# GOVERNMENT POLICY AND INDUSTRIAL INVESTMENT DETERMINANTS IN SPANISH REGIONS

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**D-2009-02**

**February 2009**

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We thank Javier Andrés and J. Ramón Ruiz for useful comments. The authors of this paper acknowledge and appreciate the funding received from the European Regional Development Fund (ERDF), Fundación Rafael del Pino and project SEJ2006-05116/ECON.

**Abstract**

The aim of this paper is to analyse the effect of public policies on private industrial investment in Spanish regions by means of a dynamic panel regression model with data collected from 1980 to 2000. We derive and estimate a Euler investment equation that accounts for the influence of both technological and human capital and public infrastructure, which may affect regional efficiency and, therefore, industrial investment. Our results indicate that investment has been sensitive to public infrastructure, particularly in the 1980s, while the effect of human capital was felt throughout the period.

*Keywords:*Panel data; industrial investment; government policies, regions.
*JEL Classification:* C23, E22, R42, R58

## 1. Introduction

This paper is an empirical investigation into the effects of government policy on private investment in regional industry (12 branches of industrial activity, excluding energy, from the NACE R-25) in the 17 Spanish regions over the period dating from 1980 to 2000. The aim of this paper is to analyse the effect of public policies aimed at endowing Spanish regions with infrastructure and human and technological capital within a basic theoretical framework of determining investment. Such policies are becoming the cornerstone of public interventions in Spain regarding the fostering of factors that boost growth and productivity.

On a regional scale, Spanish economic policy, and more specifically industrial policy, has undergone significant changes since the Democratic Constitution was passed in 1978. The industrial policy employed throughout the period covered by the State Development Plans[1] (1964-75) rendered very poor and reversible results[2]. In an attempt to correct regional imbalances, localisation subsidies, tax exemptions and development poles were employed in order to mobilise capital.

Regional economic policy began to change with the reinstatement of democracy and the new political and administrative organisation of the State. The birth of the *'Comunidades Autónomas'* (Autonomous Regions) followed by Spain's integration into the European Economic Community (1986) further fuelled this change. Since then, the aim has been to foster regions' own productive resources by means of horizontal policies: (community, state, regional and local) government policies aimed at endowing regions with infrastructure and human and technological capital.

Investment in infrastructure over this period (1980 to 2000) rose from 2.2% in 1980 to 5.5% of GDP in 1991, before dropping to 4.5% in 2000. Public expenditure on education and professional training grew from less than 3% in 1980 to 4.9% in 1993 to later stabilise at around 4.3%[3]. Public expenditure on R&D has faired much worse, remaining below 0.5% in 1980 and below 1% in 2000.

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[1] *'Planes de Desarrollo Estatales'* in Spanish.

[2] See Cuadrado (1994), Argüelles (1997) and Velasco (2000) for the results in Spanish regions. Some authors suggest that such policies only achieve more permanent effects if an economy has already achieved a certain level of development (Murphy et al., 1989).

[3] While remarkable progress has been made over this period in terms of the average number of years of schooling, which rose from 6 in 1980 to more than 8 in 2000, these figures are still far from those boasted by the United States (over 12 and 13 in the same years) and the European Union (between 10 and above 11 respectively).

The economic literature includes a great deal of research on the impact of public capital on regional or national output, particularly since the publication of the papers by Aschauer in 1989. The first of these two papers, Aschauer (1989a) also inspired numerous studies in Spain. Evidence was found that public capital had a positive influence on private output and aggregate productivity on both a national and regional scale. However, there is a great deal of debate over how significant this impact is[4].

The second paper by Aschauer (1989b) analysed how public investment crowds out private investment and, indirectly, how it can crowd in private capital. This paper's impact on regional research was, however, much less significant. Generally speaking, the literature regarding the impact of public capital has focused on the effect it has on output, employment and productivity. However, investment indicators are really those which capture and anticipate the buoyancy of a region and its growth prospects for the future.

In Spain, evidence of complementariety has been found between infrastructure and private capital for Spanish regions.[5] The effect of public infrastructure on output and private industrial capital is, however, less obvious. García-Milá and Marimón (1996) employed a sector-by-sector approach in Spanish regions, finding that public investment in infrastructure only had an appreciable effect on semi-public sectors - construction and public services - but not on manufacturing. Boscá, Dabán and Escribá (1999) obtained negative values for the shadow price of infrastructure in five regions (out of the 17 in Spain) in the manufacturing sector over the period dating from 1980 to 1993[6].

Furthermore, only a small number of papers have studied the effects of infrastructure together with human and technological capital. Fernández and Polo (2002), using a production function extended Aschauer-style, obtain that the effect of infrastructure on aggregate private productivity diminishes as other types of public capital initially omitted, such as human (see de la Fuente and Vives, 1995) and technological capital are incorporated. However, public policy increasingly tends to assign more weight to education and investment in R&D. Hence, there is good reason to analyse the absolute and relative effectiveness of such policies on the manufacturing sector.

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[4]Apart from the well known econometric problems related to estimating production functions. Two classic surveys carried out for the Spanish economy are those by Draper and Herce (1994) and De la Fuente (1996). More recent surveys include Fernández and Polo (2001) and Martinez and Díaz (2006).

[5] In Spain, the relationship between infrastructure and private capital has mainly been studied by means of a dual approach, estimating cost functions. See Boscá, Escribá and Murgui (2002) and Moreno, Lopez-Bazo and Artis (2002).

[6] Unlike the results obtained for the private productive sector as a whole, shadow price trends reveal that the shortage of infrastructure required by industry disappeared gradually in all regions.

Industry underwent a significant transformation between 1980 and 2000. At the beginning of the 1980s, the manufacturing sector was specialised in branches with weak demand and low technological content. These sectors were hardest hit by the crisis in the early 1980s and early 1990s. As a result, two highly significant changes occurred: on the one hand, the industry became increasingly specialised in more innovative and dynamic sectors (Velasco, 2000) and on the other hand, industrial activity underwent significant regional reallocation[7].

In order to study the role played public policy in regard to regional industrial investment, we derive and estimate a structural investment function that is not only broken down into regions, but also into 12 different branches of manufacturing activity. This function is estimated using the Generalised Method of Moments (Arellano and Bover, 1995, and Blundell and Bond, 1998) in order to deal with explanatory variable endogeneity and sample heterogeneity accordingly. The paper is organised as follows. Section 2 reviews previous empirical research in which regional investment functions have been estimated. Section three defines the theoretical framework by combining sector and regional government determinants. Section 4 discusses the econometric approach used and presents the data. Section 5 analyses the results obtained and section 6 concludes.

## 2. Investment and Previous Empirical Research

The literature in which regional investment functions are estimated is remarkably scarce[8]. There is hardly any recent research and in addition to this, most is based on approaches that are too similar to conventional national aggregate approaches and therefore include very few region-specific features among the explanatory variables that could guide regional policymaking. Furthermore, there is hardly any sectoral data and when specific sectors are studied, the approach used is more of a case study than an attempt to analyse

[7] Apart from the changes affecting the main industrial centres (Madrid, Catalonia and the Basque Country), the Mediterranean (which includes Catalonia, Valencia and Murcia) became an increasingly important industrial centre, the industrial and technological framework in the Ebro Valley (which includes Aragon, La Rioja and Navarra) was consolidated and the heavy industry (metallurgy, metallic processed products) on the Cantabrian Coast ( Galicia, Asturias, Cantabria and the Basque Country) saw its presence reduced (Escribá and Murgui, 2008).

