Three essays on peripherality and economic development

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Abstract

Chapter 1 derives a panel data econometric specification which relates the different factors that explain the pattern of economic growth in Spain along the 1989-2010 period. The growth of GDP per capita (GDPpc) in Spain up until the crisis of 2008 was characterised by strong job creation and productivity stagnation. Unlike other European countries, Spain did not experience the phenomenon of capital deepening with increasing productivity, as the GDPpc intense growth in Spain was of a rather extensive growth, mainly based on a capital widening process. After the crisis, the situation was dramatically reversed with productivity increases resulting from a brutal contraction of employment.

Chapter 2 analyse the main features which characterize the regional development in Spain since the launching of the European Cohesion Policy (1989) to the present. Over the last twenty years, Spain has stood out for the rapid growth of per capita income, capital accumulation and creation of employment. However, the most important structural phenomenon of growth of the Spanish economy, especially in the decade from 1998-2007, was the limited growth in terms of output per worker and total factor productivity (TFP), which in combination with wage increases has led to a loss of competitiveness for Spain both at global level and as at EU.

Chapter 3 presents the main aspects of the role and functions of infrastructure investments in EU policies. The approach focuses on the policy of economic and social cohesion but also considers the European transport policy and especially the trans-European transport networks (TEN). Investments in transport infrastructure projects and public services (telecommunications, energy, water, sanitation, etc.) played an important role in regional development policy, preferably financed by the ERDF Fund in the less developed countries of southern Europe (Greece, Spain and Portugal). The unification of the internal market led to the new policy of economic and social cohesion conceived as an investment policy aimed at reducing disparities in growth in the less developed regions. The priorities in infrastructure and transport projects have evolved with the different political enlargement of the Union. Despite that has been praised and criticized the role of investment in transport infrastructure within the European cohesion policy, it still relevant investment for less developed regions and TEN-T retains considerable importance.

Resumen

El capítulo 1 se deriva una especificación econométrica de datos de panel que relaciona los diferentes factores que explican el patrón de crecimiento económico en España en el periodo 1989-2010. El crecimiento del PIB per cápita (PIBpc) en España hasta la crisis de 2008 se caracterizó por una fuerte creación de empleo y el estancamiento de la productividad. A diferencia de otros países europeos, España no ha experimentado un fenómeno de intensificación del capital con aumento de la productividad, ya que el fuerte crecimiento del PIBpc en España fue más bien un crecimiento de tipo extensivo, principalmente basado en un proceso de ampliación de capital. Después de la crisis, la situación se revirtió drásticamente con aumento de la productividad debido a una contracción brutal del empleo.

El capítulo 2 analiza los principales rasgos que caracterizan el desarrollo regional en España desde la puesta en marcha de la Política Europea de Cohesión (1989) hasta la actualidad. Durante los últimos veinte años, España ha destacado por un rápido crecimiento de la renta per cápita, acumulación de capital y creación de empleo. Sin embargo, el fenómeno estructural más importante de fuerte crecimiento de la economía española, especialmente en la década 1998-2007, fue el limitado crecimiento en términos de producción por trabajador y la productividad total de los factores (PTF), y en combinación con los aumentos salariales ha llevado a una pérdida de competitividad de España a nivel mundial y dentro tanto a la UE.

El capítulo 3 presenta los principales aspectos del papel y las funciones de las inversiones en infraestructura de las políticas de la UE. El enfoque se centra en la política de cohesión económica y social, pero también considera la red de transporte, especialmente la transeuropea (RTE) y la política europea de transportes. Las inversiones en proyectos de infraestructura de transporte y servicios públicos (telecomunicaciones, energía, agua, saneamiento…) juegan un papel importante en la política de desarrollo regional, básicamente financiado por los Fondos FEDER en los países menos desarrollados del sur de Europa (Grecia, España y Portugal). La unificación del mercado interior llevó a la nueva política de cohesión económica y social concebida como una política de inversión dirigida a reducir las disparidades en el crecimiento en las regiones menos desarrolladas. Las prioridades en los proyectos de infraestructura y de transporte han evolucionado al mismo tiempo que los diferentes ampliación político de la Unión. Se ha elogiado y criticado el papel de la inversión en infraestructuras de transporte dentro de la política de cohesión europea, pero conserva una importancia considerable en la inversión en las regiones menos desarrolladas y de la RTE-T.

