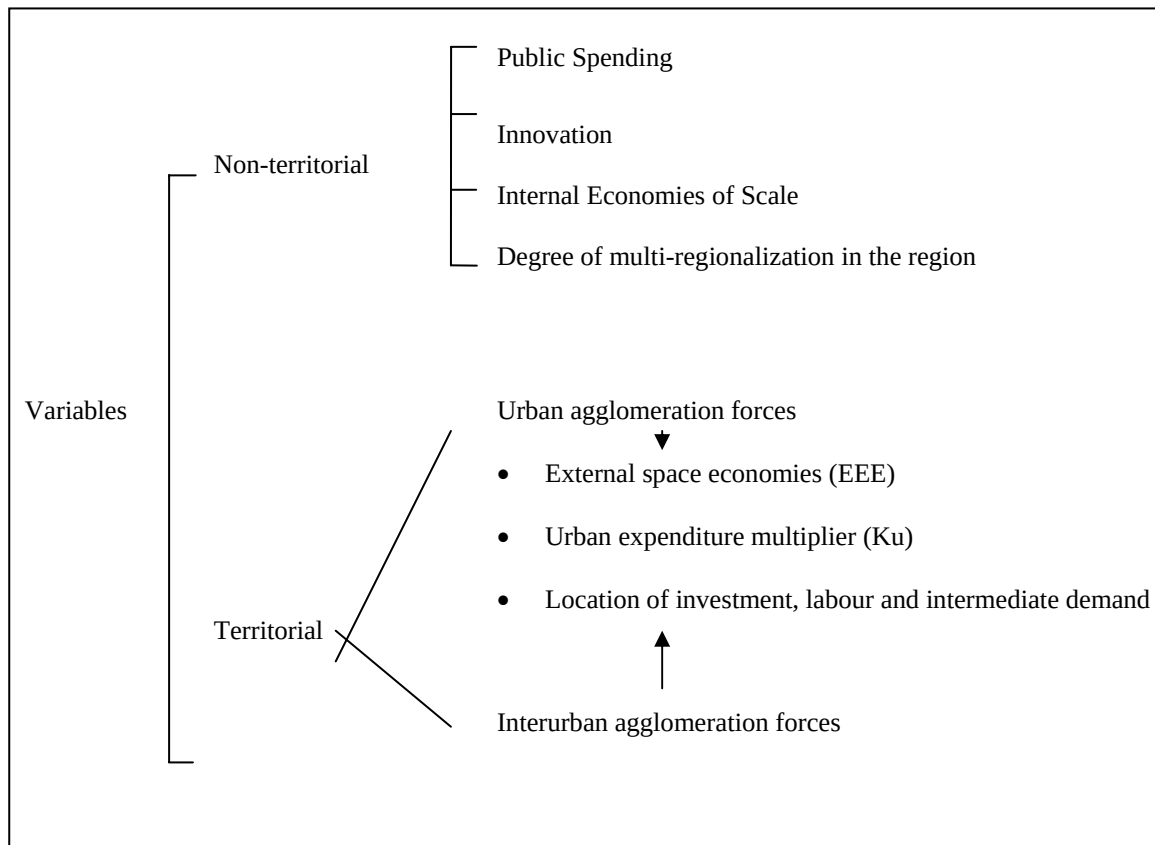
A distinction has also been made between two types of territorial variable: *Urban Agglomeration Forces (FAU)* and *Interurban Agglomeration Forces (FAI)*. Both represent the same process; the only difference between them is that whilst the first act within a single agglomeration of resources, the second interact between two or more concentrations of resources. The processes as reflected in these concepts are *External Space Economies* on the supply side and *Urban Expenditure Multiplier* and *Locational Inertia of Investment, Labour and Intermediate Demand* on the demand side.

¹ Aschauer (1989) established a positive relationship between public spending levels and the economic growth rate.

Four non-territorial variables have been considered: innovation, internal economies of scale, the existence of multi-regional enterprises in the region, and the level of public capital stock, in order to verify Aschauer's (1989c) hypothesis.