[8] The absence of subnational data on investment and capital stock has resulted in an extraordinary shortage of papers in which regional investment functions are estimated. Nor has such work been carried out in Spain, despite there being data bases that provide information broken down into sectors and regions for the main economic variables.

developments in regional fixed capital formation from the perspective of different sectors (Gertler, 1984 and 1986).

Whitmore (1981) emphasized the need to include the theory of capital formation in the space dimension. Paci (1985) proposed a putty-clay investment model for an Italian region in order to discern how tax incentives affected effective factor prices and therefore investment[9] using data broken down into seven different industries. The most significant findings of this research were that the wage rate affected investment positively, user cost affected investment negatively and that there was no accelerator effect.

Garofalo and Malhotra (1987) analyse the impact of changes in factor prices on net investment in US regions and criticise previous explanations of regional investment, such as those included in the work by Browne, Mieskowski and Syron (1980) for excluding aspects related to efficiency and technical progress from investment models. However, in the research by Garofalo and Malhotra, technical progress is taken as an exogenous variable and the outcome was that total net regional investment is highly sensitive to changes in factor prices. Greenwald, Levinson and Stiglitz (1992) note the presence of imperfect capital markets in US regions and how important regional profits are. The variables that Bachetta (1994) takes into consideration for some European Union countries are identical to those that would be used in a national-scale study. He found that regional investment depends on both regional and national demand, but only on regional profits.

In a more recent paper similar to the research on Italy carried out by Faini and Schiantarelli (1985) and even more pioneering than the work by King (1972), Schalk and Untiedt (2000) estimate investment and labour demand equations for the manufacturing sector in the regions of Federal Germany, using a cost minimisation model with a putty-clay production function. According to this research, investment demand will depend positively on the increase in output and the wage/user cost ratio. An important role is also attributed to regional efficiency, influenced by the availability of infrastructure, skilled labour and agglomeration economies. Feser (2001) estimates a production function together

[9] A great deal of literature tackles the effect of tax incentives on regional investment in which the variable to be explained is not regional investment but mainly regional employment, or in some cases, the creation of new companies. In fact, investment does not normally appear as a variable to be explained, although incentives are aimed at boosting it (Rees and Miall 1981). Representative examples include the work by Krmenec (1990), Sheehan (1994) and even the important research carried out by Bartik (1985 and 1989). Other authors such as Kim (1975) and Ghali and Renaud (1971) were not concerned with investment, but rather with regional growth. The last two authors question the disproportionate attention paid to the role of exogenous variables such as exports in regional economics and the lack of attention paid to the dynamics of the region itself, which is closely related to investment.

with inverse factor demand functions in order to test the relative importance of allocation economies compared to urbanisation with data from companies in two industrial sectors in the US.

In the literature on regional determinants of foreign direct investment allocation, aspects that affect efficiency, externalities, economies of agglomeration, infrastructure endowment and human capital are commonly included[10]. As a result, an analysis is conducted of how the most structural government policies can affect how much foreign direct investment is attracted. In contrast, the literature on domestic investment normally consists of studying the effects of tax incentives via user cost.

Research on regional manufacturing investment in Spain has been restricted to allocation. Such research includes Giraldez and Villegas (1984), Escribá, Pernias and Taguas (1995) and the extensive study directed and coordinated by Aurioles and Cuadrado (1989) using the Spanish Ministry of Industry and Energy Register of Industrial Establishments to describe the process of industrial readjustment that occurred in the Spanish economy over the period 1980-1987, with additional applications to some specific Spanish regions. However, generally speaking, all the research into investment described above is eminently descriptive, the main objective being to identify the changes in investment allocation trends over the periods under consideration, although some suggestions are made regarding the factors that influence regional investment and even the importance of official aid and incentives is frequently questioned. A more recent research paper by Escribá and Murgui (2008) for the period 1964-2000 finds that the industrial allocation of manufacturing investment in Spanish regions has been greatly influenced by the different levels of transport infrastructure and human capital available, together with the traditional factors of cost and demand, but has hardly been affected by economies of agglomeration. Notwithstanding, none of the above research tackles the derivation and estimation of investment functions.

## 3. A Euler Equation Model

Dynamics have been central to developments in economics and econometric models of business fixed investment. According to Chirinko (1993), the literature can be divided into two categories depending on whether dynamics are treated

[10] Cheng and Kwan (2000) find infrastructure endowment and human capital to increase foreign direct investment in Chinese regions, Guimaraes, Figueiredo and Woodward (2000) find transport infrastructure does the same in Portuguese regions, while in Spain Lopez and Mella (1991) and Pelegrín (2002) find evidence of the importance of human capital endowment.

implicitly or explicitly. Unlike the implicit approach employed in the scant papers that have estimated regional investment functions to date, in this section we present a structural model in which these dynamic elements appear explicitly in the optimisation problem and the estimated coefficients are linked explicitly to the underlying technology and expectation parameters. We will use an approach that combines the Euler equation and adjustment cost technology.

The version of the Euler equation model we estimate is based on Bond and Meghir (1994). A regional industry[11] $i$ maximises the present discounted value of current and future net dividends ($R$). Let $K_{it}$ denote capital stock, $L_{it}$ the amount of hired labour, $I_{it}$ gross investment , $\omega_t$ the price of labour, $p_{it}^{I}$ the price of investment goods, $p_{it}$ the price of output, $\delta$ the depreciation rate and E(.) the expectations operator conditional on information available in period t. Defining $r_t$ to be the rate of return and $\beta_{t+j}^{t} = \prod_{i=0}^{j-1}(1+r_{t+i})^{-1}$ the discount factor, the regional industry solves

$$\begin{aligned} &Max\ \mathrm{E}_t\left[\sum_{j=0}^{\infty} \beta_{t+j}^{t}\, R\left(K_{i,t+j}, L_{i,t+j}, I_{i,t+j}\right)\right] \\ &s.t.\quad K_{it} = (1-\delta)K_{i,t-1} + I_{it} \end{aligned} \tag{1}$$

where $R_{it} = p_{it}\, Q_{it} - \omega_{it}\, L_{it} - p_{it}^{I}\, I_{it}$ and $Q_{it} = A_{it}\, F(K_{it}, L_{it}) - Z(K_{it}, I_{it})$ is the net output of adjustment costs $Z(K_{it}, I_{it})$ and depends on the level of efficiency $(A_{it})$.

The Euler equation characterizing the optimal path of investment is given by

$$-(1-\delta)\beta_{t+1}^{t}\mathrm{E}_t\left(\frac{\partial R_{i,t+1}}{\partial I_{i,t+1}}\right) = -\left(\frac{\partial R_{it}}{\partial I_{it}}\right) - \left(\frac{\partial R_{it}}{\partial K_{it}}\right) \tag{2}$$

To allow for imperfect competition we let $p_{it}$ depend on output, while the price elasticity of demand is assumed constant (η>1). Assuming that $F(K_{it}, L_{it})$ is constant returns to scale and the adjustment cost function, $Z(K_{it}, I_{it}) = b/2\,[I_{it}/K_{it} - a]^2 K_{it}$ is linearly homogeneous in investment and capital. This gives

$$\left(\frac{\partial R_{it}}{\partial I_{it}}\right) = -p_{it}\alpha b \frac{I_{it}}{K_{it}} + p_{it}\,\alpha b\, a - p_{it}^{I} \tag{3}$$

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[11] Assuming that company behaviour can be extrapolated to each regional industry. Obviously, using regional data broken down into branches of industry has aggregation problems and company account data, which are aggregated over the different productive units of each company, are not exempt of such problems. This was pointed out by a referee.

$$\left(\frac{\partial R_{it}}{\partial K_{it}}\right)=\alpha\, p_{it}\frac{Q_{it}}{K_{it}}-\alpha\, p_{it}\frac{\omega_{it}}{p_{it}}\frac{L_{it}}{K_{it}}+\alpha\, p_{it}\, b\left(\frac{I_{it}}{K_{it}}\right)^{2}-\alpha\, p_{it}\, b\, a\frac{I_{it}}{K_{it}} \tag{4}$$

where $\alpha = 1-1/\eta > 0$.

