Regional development in Spain 1989-2010: capital widening and productivity stagnation

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REGIONAL DEVELOPMENT IN SPAIN 1989-2010: CAPITAL WIDENING AND PRODUCTIVITY STAGNATION

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ABSTRACT

This paper analyses the different factors that explain the pattern of economic growth in Spain along the 1989-2010 period. The results of our analysis provide strong evidence of stagnation in productivity throughout most of the period under study. The large investments and the strong growth in capital stocks were practically absorbed by an intense process of job creation. As a consequence, the capital/labour ratio and labour productivity levels had a very low growth, whereas total factor productivity (TFP) decreased over the period of analysis. Therefore unlike other European countries, Spain did not experience a phenomenon of capital deepening with an increase in productivity. The intense GDP pc growth in Spain was of a rather "extensive" type, mainly based on a capital widening process.

Key Words: Regional development, Infrastructures, Capital widening, Productivity stagnation, Total Factor Productivity

JEL Classification: R10, R11, R12, R13, R14

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1. INTRODUCTION

Growth accounting techniques (Aghion and Howitt 2007, Solow, 1956) are commonly used to explain the process of regional economic development. These techniques allow the decomposition of growth rates into their different components, as well as they help to explain long-term growth tendencies (Jorgenson, 1995) by analysing total factor productivity (TFP) growth patterns.

In recent decades, most advanced European countries experienced sustained economic growth based on processes of capital deepening. As many studies pointed out (Jorgenson and Stiroh, 2000; Whelan, 2000), these processes can generate increases in knowledge capital and technological improvements, as well as increases in productivity per employee. Some studies in recent decades have empirically shown large variations in the shares of labour in GDP and in the capital-labour ratios of OECD countries (Blanchard, 1997; Bentolila and Saint-Paul 2003).

The pattern of economic growth in Spain has three distinctive features: 1) A large investment effort considerably higher than in other countries; 2) The investment flows were mainly addressed to business capital; and finally 3) A strong infrastructure development, mainly environmental, social and transport infrastructures. Unlike most developed European countries, along the 1989-2010 period Spain followed a pattern of growth of extensive type based on a capital widening process, where the increase of capital stocks was mainly absorbed by an intense process of job creation and high employment levels, while the capital/labour ratios and the productivity per employee had a very low growth.

Low interest rates and an unlimited access to credit induced a strong boom (housing, economic...) from the late-90s. The sharp increase in capital stock was accompanied by a significant growth in the working population, especially in immigrants oriented to sectors such as construction and tourism with a large share of low qualified employees. Consequently, productivity per employee and TFP levels stagnated over the period 1994-1999 and decreased during the economic boom in the period (1999-2008) coinciding with the first stages of the Euro as the new currency in Spain. The outbreak of the current economic crisis in 2008 had a deep impact on the Spanish economy resulting in GDP recession and an acute job destruction with a rapid and deep downfall in employment levels and shrinking levels of GDP per capita. On the other hand, productivity per employee increased as a consequence of the strong adjustments in employment levels.

The main features of the pace of growth in the Spanish economy are apparent when compared to the EU-15 (FBBVA, 2006). Since the mid-90s until 2008, the ratio of labour productivity in Spain compared to the EU15 average fell steadily (from 81.3% in 1989 to 69.7% in 2007), with the pattern shifting to growth following the 2008 crisis (74.0% in 2010). On the contrary, regarding the evolution of GDP per capita, Spain experienced a clear convergence process with the EU-15 average up until 2008, when this path was reversed by the deep and long economic crisis in Spain.

The downward trend of total factor productivity (TFP) in the early 2000s is confirmed by the evidence provided by Mas and Quesada (2006) using panel model data together with longitudinal data by year and sector. Recently, Escribá and Murgui (2011) found similar patterns although their estimates are based on sectorial panel data focusing instead on the interregional variation in TFP.