The theory is summarized in Chart No. 1.

Chart No. 1



Not all these processes are going to be discussed since all the non-territorial variables have been extensively developed in previous literature². However, a definition will be provided of what has been termed territorial variables, in order to demonstrate their positive effect on economic growth.

*External Space Economies*³ are growths in profit experienced by firms as a consequence of being located close to other established firms. The advantages can be quantified in terms of the sharing of common suppliers, proximity to a highly qualified labour supply, the common use of specific public services, etc. All these factors will increase profits, which can then be invested, giving rise to economic growth through the Keynesian multiplier effect.

Urban Expenditure Multiplier is the differential expenditure that appears as a consequence of the concentration of resources. This process is related to the appearance of local goods and services. These

² For an extensive analysis vid Doctoral Thesis Gómez (2001)

³ Vid Costa and Callejón (1996)

are goods and services that are only produced and/or demanded in certain places either naturally or for socio-economic reasons. The existence of this type of goods will have an impact on demand, so once again economic growth will take place through the Keynesian multiplier effect.

The last territorial phenomenon is *Locational Inertia of Investment*⁴. This process reflects the tendency of firms to continue to invest in the same places. This happens because in oligopolistic economies, such as those in developed countries, production capacity is not always completely utilized. When firms decide to invest, they search for the most profitable place to develop and this will be the same place where they have already invested so that previously unutilized capacities can be taken advantage of.

2. SPATIAL ECONOMETRIC TECHNIQUES

When working with spatial data, spatial econometrics must be used due to the appearance of two phenomena: spatial dependence and spatial heterogeneity.

Spatial Dependence is understood to mean the relationships that exist between different places, as stated by Tobler (1979) in the first law of geography:

“All things are related, but closer things are more related.”

Spatial Dependence is the main reason for utilizing these techniques⁵ because, of course, spatial heterogeneity can be solved with the use of conventional econometric techniques. The problem is that it is not always easy to distinguish between spatial dependence and spatial heterogeneity because tests do not differentiate between them with sufficient accuracy. In this paper, only the existence of spatial dependence will be taken into account because spatial heterogeneity is a well-known phenomenon in conventional econometrics.

Spatial Dependence appears for two reasons, the reality of the process under study and the use of spatial data in the analysis.

In connection with the first source, the reality of the process under study, it has been found that in practice there are interaction, dispersion, diffusion and exchange processes that make things relate in different places. In the case in question, it is seen that regions with high per capita income are located close together, as are regions with a low per capita income. So it can be concluded that some interactions affecting economic growth are being produced between adjoining regions. Spatial Dependence tries to reflect these interactions.

⁴ Vid Bueno (1990)

⁵ For an extensive analysis vid Anselin L. (1988)

Regarding the second source, the use of spatial data, it is sometimes found that data is collected on an aggregate scale. Often there is a small relationship between the scale at which data is collected and the spatial scope of the phenomenon being studied. This idea is reinforced by the arbitrary delimitation of the space. This delimitation also gives rise to spatial dependence because some observations that should not be collected in the primary unit of observation may be collected, and some observations that should be included may be left out. This particularly refers to observations that are near a border. This border is implemented by social, economic, historical or political factors but not by the spatial spread of the phenomenon being studied, which in this case is per capita income.

Spatial dependence can be considered to be similar to time dependence, but it is different in the fact that spatial dependence is multidirectional and time dependence is bi-directional. Therefore, a matrix must be used to link all the regions together⁶.

Whenever spatial dependence is found, spatial econometric techniques must be used. This phenomenon can be found in the case of per capita income. It has been detected that high per capita income regions are located close together and therefore it can be concluded that there must be some relationship between neighbouring regions. If the aim is to construct a model to explain per capita income, spatial dependence must be taken into account.

Many models have been developed for the purpose of analyzing this spatial dependence. In this paper an auto-regressive model instead of a moving average model has been used because although the results are similar the mathematical expressions in the former are easier.