To implement this model, we evaluate the expectation $\mathrm{E}_t\left(I_{i,t+1}/K_{i,t+1}\right)$ at realized value $\left(I_{i,t+1}/K_{i,t+1}\right)$ plus a forecast error. The resulting empirical Euler equation under the null of no financial regimes is

$$\begin{aligned}\left(\frac{I_{i,t+1}}{K_{i,t+1}}\right)=a(1-\Phi)+(1+a)\Phi\left(\frac{I_{it}}{K_{it}}\right)-\Phi\left(\frac{I_{it}}{K_{it}}\right)^{2}-\frac{1}{\alpha b}\Phi\left(\frac{B_{it}}{K_{it}}\right)+\\+\frac{1}{(\eta-1)b}\Phi\left(\frac{Q_{it}}{K_{it}}\right)+u_{i,t+1}\end{aligned} \tag{5}$$

where $\Phi=(1+r)/(1-\delta)\left(p_{i,t+1}/p_{it}\right)$ and $\left(\frac{B_{it}}{K_{it}}\right)=\left(\frac{Q_{it}}{K_{it}}\right)-\frac{\omega_{it}}{p_{it}}\left(\frac{L_{it}}{K_{it}}\right)-\frac{c_{it}}{p_{it}}$ is the gross economic profit rate and $c_{it}$ is the nominal user cost of capital.

This equation (5) is the one commonly estimated in microeconometric research[12]. The coefficient on lagged investment is positive and greater than one. The coefficient on lagged investment squared is negative and greater than one in absolute value. The coefficient of the lagged economic profit rate is negative under the assumption that investmet is not overly sensitive to cash flow. The output term controls for imperfect competition and the coefficient is positive. In this paper we also estimate equation (5) and the results are presented in Table 3.

Regional industry output depends firstly on typically sectoral variables: it depends positively on the labour/capital ratio in the regional industry and negatively on the investment/capital ratio in the regional industry $\left[\frac{Q_{it}}{K_{it}}=A_{it}\,F\left(\frac{K_{it}}{K_{it}},\frac{L_{it}}{K_{it}}\right)-Z\left(\frac{K_{it}}{K_{it}},\frac{I_{it}}{K_{it}}\right)=f\left(A_{it},\frac{L_{it}}{K_{it}},\frac{I_{it}}{K_{it}}\right)\right]$. However, it also depends on region-specific variables which affect the productivity of the private factors

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[12] Most of the papers in this discipline use an extended version of this equation in order to verify investment sensitivity to cashflow,and suggest the importance of financial constraints. See Bond and Meghir (1994), Janz (2002), Bond et al (2003). In Spain, Estrada and Vallés (1998) and Hernando and Tiomo (2002).

used in the regional industry[13]. That is, $A_{it}$ is a regional-specific technology parameter which reflects the technical efficiency of all factor inputs included in the regional industry production function.

Furthermore, we assume business technical efficiency in a region depends positively on capital availability in public infrastructure $(G_{it})$, skilled labour or human capital $(H_{it})$ and technological capital $(Tg_{it})$, that is, $A_{it} = A(G_{it}, H_{it}, Tg_{it})$. By using Taylor's expansion, we obtain the following empirical specification:

$$\left(\frac{I_{i,t+1}}{K_{i,t+1}}\right) = \beta_0 + \beta_1\left(\frac{I_{it}}{K_{it}}\right) - \beta_2\left(\frac{I_{it}}{K_{it}}\right)^2 - \beta_3\left(\frac{B_{it}}{K_{it}}\right) + \beta_4\left(\frac{L_{it}}{K_{it}}\right) + \beta_5 \ln G_{it} + \beta_6 \ln H_{it} + \beta_7 \ln Tg_{it} + v_{i,t+1} \qquad (6)$$

## 4. Econometric Methods and Data

### 4.1. Econometric Methods

Economic relations are deep in the process of dynamic adjustments. The specification of time data series commonly includes lagged values for regressors, the endogenous variable or both. Including the lagged endogenous variable, as is the case in investment models, gives an appropriate picture of the capital accumulation process but leads to problems of inference. In dynamic panel models such as the one this paper aims to use, the emergence of individual unobserved effects makes these problems worse still, as can be appreciated below.

Based on equation (6), the basic empirical specification we consider can be written as:

$$\left(\frac{I_{it}}{K_{it}}\right) = \beta_1\left(\frac{I_{it-1}}{K_{it-1}}\right) - \beta_2\left(\frac{I_{it-1}}{K_{it-1}}\right)^2 - \beta_3\left(\frac{B_{it-1}}{K_{it-1}}\right) + \beta_4\left(\frac{L_{it-1}}{K_{it-1}}\right) + \beta_5 \ln G_{it-1} + + \beta_6 \ln H_{it-1} + \beta_7 \ln Tg_{it-1} + \mu_i + d_t + \varepsilon_{it} \qquad (7)$$

Bearing in mind that subscript *i* denotes regional industries and $\mu_i$ refers to industry/region-specific effects that remain unchanged over time

[13] Aschauer (1988) and Lynde (1992), albeit not in the field of investment function estimation, examine how public fixed capital stock affects the rate of return on private capital and the profit rate respectively, but really why "unpaid" public capital affects production efficiency and/or cost reduction.

(geographical allocation, region and industry-specific idiosyncratic features, etc.) and that $d_t$ captures the time effects that have an impact on all regional industries (national policymaking, growth in technical efficiency on a national scale, etc.). We will treat such time effects as fixed – unknown constants – by including a set of time dummies in all regressions[14]. $\varepsilon_{it}$ represents random disturbances.

Dynamic panel data regressions are known to have several econometric problems. The first main problem is the heterogeneity of the sample (in our case unobservable variations among regional industries). Unless these specific effects are dealt with correctly, inconsistent estimators will be obtained. The second problem is the presence of the lagged endogenous variable as a regressor, which means that it is correlated to the errors.

Equation (7) is estimated using panel data techniques, both in levels and first differences. Our joint estimation is carried out using the Arellano and Bover (1995) and Blundell and Bond (1998) System Estimator (hereafter SYS-GMM). When there is a high degree of persistence and few time observations, SYS-GMM is shown to yield potentially large efficiency gains vis-à-vis the pure First-Difference (hereafter DIFF-GMM)[15].

The idea of the DIFF-GMM proposed by Arellano and Bond (1991) is to take the first differences in order to eliminate the possible source of inconsistency created by the presence of $\mu_i$ and use the levels of the explanatory variables lagged two or three periods as instruments to correct their endogeneity. In order to simplify the explanation of this type of estimation, let us assume that equation (7) can be expressed in general terms as:

$$y_{it} = \alpha\, y_{i,t-1} + \beta\, x_{it} + u_{it} \qquad (8)$$

where $y_{it}$ is the gross accumulation rate –the endogenous variable- $y_{i,t-1}$ the lagged endogenous variable and $x_{it}$ the series of explanatory variables included in equation (7).