This paper studies the determinants of labour productivity in Spain by means of the Solow model (1956) expanded with infrastructure and human capital. The model estimation is carried out using data for 17 Spanish regions (NUTs II level) over the period 1989-2010. The analysis in this paper focuses on the role of the various factors of production with special emphasis on the gap in transport infrastructure provision, private business capital and human capital and the evolution of TFP over time. The results of the estimation show a trend of stagnant productivity per employee and shrinking total factor productivity (TFP) during the intense phase of economic growth experienced in Spain from the late 90s until 2008. The econometric evidence is robust, but it is worth mentioning that the country also experienced a process of modernisation and diffusion of electronic, information and communication technologies during the period under analysis. In the last years the Spanish economy was also able to readjust their competitiveness and foreign balance. It is hard to unravel to what extent a productivity paradox could be present in Spain, but as Solow highlighted in 1987: "*You can see the computer age everywhere but in the productivity statistics*".

Our analysis show that the capital/employee ratio remained constant throughout most of the period under analysis and that productivity per worker decreased in most Spanish regions despite the large investment efforts. Throughout this process of capital accumulation, endowments in transport infrastructure doubled and infrastructural as well as accessibility gaps were largely bridged in most Spanish regions. In order to capture the adverse bottleneck effects to economic performance by the lack of adequate endowments of infrastructural networks (non-existent or extremely poor), a new variable was employed in this study. A comparative index of the adequacy of regional infrastructural endowments was defined as a measure of regional distances to the most complete and modern reference endowments at the top of the regional ranking. This index was implemented as a comparative saturation level of infrastructure provisions (with regard to the best endowed region) and used as an explanatory variable together with business and human capital in an extended version of Solow's (1956) model. This infrastructure saturation index shows the path followed by each region with regard to the allocation of capital in infrastructure comparatively with the highest standard of the most developed region. As infrastructure endowment and accessibility gaps are gradually bridged in less developed regions, the influence of infrastructure capital on productivity growth should be significantly reduced. The impact of infrastructure capital endowments must be contingent on the size of comparative infrastructure gaps, which are captured by the infrastructure saturation index.

2. BRIEF LITERATURE REVIEW

In the 1980s, within the extended Solow models, authors such as Aschauer (1989) and Munnell (1990) began to study the effect of infrastructure as a new production factor, trying to explain the drop in productivity experienced since the 60s by the world's most developed economies as a result of a lack of investment in infrastructure.

There is an extensive literature with arguments both for and against Aschauer's theory on the effectiveness of public investment policies and economic growth (Tatom, 1991; Ford and Poret, 1991). Due to diminishing returns, investments made in an economy with a low provision of infrastructure should generate greater returns and economic growth than those experienced when the stock is greater. This indicates the existence of an optimal trajectory of public capital accumulation in infrastructure (Canning and Fay, 1993; Canning and Pedroni, 1999; Roller and Waverman, 2001; Calderón and Servén, 2004). Recent works have provided evidence of poor productivity developments since the mid-90s in European countries compared with other countries, mainly the United States (Mas et al., 2008; Fitoussi, 2013).

In relation to human capital as a productive factor (Barro and Lee, 1994), recent studies using the general equilibrium model of new geographical economics have shown that peripherality and low market access pose a significant penalty to the accumulation of highly qualified human capital (Lopez-Rodriguez et al., 2007, Redding and Schott, 2003). This suggests a new channel of influence of transport infrastructure and market access on private investment in the qualification of human capital. However, recent literature highlights that economies of agglomeration operate at “overlapping scales” and that important concentration forces at work are in metropolitan areas and central regions (Farole et al. 2011). An infrastructure network and good connections with central areas can result in a "pull effect" on long-term productivity growth by reducing business costs and facilitating mobility of qualified labour.

This paper focuses on a different aspect, which has not yet been studied, the contribution of the various factors of production (with an emphasis on transport infrastructure capital) to productivity per employee and TFP in Spain. The methodology is based on an expanded Solow model distinguishing private and infrastructure (public) capital, as well as including human capital which is estimated using a panel database for the Spanish regions over the period 1989-2010. The analysis carried out in this article is related to the earlier work of Mas and Quesada (2006) investigating the evolution of productivity in Spain with longitudinal data by year and production branches. Other previous studies on Spanish regions’ productivity and the inverse correlations found with employment levels and labour market performance are also worth mentioning (Maroto-Sanchez and Cuadrado-Roura, 2006; Cuadrado-Roura and Maroto-Sanchez, 2009; Cuadrado-Roura and Maroto-Sanchez, 2011; Escribá and Murgui, 2013).