When using an auto-regressive model, a distinction has to be made between a *Spatial Lag* model and a *Spatial Error* model. From a theoretical point of view a Spatial Lag Model is preferable because it models spatial dependence on the dependent variable whereas the Spatial Error model models it on residual terms, and these terms can be influenced by many other factors, not only spatial dependence.

3. CHOICE OF INDICATORS

As previously mentioned in the theoretical section, this model explains per capita income using two kinds of variable: territorial and non-territorial. One auto-regressive variable has also had to be included in order to take into account the phenomenon of spatial dependence present in per capita income. This variable is constructed by multiplying a weight matrix by the vector of regional per capita income. To measure per capita income the VAB at market prices was taken and divided by the regional population in order to reach the per capita values⁷.

⁶ The choice of this matrix will be very important because the results of the models are very sensitive to the matrix utilized. In this paper the inverse matrix of an inter-regional distance matrix has been chosen in order to reflect the phenomenon described in the theory of Interurban Agglomeration Forces.

⁷ When the econometric analysis was started, heteroskedasticity problems were encountered, so the square root was extracted to the per capita income. Data were obtained from the BBVA Foundation because it is the only institution that provides a measure of the public capital stock for the Spanish regions.

There were two alternatives when selecting the weighting matrix. A first order binary geographical contiguity matrix could be used. The elements of this matrix will be one when regions have a common border and zero if there is no shared border between them. The problem is that this matrix does not take into account the border's length and it can be assumed that the longer the border the greater spatial dependence will be. In order to improve this limitation a distance weighting matrix was constructed and its inverse was calculated in order to obtain a positive correlation between the auto-regressive and dependent variables. This means that the nearer the regions are, the more similar the per capita income will be.

Having selected the weighting matrix, the indicators for the non-territorial and territorial variables then had to be determined. With reference to the territorial variables, a global indicator that reflects Spatial Externalities, Urban Expenditure Multiplier and Location Investment had to be found because if an indicator were to be included for each individual process multiple co-linearity problems would arise. Therefore, an indicator had to be found that reflects the existence of an agglomeration. A wide variety of indicators was tested, as follows: towns with a population in excess of 20,000 people, the number of automobiles divided by the number of kilometres of highway, the flow of flight passengers divided by the population, buildings with 5 or more floors divided by the number of main houses, hotels with more than 4 stars divided by the total number of hotels, first-class restaurants divided by the total number of restaurants, etc. It was found that the indicator that best reflects the existence of an agglomeration was buildings with 5 or more floors divided by the number of main houses⁸ (A5).

Two indicators were used to measure the impact of non-territorial variables: the mean size of the firms in the region and public capital stock. The mean size of the firm was obtained by dividing the VAB by the number of active establishments. Another indicator could have been obtained using Labour in places with more than 100 workers instead of VAB, but in this case the difference in productivity that exists between different jobs is not reflected. A firm's size has a positive correlation with the appearance of innovation, the number of multi-regional firms and the existence of economies of scale. It is mainly in the larger enterprises where this process tends to occur⁹. Also included in the model is an indicator of public regional capital stock¹⁰. In the last section of this article this indicator has been broken down into its different types of infrastructure. First, productive and social infrastructures have been considered and roads, water, ports, airports, urban infrastructures, health and education were also examined in order to determine their impact on economic growth.

When deciding between different indicators, mainly the proposed economic theory was used although some descriptive statistics, such as the cross-correlation of each indicator with the dependent variable, were also used.

⁸ Data were taken from the Censo de Viviendas (Housing Count) (INE).

⁹ To construct this indicator VAB data from the BBVA and data from the Censo de Locales y Edificios (Buildings and Commercial Premises Count) (INE) were used.

¹⁰ Public capital stock were obtained in constant 1986 prices, so changes had to be made to the VAB series in order to work with homogeneous series.

Thus, the final model is the following:

$$R_{pc} = \rho W r_{pc} + \beta_1 TM + \beta_2 A5 + \beta_3 \text{Public Capital Stock}$$

where R_{pc} is the per capita regional income, TM the mean size of the enterprise and $A5$ the agglomeration variable.