The estimator DIFF-GMM takes first differences from equation (8) thus eliminating industry/region-specific effects.

$$\Delta y_{it} = \alpha\, \Delta y_{it-1} + \beta\, \Delta x_{it} + \Delta\varepsilon_{it} \qquad i = 1,2,\ldots,N \quad t = 3,\ldots,T \qquad (9)$$

[14] It would also be possible to express the variables in deviations from their average over time, which makes including time dummies unnecessary.

[15] See Blundell and Bond (1998).

Assuming residuals are not serially correlated, the values of $y_{it}$ lagged two or more periods can be used as instruments of the first differences system, such that the conditions of orthogonality or moment restrictions would be[16]:

$$\mathrm{E}(y_{it-s}\ \Delta\varepsilon_{it}) = 0 \qquad t = 3,\ldots,T \quad y \quad s \geq 2 \tag{10}$$

but a GMM estimation using only (10) may well be insufficient. Explanatory variables are commonly used as additional instruments. However, the set of valid instruments will vary depending on what assumption is made in reference to explanatory variable exogeneity. If the variables are strictly exogenous, the values of $x_{it}$ can be used as instruments to estimate the first differences model, such that moment restrictions would be given by:

$$\mathrm{E}(x_{it-s}\ \Delta\varepsilon_{it}) = 0 \qquad t = 3,\ldots,T \quad \text{and for all } s \tag{11}$$

But if the explanatory variables are endogenous in the sense that $\mathrm{E}[x_{it}\ \varepsilon_{is}] \neq 0$ where $t \geq s$, that is, current and past shocks ($\varepsilon_{it}$ *and* $\varepsilon_{it-s}$) affect the current value of $x_{it}$. Orthogonality conditions are given by:

$$\mathrm{E}(x_{it-s}\ \Delta\varepsilon_{it}) = 0 \qquad t = 3,\ldots,T \quad y \quad s \geq 2 \tag{12}$$

As a result, the values (lagged two or more periods) of the endogenous explanatory variables can be used as instruments. The consistency of the DIFF-GMM estimator lies in how valid moment conditions are, that is, residuals must be serially uncorrelated and explanatory variables must be exogenous. The overidentification test proposed by Sargan (1958) and Hansen (1982) is used to discern the validity of orthogonality conditions – providing the instruments as a group are exogenous. The statistics proposed by Arellano and Bond (1991) are used to test the presence of serially correlated residuals and the null hypothesis is that of no residual autocorrelation[17].

However, when there is a high degree of persistence in the series and few time observations, the DIFF-GMM estimator behaves poorly (Blundell and Bond, 1998). Indeed, these two authors show how the first differences estimator can lose a great deal of efficiency due to information on moment restrictions being ignored. That is, the lagged levels of the explanatory variables are weak instruments for first differences. In our case, as we will see in Table 2 later in this article, some variables have a high degree of persistence, that is, they vary significantly from one individual to another, but appear to be quite stable over

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[16] See Arellano and Bond (1991) for a more in-depth explanation.

[17] Therefore, first order autocorrelation, AR(1), is expected as $\Delta\varepsilon_{it} = \varepsilon_{it} - \varepsilon_{it-1}$ will be correlated to $\Delta\varepsilon_{it-1} = \varepsilon_{it-1} - \varepsilon_{it-2}$, but not higher order autocorrelation.

time. Hence, a system of equations including difference as well as level equations can be estimated in order to solve this problem. The estimator used is the system estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998), which increases the first-differenced moment conditions (10)-(12) by the level moment conditions

$$\mathrm{E}(\varepsilon_{it}\ \Delta y_{it-1}) = 0 \qquad t = 3,\dots,T \tag{13}$$

which makes it possible to use the lagged differences of $y$ as instruments in the level equation (8). In addition to this, level moment conditions for the strictly exogenous explanatory variables would be

$$\mathrm{E}(\varepsilon_{it}\ \Delta x_{it-s}) = 0 \qquad t = 2,\dots,T \quad \text{and for all } s \tag{14}$$

and as regards the explanatory variables that we consider endogenous, the moment conditions for the level equation would be

$$\mathrm{E}(\varepsilon_{it}\ \Delta x_{it-s}) = 0 \qquad t = 3,\dots,T \quad y \quad s \geq 1 \tag{15}$$

How valid the moment conditions are for level equation (13)-(15) depends on there being no autocorrelation between $\mu_i$ and the explanatory variables in first differences. For more information see Blundell and Bond (1998). This estimator is more efficient than DIFF-GMM if these moment conditions are accepted as valid. For this reason, it is important to be able to test the validity of moment conditions (10)-(15) by means of Sargan or Hansen's test and also to assess whether or not additional moment conditions for level equations are valid using the Hansen-difference test.

### 4.2. Data

In this article a panel of data with a sample of 12 industries in all 17 Spanish regions[18] over a period dating from 1980 to 2000[19] is used. All the data used are from the BD.MORES data base[20] (Dabán et al (2002)), except for human capital (De la Fuente and Doménech, 2006).

Both a description of the variables used in the analysis and also how they were estimated is provided in Table 1. A more detailed description of other variables is included in Appendix 2.

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[18] See Appendix 1.

[19] Data are from a balanced panel and while availability dates back to 1980, the first two periods are lost due to the lags used for the instrumental variables (t-2).

[20] The elaboration of the R&D series is detailed in Escribá and Murgui (2007).

**TABLE 1: Industrial Accumulation Rate Determinants**

| Variable | |
|---|---|
| *Dependent Variable* | |
| Accumulation Rate $(I_{it}/K_{it})$ | Industrial investment and capital stock ratio in each regional industry |
| *Explanatory variables* | |
| 1. Profit rate $(B_{it}/K_{it})$ | Rate of real profit to capital in each regional industry |
| 2. Output –Capital $(Q_{it}/K_{it})$ | Output-capital stock ratio in each regional industry |
| 3. Labour –Capital $\left(\frac{L_{it}}{K_{it}}\right)$ | Labour capital stock ratio in each regional industry |
| 4. Regional infrastructure endowment $(G_{it})$[a] | Regional public capital stock in transport infrastructure (roads, ports, railways and airports) |
| 5. Human capital $(H_{it})$ | Average school enrolment data series for Spanish regions |
| 6. Public capital in regional R&D $(Tg_{it})$[a] | Public administration and educational centre capital stock in R&D in each region |

**Note**: [a] Regional infrastructure endowment $(G_{it})$ and Public capital in regional R&D $(Tg_{it})$, unlike Human capital $(H_{it})$, depend on the size of the region. As a result, the productivity of regional industrial investment will depend on how scarce it is in relative terms when compared to public regional capital endowment. This will be relatively congested in light of its relationship to that of the sector in the region. In contrast, human capital in years of schooling is unaffected by the size of the region. See Appendix 2.

Although the accumulation rate has varied considerably across regional industries (see Tables A.1 and A.2 in of Appendix 1), there have been four clear stages, as can be appreciated in Figure A.1 in Appendix 1. In both the 1980s and 1990s, industry suffered a period of recession and another of expansion.

Since halfway through the 1980s and up to the early 1990s, the public sector made a huge effort to modernise the Spanish economy. The trend these public expenditure items displayed in relation to industrial investment was much more stable in the 1990s and even sloped downward in the case of infrastructure[21].

[21] Public investment has steadily decreased since 1994, among other reasons due to the effort that was made in order to comply with nominal convergence objectives in order to gain access to the EMU.