Resumo

O capítulo 1 derívase unha especificación econométrica de datos de panel que relaciona os diferentes factores que explican o patrón de crecemento económico en España no período 1989-2010. O crecemento do PIB per cápita (PIBpc) en España ata a crise de 2008 caracterizouse por unha forte creación de emprego e o estancamento da produtividade. A diferenza doutros países europeos, España non experimentou un fenómeno de intensificación do capital con aumento da produtividade, xa que o forte crecemento do PIBpc en España foi máis ben un crecemento de tipo extensivo, principalmente baseado nun proceso de ampliación de capital. Logo da crise, a situación se reverteu drasticamente con aumento da produtividade debido a unha contracción brutal do emprego.

O capítulo 2 analiza os principais trazos que caracterizan o desenvolvemento rexional en España desde a posta en marcha da Política Europea de Cohesión (1989) ata a actualidade. Durante os últimos vinte anos, España destacou por un rápido crecemento da renda per cápita, acumulación de capital e creación de emprego. Con todo, o fenómeno estrutural máis importante de forte crecemento da economía española, especialmente na década 1998-2007, foi o limitado crecemento en termos de produción por traballador e a produtividade total dos factores (PTF), que en combinación cos aumentos salariais ten levado a unha perda de competitividade de España a nivel mundial e dentro tanto á UE.

O capítulo 3 presenta os principais aspectos do papel e as funcións dos investimentos en infraestrutura das políticas da UE. O enfoque céntrase na política de cohesión económica e social, pero tamén considera a rede de transporte, especialmente a transeuropea (RTE) e a política europea de transportes. Os investimentos en proxectos de infraestrutura de transporte e servizos públicos (telecomunicacións, enerxía, auga, saneamento...) xogan un papel importante na política de desenvolvemento rexional, basicamente financiado polos Fondos FEDER nos países menos desenvolvidos do sur de Europa (Grecia, España e Portugal). A unificación do mercado interior levou á nova política de cohesión económica e social concibida como unha política de investimento dirixido a reducir as disparidades no crecemento nas rexións menos desenvolvidas. As prioridades nos proxectos de infraestrutura e de transporte han evolucionado ao mesmo tempo que os diferentes ampliación político da Unión. O papel do investimento en infraestruturas de transporte foi eloxiado e criticado dentro da política de cohesión europea, pero conserva unha importancia considerable no investimento nas rexións menos desenvolvidas e da RTE-T.

Introduction

El objetivo de la presente tesis doctoral es triple: a) Analizar los factores que influyen en el crecimiento económico y la productividad laboral de las regiones españolas a lo largo del periodo 1989-2010, b) Analizar si los patrones de localización geográfica de la actividad económica debido a las diferencias en la dotación de infraestructuras y acumulación de capital humano tienen influencia para el desarrollo en el caso español y c) analizar en qué medida los patrones de crecimiento observados en las regiones españolas pueden vincularse a la ayuda de los Fondos de la Política de Cohesión de la UE.

La investigación que se presenta en esta tesis doctoral se inicia (capítulo 1) con un análisis mediante datos de panel de la evolución de la productividad de la economía española para el periodo 1989-2010 y su explicación a través de la ecuación del modelo de Solow (1956) ampliado con las aportaciones de Aschauer (1989) sobre las infraestructuras, la cual ha recibido tanto elogios como críticas en la literatura reciente, y de Barro y Lee (1994) sobre el capital humano.

La evolución favorable de la economía española desde mediados de los años 90 hasta el inicio de la crisis de 2008 ha permitido una mejora notable de los niveles de desarrollo económico. El crecimiento del PIB per cápita (PIBpc) en España en la época de expansión se caracterizó por una fuerte creación de empleo y estancamiento de la productividad. A diferencia de otros países europeos, España no ha experimentado un fenómeno de intensificación del capital con aumento de la productividad, ya que el fuerte crecimiento del PIBpc en España fue más bien un crecimiento de tipo extensivo, principalmente basado en un proceso de ampliación de capital. Después de la crisis, la situación se revirtió drásticamente con aumento de la productividad debido a una contracción brutal del empleo.