4. THE MODEL

The model's layout was started by making an exploratory analysis in order to demonstrate whether or not the process of Spatial Dependence is present in per capita income, as seen in the theory, and to demonstrate whether this spatial dependence can be modelled by using an auto-regressive model.

4.1 EXPLORATORY ANALYSIS

As a consequence of using lineal auto-regressive models, it was necessary to establish whether it is possible to model per capita income by using a linear mathematical function and also whether or not the dependent variable suffers from any auto-regressive processes. Therefore, some dispersion graphics and autocorrelograms¹¹ had to be constructed.

The model was laid out for two sets of data: data from a recession year (1981) and data from an expansive year (1991), in order to determine if these territorial and non-territorial processes explain economic growth irrespective of the phase of the economic cycle in progress.

A) Spatial Dependence

The first step in the exploratory analysis consisted of establishing whether or not spatial dependence appears in the per capita income of Spain's regions. It had been seen that in the theoretical analysis this phenomenon was present, so now it had to be demonstrated that it is present when carrying out an empirical analysis. With this objective the spatial dependence tests developed by Moran and also the test developed by Geary¹² were used.

The results shown in Table No. 1 are positive, reflecting the existence of positive spatial dependence. The interpretation of these tests is the opposite. In order to establish positive spatial dependence, Moran's test must have a bigger value than the mean and Geary's test must have a value for the statistic that is smaller than the mean. Thus, as can be seen in the Table, there is positive spatial autocorrelation for both data sets. This means that regions with high per capita income are located next to

¹¹ These graphs have not been included but the results that they offered were positive, indicating that per capita income can be modeled using this lineal auto-regressive model.

¹² In order to apply this test the utilization of a weighting matrix is needed. As mentioned above, the inverse of a distance-weighting matrix was used.

regions with high per capita income, and the same occurs in the case of regions with low per capita income.

Table No. 1: Spatial Dependence Tests

	I Moran	Mean	C Geary	Mean
1981	0.157067	-0.020	0.807160	1.00
1991	0.195333	-0.020	0.758508	1.00

If the Moran Test dispersion plot is constructed, this proof can be evaluated as demonstrated in the next section.

B) Dispersion Plot for Moran's Test

B.1) 1981 Data Set

The results obtained, as shown in Figure No. 1, establish a clear spatial association with the dependent variable. Regions with high per capita income are located in the north-east of Spain, so spatial dependence is clearly positive, as was determined by the spatial autocorrelation tests. However, spatial dependence is not 100% positive because, as shown in Figure No. 1, there are regions above the line dividing high per capita income areas from low per capita income areas that have no positive spatial dependence, as can be seen from the fact that they are not surrounded by regions with a similar level of per capita income. This is the case of Burgos, Soria and Cuenca, which are regions with low per capita income surrounded by regions with high per capita income. At the same time, Oviedo, Valladolid, Madrid, Alicante and Majorca are regions with high per capita income surrounded by regions with low per capita income.

Figure No. 1: Dispersion Plot for Moran's Test (1981 Data Set)



B.2) 1991 Data Set

Positive spatial association is maintained when the 1991 data set is used, as shown in Figure No. 2. In this case some regions that do not follow the positive spatial dependence pattern can be found. This is the case of Burgos, which changed from being a low per capita income region to a high per capita income region in 1991. On the other hand, Gran Canaria, Tenerife, Asturias, Palencia, Oviedo and Cantabria changed from being considered high per capita income regions to low per capita income regions. All these changes are near in space and do not invalidate the hypothesis of positive spatial dependence.

Figure No. 2: Dispersion Plot for Moran's Test (1991 Data Set)



4.2 ECONOMETRIC ANALYSIS

Now that the existence of positive spatial dependence has been demonstrated, model estimation can commence¹³. Following the indication of spatial dependence diagnostics¹⁴, spatial dependence was modelled on per capita income using a Spatial Lag model.