Finally, it is interesting to note that the econometric analysis carried out in this article is based on the database compiled by the “Instituto Valenciano de Investigaciones Economicas” (IVIE) in connection with the “Fundación BBVA” (FBBVA). Furthermore, the conclusions drawn from this study substantially fit with the main findings pointed out in the productivity reports for Spain (FBBVA-Ivie, 2013 and La Caixa, 2007) and related documents issued by IVIE on the capitalisation of the Spanish economy.

3. EMPIRICAL STRATEGY

Drawing from the seminal paper by Aschauer (1989) on infrastructure provision and the contribution of Hall and Jones (1999) on human capital measured in efficiency units, we depart from a Cobb-Douglas expanded aggregate production function as follows:

$$Y_{(i,t)} = A \cdot K^{\delta_l}_{hum(i,t)} \cdot K^{\delta_k}_{priv(i,t)} \cdot K^{\delta_g}_{inf\,(i,t)} \qquad (1)$$

Where Y measures the actual production of goods and services, K_{hum} represents the level of aggregate human capital, K_{priv} represents the stock of corporate aggregate capital, K_{inf} represents the stock of public capital (measured by infrastructure capital), and finally, A stands for a measure of total factor productivity (TFP).

The expanded Cobb-Douglas production function provides an appropriate tool for analysing labour productivity in Spanish regions and estimating the elasticity values for the different production factors. Although some authors (Antràs, 2004) pointed out that this specification can overestimate or underestimate productivity related coefficients, this does not seem likely in the Spanish case as labour productivity in most Spanish regions has remained stagnant along a growth process mainly based on a process of capital widening.

Drawing from the contribution of Barro and Lee (2010), human capital is measured as the weighted average of the length of each educational level multiplied by the corresponding percentage of the working population aged 25-64. Accordingly, human capital is given by the following expression:

$$K_{hum(i,t)} = L_{(i,t)} \cdot e^{\varphi(s)_{(i,t)}} \quad (2)$$

- $L_{(i,t)}$ denotes the level of labour for every region and year
- $\varphi_{(i,t)}(s)$, denotes the stock of human capital per employee as the weighted average of the duration of each educational level

Substituting this expression into equation (1), we obtain the next expanded production function:

$$Y_{(i,t)} = A \cdot \left(L_{(i,t)} \cdot e^{\varphi(s)_{(i,t)}} \right)^{\delta_l} \cdot K^{\delta_k}_{priv(i,t)} \cdot K^{\delta_g}_{inf(i,t)} \quad (3)$$

At this point, we introduce a growth path in total factor productivity (TFP) and break it down to two components. The first one captures the average cumulative rate of growth along the time trend (λ.t), whereas the second one aims to estimate the boost effect in TFP induced by increasing the rate of GDP invested in R&D. This way, TFP can be expressed as follows:

$$A = A_0 \cdot e^{\lambda \cdot t + \mu \cdot \rho_t} \quad (4)$$

Where $\lambda \cdot t$ represents the growth trend of TFP over time and $\mu \cdot \rho_t$ corresponds to the boosting effect of R&D intensity on the growth of TFP. Thus, ρ_t is defined as the increase in the percentage of GDP spent in R&D across different years. In order to compare it with the time trend in TFP, we must approximate its average cumulative rate of growth by means of λ_ρ according to the following expression:

$$\lambda_\rho = \frac{\ln \rho_t - \ln \rho_{t_0}}{t}, \text{ Remember that } \rho_t = \rho_0 \cdot e^{\lambda_\rho \cdot t} \quad (5)$$

Introducing the new variable controlling for the R&D impact on TFP in the previous growth model (3), the final expression of the model becomes:

$$Y = \left(A_0 \cdot e^{\lambda \cdot t + \mu \cdot \rho_t} \right) \cdot \left(L_{(i,t)} \cdot e^{\varphi(s)_{(i,t)}} \right)^{\delta_l} \cdot K^{\delta_k}_{priv(i,t)} \cdot K^{\delta_g}_{inf(i,t)} \quad (6)$$

Which expressed in a logarithmic form takes the following expression:

$$LnY_{(i,t)} = LnA_0 + \lambda \cdot t + \mu \cdot \rho_t + \delta_l \cdot LnL_{(i,t)} + \delta_l \cdot \varphi(s)_{(i,t)} + \delta_k \cdot LnK_{priv(i,t)} + \delta_g \cdot LnK_{inf(i,t)} \quad (7)$$