A pesar de que el patrón de crecimiento de la economía española en la década de los años 2000 era frágil e insostenible en el largo plazo (capítulo 2) basado en una excesiva confianza en la integración económica en la UE, la evolución del crecimiento de las diferentes regiones españolas ha sido desigual. Para estudiar el comportamiento general de la economía española y de cada una de sus regiones se analizan los principales patrones de crecimiento en España y su desarrollo diferente respecto de la UE-15.

Para hacer frente a esta fragilidad de la economía española se proponen medidas necesarias para el aumento de la productividad: 1) mayor tamaño de las empresas para competir en un mundo cada vez más globalizado. 2) reorientación del patrón productivo español hacia actividades de mayor valor añadido y un uso más intensivo de las TIC. 3) Fomentar la comercialización de los resultados de la economía del conocimiento y la innovación tecnológica.

El patrón de crecimiento español se enmarca dentro de las políticas de cohesión territorial y de red de transporte de la Unión Europea (capítulo 3). Por ello se

explicarán los principales aspectos y funciones que las inversiones comunitarias, principalmente de los Fondos de Cohesión y del FEDER, en infraestructuras de transporte y servicios públicos (telecomunicaciones, energía, agua, saneamiento...) si han supuesto un progreso de las regiones de los países del sur de Europa menos desarrolladas (Grecia, España y Portugal) para la unificación del mercado interno europeo.

Desde entonces, las prioridades de los proyectos de infraestructura y transporte en la política de cohesión (así como en el papel de los diferentes fondos que participan) han evolucionado, pero el peso de las inversiones en infraestructuras sigue manteniendo una importancia considerable en las regiones menos desarrolladas y en la Red Transeuropea de Transporte (RTE-T).

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Chapter 1 - Regional development in Spain 1989-2010: Capital widening and productivity stagnation

1.1. 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 remained almost constant 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, TFP

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

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1.2. 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 an extensive type pattern of growth 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 remained almost constant. Low interest rates and an unlimited access to credit induced a strong boom (housing, financial...) 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 a GDP recession and acute job destruction with a rapid and deep downfall in employment levels, as well as 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.

1.3. 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., 2010; 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 are at work 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 fully studied yet for the period 1989-2010, the contribution of the various factors of production (with an emphasis on transport infrastructure capital) to productivity per employee and TFP in Spain. Other studies have made significant contributions on this subject with different methodologies such as the stochastic frontier (Pedraja et al., 1999; Delgado and Alvarez-Ayuso, 2004) or with a sector approach (De la Fuente and Vives, 1995; Cantos et al, 2002; De la Fuente, 2010).

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, 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.

1.4. 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:

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

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:

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

• $L_{(i,t)}$ 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:

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

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:

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

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:

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

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:

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

Which expressed in a logarithmic form takes the following expression:

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

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:

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

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

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

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

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

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

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

- $lny_{po(i,t)}$ 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[1]
- $\mu \cdot \rho_t$ 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 corporate 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 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:

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

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

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:

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

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:

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

- $lny_{po(i,t)}$ 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
- $satindex_{i,t}lnkinf_{po,i,t}$ 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).

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.

1.5. Data and descriptive 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 statistical data stem from the regional database developed by

the BBVA Foundation-IVIE for the Spanish economy, with two sections providing regional data on Capital Stocks and Human Capital in the Spanish Economy.

This database has been consistently developed in accordance with the methodological criteria recommended by experts and international institutions in order to facilitate comparative international analysis. Furthermore, it satisfies usual reliability conditions and has been incorporated in other international databases (STAN, PDB and PDBi[2]) of the OECD and the EU KLEMS project (elaborated within the EU research policy, Sixth Framework Programme). Finally, it is worth mentioning that all monetary variables used are expressed in euros at constant 2000 values.

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.