The aim at this point is to quantify the impact of aggregate public capital stock and also to determine which of its components has a greater impact on regional economic growth.

A) Impact of Aggregate Public Capital Stock

There are two techniques for estimating a Spatial Lag model. One is based on the Maximum Likelihood method and the other is based on Instrumental Variables, a robust technique. Trials were conducted using both techniques because in some models it was found that some specification diagnostics were invalid, and so a robust technique such as Instrumental Variables¹⁵ had to be used. The results are the same irrespective of the technique used. As shown in Table No. 2, regression coefficients are similar for both data sets.

¹³ The model layout was also carried out using a conventional model and the Spatial Error model, but the results have not been included in this paper because of an incorrect specification of the model.

¹⁴ When carrying out trials using a conventional model the Spacestat program supplied some diagnostics that indicate that it is better to estimate the model using either a Spatial Lag model or a Spatial Error model.

¹⁵ Results are obtained using instruments created with the technique of Window Average, which is a weighted mean of the per capita income of the surrounding regions.

Table No. 2: Regression Coefficients for the Total Public Capital Stock Model

	1981		1991	
VARIABLES	COEFFICIENTS (z-value)		COEFFICIENTS (z-value)	
ESTIMATION TECHNIQUE	MV	VI	MV	VI
Auto-regressive variable (Wrpc)	0.638122 (13.86)	0.632711 (13.14)	0.51659 (11.55)	0.517664 (11.15)
Mean size of the firm (tmna86)	0.0136176 (5.47)	0.0138559 (5.49)	0.0166642 (8.20)	0.0166271 (8.06)
Agglomeration variable (A5)	1.90618 (2.59)	1.88449 (2.56)	1.19356 (2.39)	1.19459 (2.39)
Total public capital (tot+p)	0.134152 (2.39)	0.13815 (2.43)	0.179222 (3.91)	0.178478 (3.82)

All specification diagnostics were right for both data sets, with the exception of 1981, in which there was abnormality in residual terms, which is the reason why the results have had to be presented using Instrumental Variables.

Elasticities and the explanatory power of the independent variables over per capita income in the model are shown in Tables Nos. 3 and 4.

As already highlighted in previous sections, when Spatial Lag models are used a new variable appears, the auto-regressive variable, which reflects the importance of distance or spatial dependence in the model. As mentioned above, this variable will also reflect the existence of Interurban Agglomeration Forces. These results are shown in Table No. 3. For the 1981 data set, it was found that the mean size of the firm represents 25.97% of the explanation of regional per capita income, the agglomeration variable represents 5.9%, public capital stock 4.53% and the auto-regressive variable 63.59%.

Table No. 3: Elasticities and the Explanatory Power of Independent Variables.
Maximum Likelihood technique.

	Elasticities		Explanatory Power	
	1981	1991	1981	1991
Mean size of the firm	0.2570224	0.3421754	25.97%	34.31%
Agglomeration variable	0.0583928	0.0591848	5.9%	5.93%
Public capital stock	0.0448649	0.0809814	4.53%	8.12%
Auto-regressive variable Wrpc	0.62931680	0.5149079	63.59%	51.63%

Table No. 4: Elasticities and Explanatory Power of Independent Variables.
Instrumental Variables Technique

	Elasticities		Explanatory Power	
	1981	1991	1981	1991
Mean size of the firm	0.2643303	0.3413954	26.43%	34.23%
Agglomeration variable	0.0583487	0.0592327	5.83%	5.94%
Public capital stock	0.0466984	0.0806409	4.7%	8%
Auto-regressive variable Wrpc	0.6307189	0.5159508	63.09%	51.74%

Results are similar for the 1991 data set, as shown in Table No. 3. The only difference is that the mean size of the firm variable shows an improvement in its explanatory power of around 10% whilst at the same time there is a decrease in the explanatory power of the auto-regressive variable. This could indicate that growth is appearing due more to supply factors, which are included in the variable mean size of the firm, rather than to demand factors, which are included in the auto-regressive variable in the form of Interurban Agglomeration Forces. Results are the same irrespective of the technique used. This ensures their validity.