As can be appreciated in Figures A.2 and A.3, public infrastructure endowment grew in relation to industrial capital up to the end of the industrial crisis in the 1990s, along with public investment in R&D. The average number of years of schooling increased progressively. Unlike the 1980s when a marked increase in the three types of public capital was observed, the 1990s have not witnessed such growth. Two different stages in Spanish regional policy can therefore be distinguished that coincide with these two decades.

On observing Table A.1, which includes regional variables, we can see how, generally speaking, the highest levels of professional training are found in the most industrialised regions. In contrast, the infrastructure/industrial capital ratio is higher in the regions where industry has a lesser presence. Moreover, these same regions also recorded the largest increase from the 1980s to the 1990s. Regional investment in R&D in relation to industrial capital registers ratio that highly affected by the presence of industrial capital. Investment in R&D is highly concentrated in Madrid, Catalonia and the Basque Country.

Some of the variables under consideration in the analysis display a high degree of persistence, that is, they vary significantly from one regional industry to another or from one region to another, should this be the case, but appear to be relatively stable over time, as can be appreciated in Table 2. Therefore, more efficient estimators will be obtained from the estimation using the system of equations in differences and in levels (SYS-GMM).

**TABLE 2**

*Adjusted $R^2$ from the regressions with time and regional industry dummies*

| *Dependent variable* | *Time dummies* | *Regional industry dummies* | *Both* |
|---|---|---|---|
| $\left(I_{it}/K_{it}\right)$ | 0.065 | 0.115 | 0.185 |
| $\left(B_{it}/K_{it}\right)$ | 0.043 | 0.408 | 0.456 |
| $\left(Q_{it}/K_{it}\right)$ | 0.003 | 0.699 | 0.701 |
| $\left(L_{it}/K_{it}\right)$ | 0.005 | 0.768 | 0.778 |
| $\mathrm{Ln}\left(G_{it}/K_{it}\right)$ | 0.005 | 0.941 | 0.952 |
| $\mathrm{Ln}\left(H_{it}\right)$ | 0.668 | 0.274 | 0.982 |
| $\mathrm{Ln}\left(Tg_{it}/K_{it}\right)$ | 0.105 | 0.765 | 0.881 |

Note: OLS Estimation of pooled regional industry = 204 and sample period = 1980-2000.

## 5. Estimation Results

Table 3 presents the results of estimating industrial investment determinants in Spanish regions following a reduced specification of equation (7), that is, where the investment rate depends on its lag, on its square root, on the lagged profit rate and lagged output-capital ratio – equation (5) – as estimated in the majority of papers that use the model proposed by Bond and Meghir (1994).

In Table 3 the estimation is carried out for the entire sample period (1980-2000) and the two sub-periods; the 1980s and the 1990s, using the OLS estimator in column [1], the DIF-GMM (Arellano and Bond, 1991) in column [2] and the SYS-GMM (Arellano and Bover, 1995 and Blundell and Bond, 1998) in column [3]. Only in this table and for the entire sample do we report the results from three estimators for comparison. Therefore, by using the GMM estimate, regardless of whether it is in differences or system, consistent estimators would be obtained providing the validity of the orthogonality (Sargan or Hansen's overidentification test) is accepted and there is no residual autocorrelation. As can be observed in the lower part of Table 3, the validity of the instruments chosen is accepted as is the no second-order correlation, the AR(2) test and the Hansen Difference Test are accepted.

For the period dating from 1980 to 2000, the coefficients on the lagged investment terms are correctly signed, but smaller in absolute value than suggested by the derivation of this model regardless of the method used. The coefficient on the lagged squared term is less than minus one – as it is derived by the structural adjustment costs model- when the SYS-GMM estimator is used. The coefficient on the lagged economic profit term is negative in all cases, and significantly different from zero – an exception to DIF-GMM- which is consistent to the theoretical prediction under the null of no financial constraints. The coefficient of the lagged output-capital ratio is positive and significant in all cases which is consistent with the presence of imperfect competition in the product market.

Columns [4] and [5] include the results for the subsamples 1980-1990 and 1991-2000 respectively, only obtained by means of the SYS-GMM estimator. The coefficients of the lagged investment rate display the correct signs and values closest to one. The coefficients of the lagged profit rate are negative but are not statistically significant. The lagged output coefficients are positive and are statistically significant. As can be observed in the lower part of Table 3, the validity of the instruments chosen is accepted as is the no second-order correlation, the AR(2) test and the Hansen Difference Test.

**TABLE 3: Results of the Estimation. The Euler Equation**

| **Dependent Variable:** $\left(\frac{I_{it}}{K_{it}}\right)$ | | | | | |
|---|---|---|---|---|---|
| Period | | 1980-2000 | | 1980-1990 | 1991-2000 |
| ESTIMATION | OLS [1] | DIF-GMM [2] | SYS-GMM [3] | SYS-GMM [4] | SYS-GMM [5] |
| $\left(\frac{I_{it}}{K_{it}}\right)_{-1}$ | 0.341* | 0.343* | 0.629* | 0.638* | 0.855* |
| | (0.028) | (0.140) | (0.135) | (0.149) | (0.082) |
| $\left(\frac{I_{it}}{K_{it}}\right)^2_{-1}$ | -0.124* | -0.362 | -1.043* | -1.197* | -0.869* |
| | (0.066) | (0.443) | (0.376) | (0.371) | (0.083) |
| $\left(\frac{B_{it}}{K_{it}}\right)_{-1}$ | -0.012* | -0.021 | -0.021* | -0.015 | -0.010 |
| | (0.004) | (0.017) | (0.010) | (0.011) | (0.017) |
| $\left(\frac{Q_{it}}{K_{it}}\right)_{-1}$ | 0.025* | 0.057* | 0.035* | 0.032* | 0.026* |
| | (0.002) | (0.017) | (0.006) | (0.007) | (0.007) |
| $R^2$ | 0.258 | | | | |
| Time dummies | Yes | Yes | Yes | Yes | Yes |
| Obs. | 3060 | 2652 | 3060 | 2040 | 1631 |
| Ind-reg | 204 | 204 | 204 | 204 | 204 |
| Sargan o Hansen Test | | [0.118] | [0.241] | [0.215] | [0.158] |
| Difference Hansen test | | | [0.759] | [0.500] | [0.151] |
| AR(1) Test | | [0.000] | [0.000] | [0.000] | [0.006] |
| AR(2) Test | | [0.167] | [0.105] | [0.562] | [0.118] |

**Note**: Standard errors in brackets, for columns (2) to (5) the estimator is two-step and Standard errors have been adjusted in line with Windmeijer (2005). *Values significant at 5%. The figures reported for the Hansen test and difference Hansen test are the *p-values* for the null hypotheses, valid specification. The figures reported for the AR(1) and AR(2) test are the *p-values* for the null hypotheses, zero first-order and second-order autocorrelation. The instruments used for the estimation in first differences DIF-GMM (column (2)) are the levels of the endogenous explanatory variables [ $(I_{it}/K_{it})_{-1}$ ; $(I_{it}/K_{it})^2_{-1}$ ; $(B_{it}/K_{it})_{-1}$ ; $(Q_{it}/K_{it})_{-1}$ ] lagged two periods and all the lags up to a maximum of five. Additional instruments used to estimate the equations in levels in the SYS-GMM (column (3)) are the first differences of the endogenous explanatory variables lagged one period. In columns (4) and (5) the instruments used for the estimation in first differences are the lagged levels of the endogenous explanatory variables two periods and all possible lags up and the additional instruments used to estimate the equations in levels are the first differences of the endogenous explanatory variables lagged one period.