The contribution of every factor of production on the level of labour productivity (GDP per employee) can be estimated by breaking down the aggregate productivity per worker into the different production inputs and total factor productivity. Therefore, the expression (6) is reformulated as follows:

$$\frac{Y_{(i,t)}}{L_{(i,t)}} = \frac{\left(A_0 \cdot e^{\lambda \cdot t + \mu \cdot \rho_t}\right)}{L^{1-\delta_l-\delta_k-\delta_g}{}_{(i,t)}} \cdot \frac{\left(L_{(i,t)} \cdot e^{\varphi(s)_{(i,t)}}\right)^{\delta_l}}{L^{\delta_l}{}_{(i,t)}} \cdot \frac{K^{\delta_k}_{priv\,(i,t)}}{L^{\delta_k}{}_{(i,t)}} \cdot \frac{K^{\delta_g}_{inf\,(i,t)}}{L^{\delta_g}{}_{(i,t)}} \tag{8}$$

Using small letters to represent the corresponding per-capita variables, expression (8) can be written as:

$$y_{po(i,t)} = \left(\frac{A_0}{L^{1-\delta_l-\delta_k-\delta_g}{}_{(i,t)}}\right) \cdot e^{\lambda \cdot t + \mu \cdot \rho_t} \cdot e^{\varphi(s)_{(i,t)} \cdot \delta_l} \cdot k^{\delta_k}_{priv_{po}(i,t)} \cdot k^{\delta_g}_{inf_{po}(i,t)} \tag{9}$$

Assuming constant returns to scale, $\delta_l + \delta_k + \delta_g = 1$, the expression (9) can be written as follows :

$$y_{po(i,t)} = A_0 \cdot e^{\lambda \cdot t + \mu \cdot \rho_t} \cdot e^{\varphi(s)_{(i,t)} \cdot \delta_l} \cdot k^{\delta_k}_{priv_{po}(i,t)} \cdot k^{\delta_g}_{inf_{po}(i,t)} \tag{10}$$

Taking logarithms in expression (10), we obtain the first model (labelled as model A) estimated in this paper:

$$lny_{po(i,t)} = lnA_0 + \lambda \cdot t + \mu \cdot \rho_t + \delta_l \cdot \varphi(s)_{(i,t)} + \delta_k \cdot lnk_{priv_{po}(i,t)} + \delta_g \cdot lnk_{inf_{po}(i,t)} \tag{11}$$

- $lny_{po(i,t)}$ denotes the level of labour productivity (GDP per employee) for every region and year
- $\lambda \cdot t$ denotes the temporal trend of TFP for the entire set of Spanish regions[2]
- $\mu \cdot \rho_t$ denotes the boosting effect of R&D expenditures on GDP growth to TFP in the period
- $\varphi_{(i,t)}(s)$, denotes the stock of human capital per employee as the weighted average of the duration of each educational level
- $lnkpriv_{po(i,t)}$, denotes the level of private or business capital per employee
- $lnkinf_{po\,(i,t)}$ denotes the level of transport infrastructure capital per employee

The time span of the study is highly significant because it coincides with a period of strong devolution of public powers in Spain and a renovated effort in public investment, a large part of it aimed at improving regional transport infrastructures. This paper presents also another model, model B, where the impact of infrastructure capital is contingent on their relative provision levels, meaning that the effect of an increase in infrastructure capital on productivity depends on regional infrastructural gaps, which are measured as the relative distances to an adequate or optimal endowment of infrastructures, being that reference the level of the best-endowed and most developed region. This approach allows a more accurate analysis of the effect of transport infrastructure capital on the growth process of the Spanish regions.

Our index of comparative infrastructure endowments for each region (i) and every period (t), is calculated as the ratio of the capital stock of infrastructure in each region divided by the geometric mean (the square root of their product) of the population and the regional surface over the capital stock of infrastructures divided by the geometric mean of the population and the regional surface of the best endowed and most developed region. In this way, the values of the index are in the range (0,1] taking the value 1 for the best-endowed region and approaching

[2] Other studies have focused on sectorial variation (Mas and Quesada, 2006) and others in their variation between the Spanish regions (Escribá and Murgui, 2011)

to 0 for the worst performer region. The closer the index is to 1 the better endowed the region is. We have labelled this index as $satindex_{it}$. Mathematically, the index is defined in the following way:

$$satindex_{i,t} = \frac{\dfrac{k_{(i,t)}inf}{\sqrt{pop_{(i,t)} \cdot area_{(i,t)}}}}{Max\left(\dfrac{k_{(i,t)}inf}{\sqrt{pop_{(i,t)} \cdot area_{(i,t)}}}\right)} \quad (12)$$

Where *i* and *t* range, refer respectively to regions and years across the sample.