Another difference is found in the explanatory power of public capital. This result was expected due to the expansive trend of investments that is experienced in growth periods, such as that of the years 1986-1991.

B) Impact of the Breakdown of Public Capital

B.1 Introduction

Having quantified the impact of aggregate public capital on per capita income, the next step in the analysis consists of determining which of the components of this stock has a major influence on per capita income growth. First a distinction is made between productive and social public capital. Productive public capital is composed of road infrastructures, hydraulic infrastructures, urban structures, ports, airports and railway infrastructures. Social public capital will include education and health services.

B.2 Impact of Productive Public Capital

As can be seen in Table No. 6 all coefficients are significant, but in order to accept their validity it has to be demonstrated that all the specification diagnostics are correct. As in the previous case, it was found that there is abnormality in 1981 residual terms, and for the 1991 data set heteroskedasticity problems were encountered, so again the model had to be set up with a robust technique, such as

Instrumental Variables. Once again the results were the same irrespective of the technique used. This ensures their validity.

Table No. 5: Regression Coefficient for the Productive Public Capital Stock Model

	1981		1991	
VARIABLES	COEFFICIENTS (z-value)		COEFFICIENTS (z-value)	
ESTIMATION TECHNIQUE	MV	VI	MV	VI
Auto-regressive variable (Wrpc)	0.642 (14.34)	0.639 (13.61)	0.538 (12.51)	0.540 (12.08)
Mean size of the firm (tmna86)	0.0139 (5.52)	0.0140 (5.49)	0.0165 (7.97)	0.016 (7.81)
Agglomeration variable (A5)	1.891 (2.57)	1.881 (2.56)	1.349 (2.69)	1.350 (2.69)
Productive public capital (Kp+p)	0.139 (2.42)	0.142 (2.42)	0.197 (3.59)	0.195 (3.50)

The following tables (Nos. 6 and 7) demonstrate the elasticities and explanatory power of the independent variables in this model.

Table No. 6: Elasticities and Explanatory Power of Independent Variables.
Maximum Likelihood Technique

	Elasticities		Explanatory Power	
	1981	1991	1981	1991
Mean size of the firm	0.2636981	0.339438	26.63%	34.04%
Agglomeration variable	0.0579538	0.066909	5.9%	6.7%
Productive public capital	0.0349891	0.054827	3.53%	5.49%
Auto-regressive Variable Wrpc	0.6336223	0.536060	63.99%	53.75%

Table No. 7: Elasticities and Explanatory Power of Independent Variables.
Instrumental Variable Technique

	Elasticities		Explanatory Power	
	1981	1991	1981	1991
Mean size of the firm	0.265495	0.337527	26.84%	33.85%
Agglomeration variable	0.057616	0.066921	5.82%	6.71%
Productive public capital	0.035386	0.054302	3.58%	5.45%
Auto-regressive Variable Wrpc	0.630815	0.538107	63.76%	53.98%

The results are in line with those obtained in the previous model. Again an increase in the explanatory power of the mean size of the firm variable is found, along with a similar decrease in the auto-regressive variable. An increase in the explanatory power of the productive public capital is also found, which is a consequence, as already indicated, of the economic cycle. This is a good sign for the consistency of the models.

Having quantified the impact of productive public capital on per capita income, the next step is to try to quantify the impact of social public capital on per capita income.

B.3) Impact of Social Public Capital

The results achieved with this model established no relationship between this kind of public capital and growth in per capita income. As shown in Table No. 8, the regression coefficient presents a value that is lower than the critical value (2) for both data sets, so it cannot be considered as significant. If the Instrumental Variable technique is used, the results are similar, as is shown in Table No. 8.