Table 4 reports results for the system GMM estimation of equation (7). It is worth recalling that this equation includes the variables that capture public human capital endowment, transport infrastructure and regional technological capital and that we are interested in estimating their effect on the future investment rate through an increase in productivity. The validity of the instruments used in the Hansen test is accepted for all columns along with the absence of second-order autocorrelation as can be observed in the lower part of the table. This table presents the associated specification tests for two combinations of explanatory variables. In columns (1), (2) and (4) we consider the explanatory variables that include public policy on infrastructure and human and technological capital to be strictly exogenous and the rest, the lagged investment rate, the lagged labour/capital ratio, the lagged economic profit rate to be endogenous. In contrast, the assumption of endogeneity of all variables is mantained in columns (3) and (5). Furthermore, Table 4 only presents the results for the sample as a whole (1980-2000) when we consider the variables that reflect the public endowment of infrastructure, human and technological capital to be exogenous. When they are considered endogenous alone, the results of te estimates for the two subsamples are presented (1980-90 and 1991-2000) in light of the large number of variables to be estimated together with the fact that deeming all variables endogenous does not leave enough degrees of freedom in the estimation if the entire sample period is taken into account.

The results in column (1) refer to the estimation of equation (7) using the entire sample period. The coefficients of the lagged investment rate, the lagged investment rate squared and the lagged labour/capital ratio are significant and display the correct sign, although the lagged profit rate coefficient does not. As regards the coefficients of the variables we are interested in – if they are considered exogenous in the estimation - both the public endowment of infrastructure and also regional human capital are positive and significant. That is, they have a positive effect on productivity and, therefore, on the rate of private manufacturing investment.

The results in columns (2) and (3) of Table 4 refer to the estimation using the 1980-1990 sample. The result of the Hansen difference test (endog) confirms that the variables that capture public policy (regarding regional transport infrastructure endowment and human and technological capital) can be considered endogenous. However, the results do not change, as can be observed when columns (2) and (3) are compared. As regards the variables of interest, both human capital and also regional transport infrastructure endowment are positive and statistically significant. That is, over the period dating from 1980 to 1990, regional transport infrastructure endowment and regional human capital

## TABLE 4: Results of the Estimation. Euler Equation

| Dependent Variable: $\left( I_{it} / K_{it} \right)$ | | | | | |
|---|---|---|---|---|---|
| Period | 1980-2000 | 1980-1990 | | 1991-2000 | |
| ESTIMATION | SYS-GMM<br>[1] | SYS-GMM<br>[2] | SYS-GMM<br>All Endog.<br>[3] | SYS-GMM<br>[4] | SYS-GMM<br>All Endog.<br>[5] |
| $\left( \frac{I_{it}}{K_{it}} \right)_{-1}$ | 0.470*<br>(0.190) | 0.541*<br>(0.209) | 0.683*<br>(0.101) | 0.292*<br>(0.118) | 0.403*<br>(0.080) |
| $\left( \frac{I_{it}}{K_{it}} \right)^2_{-1}$ | -0.808**<br>(0.427) | -1.059*<br>(0.436) | -0.735*<br>(0.202) | -0.337*<br>(0.098) | -0.443*<br>(0.071) |
| $\left( \frac{B_{it}}{K_{it}} \right)_{-1}$ | 0.016<br>(0.102) | 0.0255**<br>(0.013) | 0.007<br>(0.009) | 0.019<br>(0.012) | 0.038*<br>(0.013) |
| $\left( \frac{L_{it}}{K_{it}} \right)_{-1}$ | 0.001*<br>(0.0005) | 0.002*<br>(0.0007) | 0.0014*<br>(0.0005) | 0.002**<br>(0.001) | 0.001**<br>(0.007) |
| $Ln\ (G_{it})_{-1}$ | 0.005*<br>(0.001) | 0.013*<br>(0.003) | 0.008*<br>(0.003) | 0.005**<br>(0.003) | 0.002<br>(0.006) |
| $Ln\ (H_{it})_{-1}$ | 0.021*<br>(0.006) | 0.385*<br>(0.157) | 0.086*<br>(0.042) | 0.029*<br>(0.005) | 0.027*<br>(0.007) |
| $Ln\ (Tg_{it})_{-1}$ | 0.0006<br>(0.0009) | -0.002<br>(0.001) | -0.0007<br>(0.001) | -0.001<br>(0.002) | -0.002<br>(0.002) |
| Time dummies | Yes | Yes | Yes | Yes | Yes |
| Obs. | 3060 | 2040 | 2040 | 1631 | 1631 |
| Ind-reg | 204 | 204 | 204 | 204 | 204 |
| Sargan o Hansen Test | [0.296] | [0.504] | [0.360] | [0.218] | [0.188] |
| Difference Hansen test | [0.910] | [0.457] | [0.100] | [0.121] | [0.148] |
| Diff.Hansen test (endg) | | | [0.285] | | [0.299] |
| AR(1) Test | [0.000] | [0.000] | [0.000] | [0.009] | [0.004] |
| AR(2) Test | [0.170] | [0.612] | [0.403] | [0.407] | [0.270] |

**Note**: Standard errors in brackets, the estimator is two-step and Standard errors have been adjusted in line with Windmeijer (2005). *Values significant at 5% and **values significant at 10%. The figures reported for the Hansen test and difference Hansen test are the *p-values* for the null hypotheses, valid specification. The figures reported for the AR(1) and AR(2) test are the *p-values* for the null hypotheses, zero first-order and second-order autocorrelation. In column (1) the instruments used for the estimation in first differences are the lagged levels of the endogenous explanatory variables [ $(I_{it}/K_{it})_{-1}$ ; $(I_{it}/K_{it})^2_{-1}$ ; $(B_{it}/K_{it})_{-1}$ ; $(L_{it}/K_{it})_{-1}$ ] two periods and all the lags up to a maximum of five and the exogenous explanatory variables [ $\ln(G_{it})_{-1}$ ; $\ln(H_{it})_{-1}$ ; $\ln(Tg_{it})_{-1}$ ] not lagged. In columns (2) and (4) the instruments used for the estimation in first differences are the lagged levels of the endogenous explanatory variables two periods and all the lags up to a maximum of four and the exogenous explanatory variables not lagged. Additional instruments used to estimate the equations in levels are the first differences of the endogenous explanatory variables lagged one period. In columns (3) and (5) the instruments used for the estimation in first differences are the lagged levels of the endogenous explanatory variables two periods and all the lags up to a maximum of four and additional instruments used to estimate the equations in levels are the first differences of the endogenous explanatory variables lagged one period.

had a positive impact on the investment rate in regional manufacturing companies.

The results obtained for the 1990s did not change – as was the case in for the 1980s - in regard to the lagged investment rate, the lagged investment rate squared and the labour/capital ratio, which remained significant and with the correct sign, although the first two variables did record much lower values in this sub period. However, the lagged economic profit rate is significant and has a positive effect on the current investment rate, which was not expected, as can be observed in column (5). In reference to the variables that represent public policies, the outcome changed with regard to the sub period of the 1980s. The coefficient of human capital is positive and significantly different from zero, regardless of whether it is considered exogenous or endogenous. However, investment in infrastructure is positive and significant if public policy variables are considered to be exogenous, but is not significant if they are considered to be endogenous. The result of the Hansen difference test (endog) confirms that public policy variables can be considered endogenous.

## 5. Conclusions

The objective of this paper was to analyse the role played by regional endowments of infrastructure, education and R&D when it comes to explaining the trend observed in investment in Spanish regional industries during the period dating from 1980 to 2000. In order to achieve this, we proceeded to derive and estimate a Euler-equation specification based on an extension of the version proposed by Bond and Meghir (1994) and using dynamic panel and GMM methods.