The conditional effect of infrastructure is captured by a variable that embodies the dampening effect of bridging the gap of transport infrastructure endowments with regard to their suitable reference level. In this way, the effect of transport infrastructure capital is treated as contingent on the relative levels of infrastructural endowments modulated by the saturation index:

$$satindex_{i,t}lnkinf_{(i,t)po} = satindex_{i,t} \cdot lnk_{(i,t)inf_{po}} \quad (13)$$

The introduction of this new variable replacing capital stock in infrastructure provides an alternative estimation to model A to estimate the relative influence of production factors on productivity per employee. This alternative estimation is labelled in the paper as model B and takes the following expression:

$$lny_{po(i,t)} = lnA_0 + \lambda \cdot t + \mu \cdot \rho_t + \delta_l \cdot \varphi(s)_{(i,t)} + \delta_k \cdot lnk_{priv_{po}(i,t)} + \delta_g \cdot satindex1_{i,t}\, lnk_{inf\ po(i,t)} \quad (14)$$

- $lny_{po(i,t)}$ represents the log of labour productivity for every region and year
- $\lambda \cdot t$ represents the temporal trend of TFP for the entire set of Spanish regions
- $\mu \cdot \rho_t$ denotes the boosting effect of R&D expenditures on GDP growth to TFP in the period $\varphi_{(i,t)}(s)$, represents the stock of human capital per employee as the weighted average of the duration of each educational level
- $lnkpriv_{po(i,t)}$, represents the log of private or corporate capital per employee
- $satindex1_{i,t}lnkinf_{po,i,t}$ denotes the new variable resulting from modulating regional levels of infrastructure capital by their saturation indexes (distance to the reference level of the best-endowed region at the end of the period), where $saturindex1_{i,t}$= (1 - $saturindex_{i,t}$)

The longitudinal combination of time and cross-sectional data (panel data) allows for coping with unobserved heterogeneity and minimises the possibility of estimating errors. However, the Wooldridge and Wald tests respectively detect problems of autocorrelation and heteroscedasticity in our sample. Due to the existence of heteroscedastic errors, we use panel-corrected standard errors (PCSE) in order to control for these problems. This methodology is applied to the estimation of the two models proposed in the paper, named model A and B.

4. DATA AND DESCRIPTIVE STATISTICS

The statistical dataset economic variables have been provided by the "Instituto Valenciano de Investigaciones Economicas" (IVIE) that with the "Fundación BBVA" (FBBVA) have compiled a regional accounting dataset for the Spanish economy with linked series 1980-2011 from the Spanish National Institute of Statistics (INE). These variables have been consistently developed in accordance with the methodological criteria recommended by experts and international institutions in order to facilitate comparative international analysis. Furthermore, this dataset satisfies usual reliability conditions and has been incorporated in other international databases (STAN, PDB and PDBi[3]) of the OECD and the EU KLEMS project (elaborated within the EU research policy, Sixth Framework Programme). It is worth mentioning that all monetary variables used are expressed in euros at constant 2000 values. Finally, the data from other variables, such like R&D expenditures as percentage of GDP and the average duration of each educational level, have been extracted from the Spanish National Institute of Statistics.

The database for this study is made of a panel of 374 individual observations corresponding to longitudinal year data for the 17 Spanish regions along the 1989-2010 period. The variables used for the analysis were as follows: GDP to analyze the productivity of the labour force; Net capital stock as accumulated wealth, divided into private capital as non-housing business capital and capital stock of land transport infrastructure. The employee data refer to employed persons, employed people and self-employed people. R&D expenditures are approximated as percentage of GDP and human capital is calculated as the weighted average of the duration of each level by the percentage of population aged 25-64.

Tables 1 and 2 show the descriptive statistics of the variables used in the two models estimated in the paper. It is worth highlighting that the database is a strong balanced panel with a full set of observations (374) with no values missing for any of the variables used in the analysis.