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

Table 2: Correlations between variables

	$\ln y_{po}$	t	ρ	$\varphi(s)$	$\ln k_{privpo}$	$\ln k_{infpo}$	satindexlnk_{infpo}
$\ln y_{po}$	1.0000						
t	0.1172	1.0000					
ρ_t	0.5652	0.4099	1.0000				
$\varphi(s)$	0.4940	0.8583	0.6383	1.0000			
$\ln k_{privpo}$	0.5416	0.5386	0.4395	0.6136	1.0000		
$\ln k_{infpo}$	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

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

Source: Elaborated from FBBVA-IVIE database

Graph 2: Labour productivity and output pc (median lines)
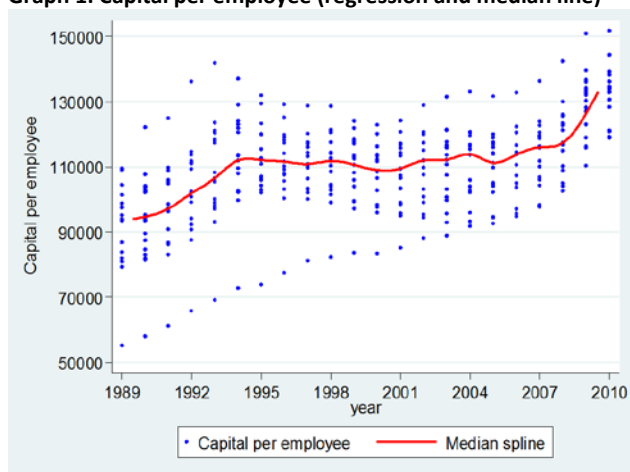
Source: Elaborated from FBBVA-IVIE database

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).
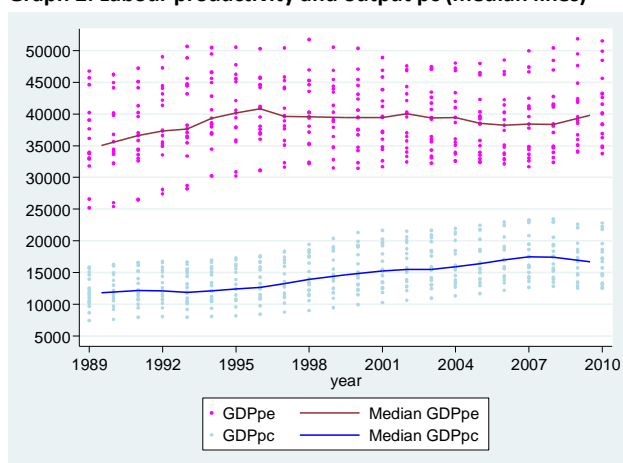
The lower part of Graph 2 shows the fast and important process of growth of GDP per capita in Spain during the period of 1999-2007. However, this intense development process was linked to a strong expansion in employment (both employed and working population) and the majority of the large investments 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.

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.

1.6. 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, lnkinfpo, whereas the second, (model B), uses a more helpful variable, the satindexlnkinfpo, 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 the period, being Madrid at 2010).

Table 3: Contributions to the productivity growth

	Model A	Model B
cons	30.49***	32.66***
	(10.99)	(11.84)
t	-0.0133***	-0.0142***
	(-9.08)	(-9.80)
ρ_t	0.0347**	0.0273*
	(3.25)	(2.52)
$\varphi(s)$	0.605***	0.553***
	(4.77)	(4.46)
lnk_{privpo}	0.581***	0.521***
	(16.19)	(17.43)
lnk_{infpo}	-0.0370*	
	(-2.02)	
$satindexlnk_{infpo}$		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.

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 (santindexlnk$_{infpo}$) 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.

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 are in line with the previous studies that analyse the role of private capital and transport infrastructure at regional growth. De la Fuente and Vives (1995) and De la Fuente (2010) show 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 accession to the EU. De la Fuente also notes that this process could involve a significant cost in terms of efficiency. In addition, Delgado and Alvarez (2004) and Pedraja et al. (1999) obtained similar results for private capital and infrastructures, measures in physical units, with a methodology based in a production function with a stochastic efficiency frontier. Moreover, Cantos et al. (2002) indicates that the infrastructures had an important role in economic growth of Spanish regions between 1965 and 1995.