Table No. 8: Regression Coefficient for the Social Public Capital Stock Model

	1981		1991	
VARIABLES	COEFFICIENTS (z-value)		COEFFICIENTS (z-value)	
ESTIMATION TECHNIQUE	MV	VI	MV	VI
Auto-regressive variable (Wrpc)	0.73 (14.64)	0.73 (13.77)	0.63 (11.84)	0.63 (10.92)
Mean size of the firm (tmna86)	0.01 (4.73)	0.01 (4.70)	0.01 (6.42)	0.01 (7.38)
Agglomeration variable (A5)	2.39 (3.21)	2.38 (3.21)	1.59 (2.87)	1.00 (2.02)
Social public capital (ks+p)	-0.43 (-0.79)	-0.41 (-0.74)	0.15 (0.29)	0.03 (0.05)

The interpretation of these results does not consist of eliminating this kind of investment, although it seems to be a problem of measurement. It is known beyond doubt that the better the health and education infrastructures of a region, the greater its possibilities of economic growth. In line with the theory of Drucker (1989), social public capital is an important factor in industrial location because this investment will attract qualified labour with a high provision of human capital, although this positive influence will appear after some years have elapsed. The mere implementation of infrastructures produces a demand impact on the economy and will therefore cause economic growth. Depending on the type of infrastructure other profits will ensue adding to those that arose with their construction. In the case of

health and education, this second type of profit appears some time after the infrastructure's implementation. The benefits of providing good education arise some years after the expenditure has been made.

Having analyzed the impact of productive and social capital, the next step consists of determining which components present a major impact on per capita income.

With reference to productive public capital, a distinction has been made between road infrastructure, hydraulic infrastructure, urban structures, ports, airports and railways. Trials were carried out using all of these components but significant results were only found in the case of road infrastructures. This is due to the fact that this is the largest component and also because they form part of a network of infrastructures and it is well known that this type of infrastructure has a greater impact than other localised infrastructures. The latter only bring benefits to the place where they are implemented, as compared to the former, which benefit the whole economy.

B.4) Impact of Road Infrastructure Capital Stock

Table No. 9: Regression Coefficient for the Road Public Capital Stock Model

	1981		1991	
VARIABLES	COEFFICIENTS (z-value)		COEFFICIENTS (z-value)	
ESTIMATION TECHNIQUE	MV	VI	MV	VI
Auto-regressive variable (Wrpc)	0.654344 (15.53)	0.649064 (14.80)	0.529288 (13.76)	0.530465 (13.33)
Mean size of the firm (tmna86)	0.0140328 (5.52)	0.0143043 (5.56)	0.017279 (8.87)	0.0172489 (8.73)
Agglomeration variable (A5)	1.58688 (2.04)	1.55705 (2.00)	1.09201 (2.29)	1.09269 (2.30)
Road public capital (carret+p)	0.218765 (2.40)	0.224494 (2.45)	0.33982 (4.69)	0.338971 (4.63)

As is shown in Table No. 9, all regression coefficients are significant as all of them present values larger than 2. Again, abnormal residuals for the 1981 data set were found. Therefore, these results have to be compared with those obtained using the Instrumental Variable technique. With the 1991 data set, abnormality was found in the residuals and heteroskedasticity problems were also encountered. No attempt has been made in this paper to solve these problems because the model was then going to be tested using a robust technique, as in previous sections.

As can be seen in Tables Nos. 10 and 11, the explanatory power of the independent variables is the same, regardless of the technique used.

Table No. 10: Elasticities and Explanatory Power of Independent Variables.
Maximum Likelihood Technique

	Elasticities		Explanatory Power	
	1981	1991	1981	1991
Mean size of the firm	0.2644338	0.3542236	26.76%	35.58%
Agglomeration variable	0.0485336	0.0540586	4.91%	5.43%
Road public capital	0.0307502	0.0601237	3.11%	6.03%
Auto-regressive Variable Wrpc	0.6443098	0.5270788	65.21%	52.95%

Table No.11: Elasticities and Explanatory Power of Independent Variables.
Instrumental Variable Technique

	Elasticities		Explanatory Power	
	1981	1991	1981	1991
Mean size of the firm	0.269745	0.353570	27.29%	35.55%
Agglomeration variable	0.047658	0.054090	4.82%	5.43%
Road public capital	0.031580	0.059970	3.19%	6.02%
Auto-regressive Variable Wrpc	0.639602	0.527828	64.70%	53.05%

As can be seen from these tables, results are in line with those already obtained when the impact of the aggregate and productive public capital was being measured. Once again, the rise in the explanatory power of the variable road infrastructure can be explained by the expansive trend in this period.