Table 1: Summary and description of variables	Obs	Mean	Std. D.	Min	Max
lny_{po} (logarithm of output per employee)	374	10.569	0.142	10,135	10,856
t (variable to estimate the time trend of TFP)	374	1999.5	6.3528	1989	2010
ρ_t (variable to control for the effect of GDP as an accelerator of TFP growth)	374	0.782	0.468	0.09	2.41
$\varphi(s)$ (stock of human capital per employee)	374	1.0575	.0777	0.82	1.23
lnk_{privpo} (logarithm of private capital per employee)	374	10.889	.1852	10,172	11,345
lnk_{infpo} (logarithm of capital stock in transport infrastructure per employee)	374	8.9043	.4561	7.7037	9.7432
$satindexlnk_{infpo}$ (saturation index of relative distance to the infrastructure of reference)	374	3.0290	1.5517	.6376	8.8401

Source: Own elaboration with Stata 13 from FBBVA-Ivie database

To explore the relationship between the different variables in the model, the correlation matrix in table 2 shows the direction and intensity of the correlation coefficients between all the variables in the model. It can be observed that all the variables have positive relationships between them, although there are differences in their intensities.

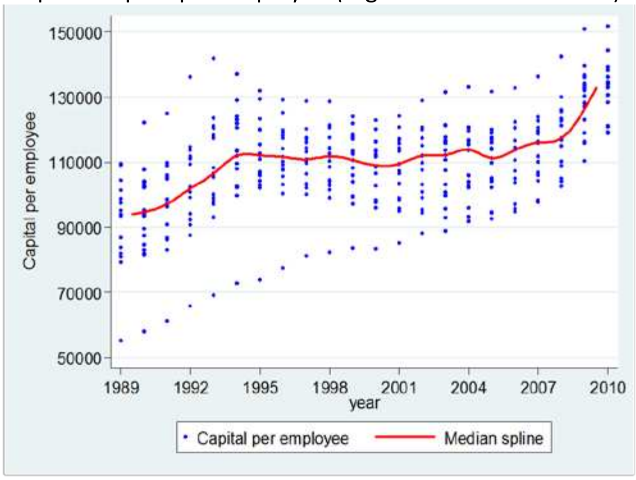
Table 2: Correlations between variables

	lny_{po}	t	ρ	φ(s)	lnk_{privpo}	lnk_{infpo}	$satindexlnk_{infpo}$
lny_{po}	1.0000						
t	0.1172	1.0000					
ρ_t	0.5652	0.4099	1.0000				
φ(s)	0.4940	0.8583	0.6383	1.0000			
lnk_{privpo}	0.5416	0.5386	0.4395	0.6136	1.0000		
lnk_{infpo}	0.0121	0.2377	0.0985	0.1047	0.4270	1.0000	
$satindexlnk_{infpo}$	0.5286	0.4844	0.6957	0.6711	0.4878	0.3349	1.0000

Source: Own elaboration with Stata 13 from FBBVA-Ivie database

[3] Structural Analysis Database (STAN), Productivity Database (PDB) and by Industry Productivity Database (IBDP).

Graph 1: Capital per employee (regression & median line)

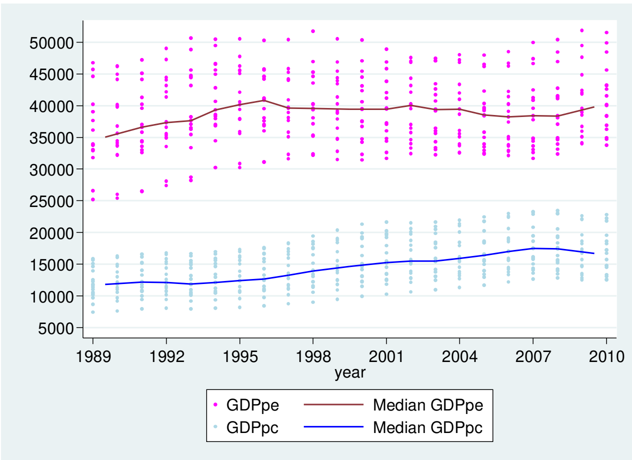


Source: Elaborated from FBBVA-IVIE database

The evolution of capital per employee in the Spanish regions, depicted in graph 1, clearly shows a stagnation path along the central part (1994-2005) of the period under study. In spite of large volume investments and increasing capital stocks, the ratio of capital per employee remained constant in most of the Spanish regions during this relatively long period of growth (1995-2005).