The dynamic panel data model is estimated using panel data techniques, both in levels and first differences (Arellano and Bover, 1995 and Blundell and Bond, 1998) System- GMM. This method controls for biases due to unobserved specific effects and endogenous explanatory variables.

Results coincide with the standard investment model of the Euler equation. The coefficients on the lagged investment rate and the lagged investment rate squared were those expected, the coefficient on the lagged economic profit term is negative in all cases, and significantly different from zero – an exception to DIF-GMM- which is consistent with the theoretical prediction of Euler's standard equation. The coefficient of the lagged output-capital ratio is positive and significant in all cases which is consistent with the presence of imperfect competition in the product market.

When this Euler equation is extended to estimate the role played by factors that affect regional productivity in the investment carried out by regional industry, the standard variables: the lagged investment rate and the lagged investment rate squared display the correct sign in both subperiods. Notwithstanding, the profit rate is generally speaking not statistically significant, except in the last period when it displays the opposite sign to that expected.

In this extended version, capital productivity depends on the one hand on typically sectorial variables: it depends positively on the labour/capital ratio in the regional industry and negatively on the investment/capital ratio in the regional industry. These variables display the correct sign and significance when determining the investment rate. Technical efficiency is another aspect that determines the productivity of capital and, therefore, the accumulation rate. The efficiency of companies in a region is influenced by the availability of public capital. Regional public sector productive physical and above all human capital has played a decisive role in private investment in manufacturing, albeit to a different extent in the various periods. In the case of regional transport infrastructure endowment, it was in the 1980s when this factor was most decisive, together with human capital. In the 1990s, with Spain integrated into the European Union and subject to foreign competition that was less and less based on low wage costs, labour qualifications emerged as the main determinant of both efficiency in regional industries and their decisions regarding capital formation and increasing productive capacity.

This paper's findings are aimed at shedding some light on the type of government policy that could boost efficiency and in turn capital formation in manufacturing industries. Spain currently suffers from a serious lack of infrastructure and technological and human capital in comparison to the main countries in the EMU. In a context of foreign competition such as that faced by industry in particular, such shortfalls make it less likely that traditional manufacturing industries intensive in unskilled labour and represented by small companies will be able to undergo the conversion process that is necessary. Despite this industrial scenario and deficient cooperation to date between public research centres and companies, there is still time for the government to react, but only if policies are ambitious and determined will they be able to sustain and foster an industrial sector capable of competing in an economy that is inevitably more externally open.

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## APPENDIX 1

The first table in this appendix below displays the average scores of the regional variables while the second table displays the average scores of the accumulation rate determinants for 12 sectors of manufacturing industry:

**TABLE A.1: Regional Variables - Average Scores**

| | $(I_{it}/K_{it})$ | | $(G_{it}/K_{it})$ | | $(H_{it})$ | | $(Tg_{it}/K_{it})$ | |
|---|---|---|---|---|---|---|---|---|
| **Region** | *1980--90* | *1991-2000* | *1980-90* | *1991-2000* | *1980-90* | *1991-2000* | *1980-90* | *1991-2000* |
| **Andalusia** | 0.085 | 0.096 | 0.676 | 1.393 | 6.096 | 7.003 | 0.051 | 0.117 |
| **Aragon** | 0.082 | 0.119 | 0.618 | 0.724 | 6.478 | 7.671 | 0.041 | 0.058 |
| **Asturias** | 0.094 | 0.073 | 0.779 | 1.021 | 6.286 | 7.689 | 0.019 | 0.051 |
| **Ballearic Islands** | 0.088 | 0.090 | 1.210 | 1.775 | 6.074 | 7.588 | 0.012 | 0.087 |
| **Canary Islands** | 0.119 | 0.107 | 1.856 | 2.253 | 6.238 | 7.462 | 0.134 | 0.242 |
| **Cantabria** | 0.074 | 0.088 | 0.407 | 0.905 | 6.534 | 7.878 | 0.022 | 0.049 |
| **Castille and Leon** | 0.093 | 0.117 | 0.964 | 1.169 | 6.615 | 7.530 | 0.021 | 0.059 |
| **Castille La Mancha** | 0.103 | 0.121 | 1.090 | 1.628 | 5.601 | 6.593 | 0.006 | 0.020 |
| **Catalonia** | 0.084 | 0.121 | 0.434 | 0.504 | 6.383 | 7.741 | 0.027 | 0.048 |
| **Valencia** | 0.099 | 0.124 | 0.531 | 0.683 | 6.127 | 7.348 | 0.031 | 0.059 |
| **Extremadura** | 0.112 | 0.129 | 1.880 | 2.566 | 5.466 | 6.565 | 0.110 | 0.144 |
| **Galicia** | 0.101 | 0.130 | 1.227 | 1.472 | 5.900 | 7.047 | 0.041 | 0.078 |
| **Madrid** | 0.087 | 0.102 | 0.521 | 0.699 | 7.129 | 8.706 | 0.211 | 0.336 |
| **Murcia** | 0.090 | 0.139 | 0.536 | 0.905 | 5.866 | 7.190 | 0.050 | 0.099 |
| **Navarra** | 0.103 | 0.138 | 0.784 | 0.622 | 6.586 | 8.123 | 0.001 | 0.031 |
| **Basque Country** | 0.074 | 0.089 | 0.327 | 0.420 | 6.854 | 8.288 | 0.004 | 0.020 |
| **La Rioja** | 0.123 | 0.127 | 1.640 | 1.013 | 6.432 | 7.703 | 0.006 | 0.015 |

**Source:** BD.MORES and De la Fuente and Doménech (2006)

**TABLE A.2: Industry - Average Scores**

| | $(I_{it}/K_{it})$ | | $(Q_{it}/K_{it})$ | | $(B_{it}/K_{it})$ | |
|---|---|---|---|---|---|---|
| | *1980-90* | *1991-2000* | *1980-90* | *1991-2000* | *1980-90* | *1991-2000* |
| 1.Metal Ores, Iron and Steel | 0.057 | 0.054 | 0.434 | 0.449 | 0.182 | 0.064 |
| 2. Minerals and non-metallic products | 0.094 | 0.108 | 0.664 | 0.653 | 0.169 | 0.163 |
| 3. Chemical Products | 0.077 | 0.106 | 0.692 | 0.858 | 0.144 | 0.057 |
| 4. Metallic Products | 0.095 | 0.114 | 1.152 | 1.337 | 0.150 | -0.046 |
| 5. Machinery | 0.102 | 0.126 | 1.686 | 2.158 | 0.239 | 0.361 |
| 6. Office machinery and electrical and optical equipment | 0.109 | 0.125 | 1.523 | 1.636 | 0.582 | 0.362 |
| 7. Transport equipment | 0.098 | 0.149 | 0.948 | 1.007 | 0.161 | 0.111 |
| 8. Food | 0.100 | 0.121 | 0.992 | 0.984 | 0.374 | 0.262 |
| 9.Textiles, clothing and footwear | 0.089 | 0.102 | 1.370 | 1.426 | 0.262 | -0.023 |
| 10. Paper and paper products | 0.089 | 0.116 | 0.720 | 0.639 | 0.151 | 0.047 |
| 11. Rubber and plastics | 0.078 | 0.098 | 0.773 | 0.733 | 0.045 | 0.131 |
| 12. Wood, cork and other manufactured products | 0.092 | 0.123 | 1.049 | 1.104 | 0.065 | -0.119 |