This paper is concluded with comments on the main results obtained.

5. CONCLUSIONS

The main conclusions of this paper are as follows:

1. An empirical study confirms that the theoretical model correctly explains the growth in per capita income. This is valid in an expansive year like 1991 and in a crisis one such as 1981, which confirms the validity of the results.
2. The results obtained in the trials using a Spatial Lag model are similar, irrespective of the technique used. The explanatory power of the mean size of the enterprise variable is about 26% for 1981 and 34% for 1991, whilst the explanatory power of the agglomeration variable is stable at around 6% for both years. For the auto-regressive variable the explanatory power is around 63% for 1981 and around 51.7% for the year 1991, and for the public capital stock, the explanatory power is 4.5% and 8% respectively.
3. The best variable for taking into account spatial dependence is that which results from multiplying the regional per capita income vector by an inverse distance-weighting matrix.
4. Results obtained in this paper ratify Aschauer's hypothesis, confirming a positive relationship between public capital investment and regional economic growth. The rise in the explanatory power of this variable between 1981 and 1991 was expected due to the large number of investments that was made during those years. It is possible that public investment has a positive effect on the rest of the productive sectors and causes economic growth through the Keynesian multiplier. It can thus be concluded that public investment can be very effective as an instrument of regional policy, reducing territorial differences within a country.
5. When public capital stock is broken down, significant results are only found for productive public stock and when broken down even further, the only significant results are in road infrastructure. The explanatory power of productive public stock is around 3.53% for 1981 and 5.45% for 1991.

It was not possible to establish the positive impact of social public capital on regional per capita income because certain problems were encountered. It would seem that the impact of this type of investment appears some time after the infrastructure has been implemented. Consideration also has to be given to the fact that most of the expenditure on this type of infrastructure is an outflow of expenditure and not stock expenditure. This also explains why a positive impact on public social capital stock was not found because not all the spending made on this type of infrastructure is included.

6. It was found that road infrastructures have a positive impact on regional per capita income due to the characteristics of this type of investment. This investment is in network infrastructures so its benefits are felt over a larger area than in the case of more localised infrastructures. The impact of road infrastructures is about 3.11% for 1981 and 6.03% for the 1991 data set. This result is in line with those obtained in the

previous models. As previously stated, the increase in explanatory power appears as a consequence of the large quantity of infrastructures carried out in this period.

7. The high explanatory power of the mean size of the enterprise variable indicates that it is a good indicator of the process described in the theory, i.e. innovation, multi-regional firms and the appearance of economies of scale. The increase in the explanatory power experienced during this period reflects that the factors determining economic growth appear more on the supply side than on the demand side during the period analyzed. This is also reflected in the decrease in the explanatory power of the auto-regressive variable.

8. The existence of some processes that only appear when resources are concentrated in the same location (the existence of Urban Agglomeration Forces) has been proven. Such processes act on the demand side (urban expenditure multiplier and location investment) and also on the supply side (spatial externalities). The explanatory power of this variable is stable, which is reasonable because agglomerations do not vary a lot in such a short period.

9. We are of the opinion that the explanatory power of the auto-regressive variable is excessive, but we have to take into account the fact that we are dealing with extremely open economies and that trade between them is probably very high, which could explain this result. It should be remembered that this variable includes the existence of Interurban Agglomeration Forces and spatial dependence, meaning that the nearer the regions are, the more exchange there will be between them and the higher spatial dependence and Interurban Agglomeration Forces will be.

6. BIBLIOGRAPHY

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