The lower part of Graph 2 shows the fast and important process of growth of GDP per capita in Spain during the period of 1999-2007. However, this intense development process was linked to a strong expansion in employment (both employed and working population) and the majority of the large investments were mainly absorbed by a strong jobs creation process with almost no capital deepening and technological improvement in TFP. Consequently, as shown in the upper part of graph, productivity per employee (GDP/employee) stagnated or even declined in Spain from the late 90s until the outbreak of the 2007 crisis.

Graph 2: Labour productivity and GDPpc (median lines)



Source: Elaborated from FBBVA-IVIE database

Both Graphs 1 and 2 together provide a visual image of the most prominent features of the growth process in Spain: 1) Stagnant capital ratio per employee and absence of capital deepening, 2) intense growth of per capita income driven both by job creation and increases in the working population, and finally 3) a serious stagnation problem in productivity per employee and a decline in TFP. These problems together with other unbalances (huge foreign payments deficit and high private indebtedness) made Spain highly vulnerable to the impact of the 2007 crisis.

5. RESULTS

Table 3 reports the results of the coefficients estimated for the two models used in the analysis. The first model (model A) uses a log transformation of regional levels of infrastructure capital, lnk_{infpo}, whereas the second, (model B), uses a more helpful variable, the $satindexlnk_{infpo}$, aimed at capturing regional distances to an adequate reference level of infrastructure endowments. This latter variable modulates regional levels of infrastructure stock using a saturation index built by taking into account regional surface areas and the population, as well as distances to the most convenient infrastructure standard in the best-endowed, most developed region along the whole period (the reference level is placed in the last years of period, being Madrid at 2010).

Table 3: Contributions to the productivity growth

	Model A	Model B
cons	30.49*** (10.99)	32.66*** (11.84)
t	-0.0133*** (-9.08)	-0.0142*** (-9.80)
ρ_t	0.0347** (3.25)	0.0273* (2.52)
φ(s)	0.605*** (4.77)	0.553*** (4.46)
$\ln k_{privpo}$	0.581*** (16.19)	0.521*** (17.43)
$\ln k_{infpo}$	-0.0370* (-2.02)	
satindex$\ln k_{infpo}$		0.0163** (2.89)
R2	0.99	0.99
Number of Obs	374	374
Number of regions	17	17

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
(*t* statistics in parentheses)
Source: Own elaboration with Stata 13 from FBBVA-Ivie database

Model A, corresponding to equation (11), shows that the variables with the greatest influence on productivity per employee in Spain are private capital (0.581) and human capital (0.605). Both coefficients in a double logarithmic equation are estimators of the correlative elasticity of both variables on productivity per employee. The variable transport infrastructure capital is only significant at the 5% level and its sign is the opposite to that expected (-0040). An interesting result in model A is that efforts in R&D expenditure boost growth of TFP. The coefficient of ρ_t is significant at the 1% level and its estimated value (0.0347) means that an increase of 1% in the average annual cumulative rate of growth of the share of R&D expenditure on GDP, induces an additional growth of 0.0347 percentage points to the average cumulative TFP rate of growth. The coefficient of ρ_t can be translated in terms of a component of the cumulative rate of growth of TFP by applying expression (5). In this way, it can be estimated that the effort in R&D expenditures contributed around 0.0014 to the period. However, the time trend of the TFP in the period is negative with an average cumulative rate (λ) of -0.013 and consequently R&D expenditure effort was insufficient to correct this tendency with the net value of the cumulative rate of growth of TFP in Spain along the whole 1989-2010 period reaching -0.012. These results show a strong stagnation problem in productivity per employee and a continuous decline in TFP along the period.

In line with the previous model, the model B estimation (based on equation 14) again shows private capital (0.521) and human capital (0.553) to be the most influential variables on the levels of productivity per employee.