**Source**: BD.MORES

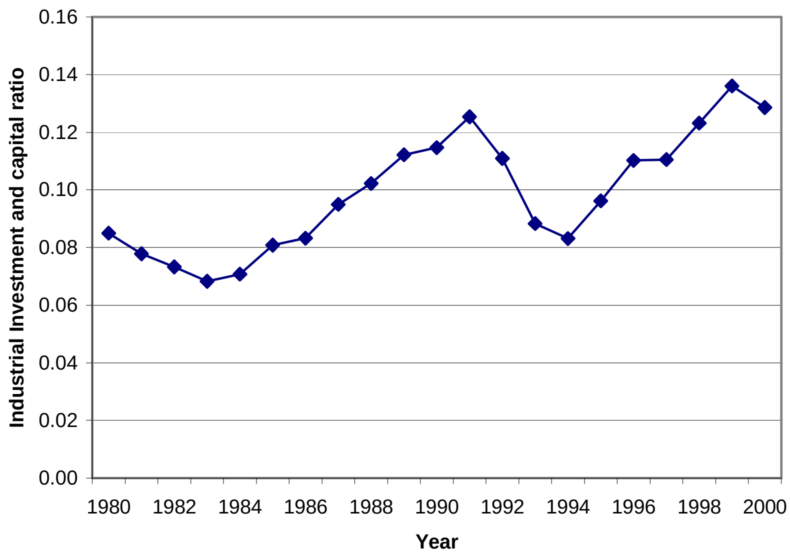


Figure A.1. Industrial Investment to Capital Stock ratio. Spain

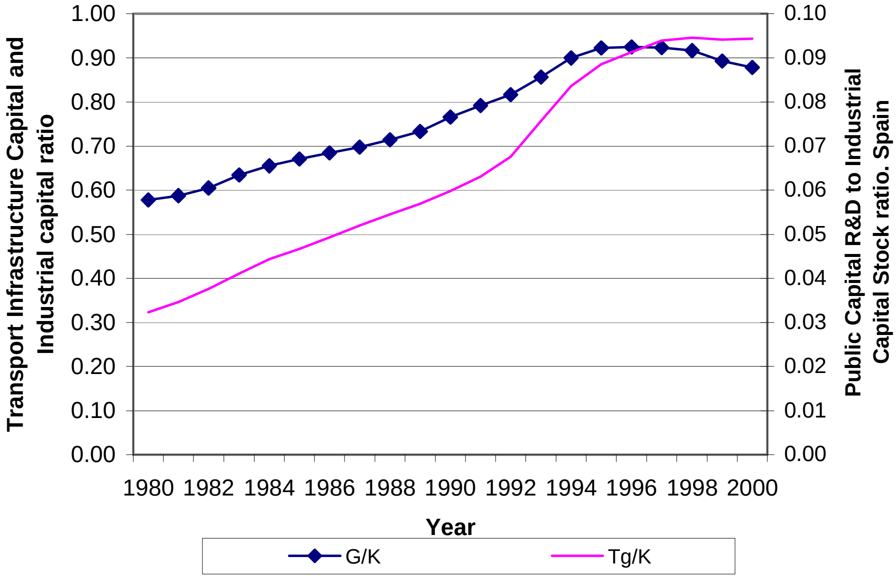


Figure A.2. Public Capital in Transport Infrastructure and Public Capital R&D to Industrial Capital Stock ratio. Spain

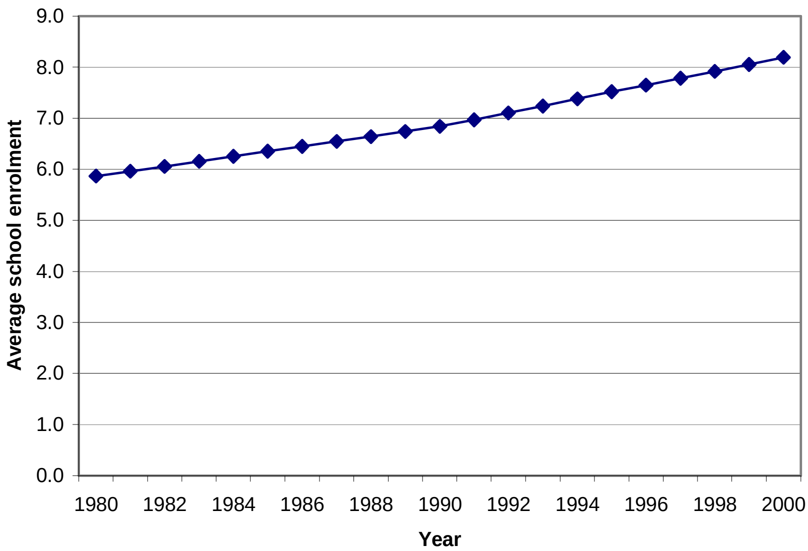


Figure A. 3. Data series of Average School Enrolment. Spain

## APPENDIX 2

The basic data for the seventeen Spanish regions are taken from the BD.MORES database. The level of regional disaggregation corresponds to NUTS2 in the Eurostat nomenclature of statistical territorial units and the level of industry disaggregation corresponds to NACE-CLIO R.25, 12 branches of activity of the manufacturing industry (See Dabán et al., 2002). The series taken from this database are:

***Wage*** $\left(\frac{\omega_{it}}{P_{it}}\right)$. The real wage in each regional industry is calculated as Gross earnings of each regional industry divided by the number of employees in each regional industry $(L_{it})$.

***User cost* of *capital***. The user cost in each industry is computed as $\left(\frac{c_{it}}{P_{it}} = \frac{p_{it}^{I}}{P_{it}}\left(r_t^n - \hat{p}_{it}^{I} + \delta_{it}\right)\right)$ where $p_{it}^{I}$ is the industry capital investment deflator, $p_{it}$ is the output deflator in each industry, $r_t^n$ is a long run interest nominal rate, $\delta_{it}$ is the capital depreciation rate in each industry, and $\hat{p}_{it}^{I}$ is the rate of growth of the industry capital investment deflator. User cost is only available in the BDMORES data base for 12 branches of industry on a national scale.

***Output (*** $Q_{it}$ ). The gross value added in each regional industry.

***Profit rate***. The rate of real economic profit to capital in each regional industry is calculated as $\left(\frac{B_{it}}{K_{it}}\right) = \left(\frac{Q_{it}}{K_{it}}\right) - \frac{\omega_{it}}{p_{it}}\left(\frac{L_{it}}{K_{it}}\right) - \frac{c_{it}}{p_{it}}$.

***Regional infrastructure endowment*** $(G_{it})$. The measure of regional infrastructure endowment is computed as the regional public capital stock in transport infrastructure regional (roads, ports, railways and airports) divided by capital stock in each regional industry. These may be offered by government or government agencies, by regulated private or public enterprises, or by public or private organizations.

***Human capital*** $(H_{it})$. The measure of human capital is computed as the average school enrolment by population over 25' data series for Spanish regions. Data series are constructed from Census Data of INE (Statistic National Bureau) in De la Fuente and Doménech (2006). This series has been calculated on a yearly basis.

***Public capital in regional R&D*** $(Tg_{it})$. The measure of Public capital in R&D is computed as the public administration and educational centre capital stock in R&D in each region divided by the capital stock in each regional industry. Data series are constructed from Total Expenditure on R&D from INE. R&D capital has been constructed using the perpetual inventory method, which specifies the capital for each period as the sum of capital of the previous period minus depreciated capital and plus the investment in the previous period. We have used a depreciation rate of 15 percent. See Escribá and Murgui (2007).