However the new variable (santindex$\ln k_{infpo}$) which intends to capture the impact of regional transport infrastructure capital as contingent on the degree of saturation of the comparative infrastructure endowments, performs considerably better than in the previous model. As reported in Table 3, capital stock in transport infrastructure conditioned by the saturation index makes a significant and positive contribution (0.0163) to productivity levels. This estimated value corresponds to a standard value of the saturation index equal to 1. Consequently, for regions and time periods with saturation indices below the standard of reference, the elasticity of output per worker with regard to infrastructure endowments (δ_g) must be obtained by dividing this coefficient by the rate of the saturation of each region in the corresponding periods. In this manner, the elasticity of the output per worker to infrastructure capital becomes higher for less developed and worse endowed regions and for the early stages of the period when most Spanish regions suffered from a significant lack of adequate infrastructure endowments. In the years 1989, 1999 and 2010, output per employee in the most peripheral and backward regions, Andalusia and Galicia exhibited elasticity with regard to regional capital in transport infrastructures of 0.066 and 0.053, consecutively whereas in 1989, these values dropped to 0.035 and 0.025 in 1999, and finally fell to 0.024 and 0.016 in 2010.

These results are in line with previous studies. De la Fuente (2010) shows evidence that public investment in infrastructure had a positive impact on production and employment in Spain and that convergence in the retributive levels of human capital between Spanish regions had been encouraged since its accession to the EU. However, he also notes that this process could involve a significant cost in terms of efficiency.

Finally, model B again shows a positive effect of R&D effort on regional levels of productivity per employee, but both the estimated parameter (0.031) and the significance level (5%) are slightly lower than in the previous model. With the exception of the reinforced role played by transport infrastructure capital in regions lacking adequate endowments, the results from both models are relatively similar.

These results confirm, once again, the problems of productivity stagnation along the phase of rapid growth in Spain over the 1989-2010 period. Apart from a possible "productivity paradox" (given that the country experienced a major change in its efforts in R&D expenditures and ICT diffusion[4]), evidence shows a serious problem of productivity in the growth model of Spain in the period. The intense investment effort was not accompanied by increased TFP or by capital deepening to increase labour productivity. The increase in capital stock was mainly absorbed by a strong growth of employment (both employees and the working population) in a clear capital widening process lacking sufficient improvements in production technology and in productivity per employee. There seems to be a “trade off” between employment and labour productivity in Spain as the productivity per employee stagnated during the growth and employment boom, whereas productivity increased once again following the 2008 crisis and the subsequent recession and brutal employment adjustments with a dramatic number of jobs destruction.

Overall, the process of the growth of the Spanish economy has been characterised by an intense rate of expansion of both GDP and of the employed population (with high rates of growth of GDP per capita) during the economic boom which started in the late 90s and lasted until the outbreak of the financial crisis of 2007 and its subsequent impact. Following 2008, the situation changed dramatically with a contraction in economic activity and strong job destruction, a brutal employment adjustment that finally led to increasing productivity.

[4] The share of households with broadband access to Internet grew from 38% in 2006 to 57.8% in 2010.

6. CONCLUSIONS

The results of our paper show evidence of the “extensive” nature (mere capital widening) of the intense growth process experienced by the Spanish economy along the 1989-2010 period. Economic growth in Spain was based on large investments and a strong path of capital accumulation but capital increases were mainly absorbed by extensive job creation and strong employment growth (both in the working and employed population). Evidence strongly supports a mere process of capital widening without triggering any significant increases in productivity per worker due to a capital deepening process or an improvement in TFP. On the contrary, there is evidence of a persistent decline in TFP at an average cumulative rate of over 1%.

It is worth highlighting that efforts in R&D expenditure were a significant driver of TFP growth. However, despite its rapid growth since the late 90s, R&D expenditure levels remained low and insufficient to reverse the negative trend of TFP. This again confirms the extensive nature and mere capital widening process of the intense growth experienced by the Spanish economy from the late 90s until the outbreak of the economic crisis.

Investment in infrastructure has proved to be extremely important in the less advanced regions of Spain, which did not have sufficient transport infrastructure to improve the functioning of the economy or its human capital. However, once the region reaches the minimum adequate level of market accessibility, the impact of infrastructure on productivity growth is reduced significantly. This is due to the nature of transport infrastructure, as their positive impact on productivity improvements in other productive factors but nevertheless this impulse is not reciprocal.

A fruitful research avenue along the lines of this paper includes a review of the historical series, region by region, looking for patterns of growth and the impact of infrastructure on enhancing market accessibility and reducing peripherality problems. An additional future research path would be the analysis of temporary differences by region with VAR models.

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