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[3]), 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.

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

1.7. 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 future 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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Chapter 2 - Regional development and structural change: The productivity paradox of Spanish peripheral regions

2.1. Introduction

Over the last twenty years, Spain has stood out for the rapid growth of per capita income, capital accumulation and creation of employment. However, the most important structural phenomenon of the strong growth of the Spanish economy, especially in the decade from 1998-2007, was the limited growth in terms of output per worker and total factor productivity (TFP), which in combination with wage increases has led to a loss of competitiveness for Spain at global level and within both at a EU.

The growth of an economy is determined by its ability to accumulate productive factors (capital and labour) and the productivity with which these factors are used. Specifically, the way in which productivity behaves is a key factor in the capacity for long-term growth potential of any economic space (Krugman, 1990). In this case it is convenient to have information on trends in terms of output per worker (apparent labour productivity) and the main variables that affect it. The apparent labour productivity or productivity measures the output obtained for each labour unit in the production process (the number of people employed in production)[4], thereby making it an indicator of productive efficiency. However, this is a partial indicator, as it can be directly influenced by the quantities used of other factors, specifically the capital-labour ratio, as well as the human capital itself and the technological characteristics of the production processes of the economy.

The aim of this chapter is to analyse the main features which characterize the regional development in Spain since its accession to the EU (1986) and the effective launching of the European Cohesion Policy (1989[5]).

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[4] Nevertheless, labour productivity is influenced by the technology that is available, the composition of the work and the amount of remaining production factors used.

[5] The new European Cohesion Policy (formally introduced by the Single European Act in 1987) was effectively started by the first 1989-93 programming period.

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2.2. Peripherality and backwardness in the Spanish regions

The pioneering study by Redding and Schott (2003) developed a theoretical explanation for the difficulty that peripheral regions have to achieve high levels of income and wealth, showing that the most highly qualified types of work are typically concentrated in industrial sectors (or localised).

The central countries are specialised in highly qualified sectors, while the peripheral areas have to compensate their competitive disadvantage of having less access to the markets with lower salaries and payments. This effect reduces the benefits of salaries paid to highly qualified workers, and reduces any incentives towards investing in human capital. In the EU there is empirical evidence of a spatial structure of educational attainment levels that takes the shape of a positive correlation between market access and the number of years spent in education, as well as between the percentage of the population with the high educational levels and market access (Lopez-Rodriguez, Faiña and Lopez Rodriguez, 2007).

As a result, the peripheral regions, lacking corrective measures, focus on poorly qualified human capital, and their populations will have lower levels of academic achievement. This also applies to specific and qualified resources, meaning that peripheral locations with low access to the main markets constitute an important penalty for their growth and convergence to the most centrally located and advanced ones.

Apart from the forecasts regarding the dynamics affecting the spatial concentration of economic activities, geographical economics models (Head and Mayer, 2004, 2006) explain the significant differences in wages and per capita income (nominal wage equation) between peripheral and central areas, extensively supported by the empirical estimation of the nominal wage equation of different settings (Lopez-Rodriguez and Faiña, 2007; Lopez-Rodriguez et al. 2007b; Redding and Venables, 2004; Hanson, 2005; Mion, 2004; Garcia-Pires, 2006).

Figure 1 shows the spatial structure of the European Union, considering all of the countries belonging to the European economic space, including Norway and Switzerland. Europe's economic activities are concentrated in a large central area (London-Paris-Ruhr), with successive concentric lines of decreasing accessibility to the markets, in a sort of core-periphery pattern or centre-periphery gradient together with the areas of concentration in the north of Italy.

The recent situation in Europe does not seem to indicate that that there has been a rapid increase in the spatial concentration due to a reduction in transportation costs and economic concentration (López-Rodríguez et al., 2007a), but instead the spatial structure of the regional differences in per capita income has clearly been maintained.

Figure 1: Spain and spatial structure of European Economic Space
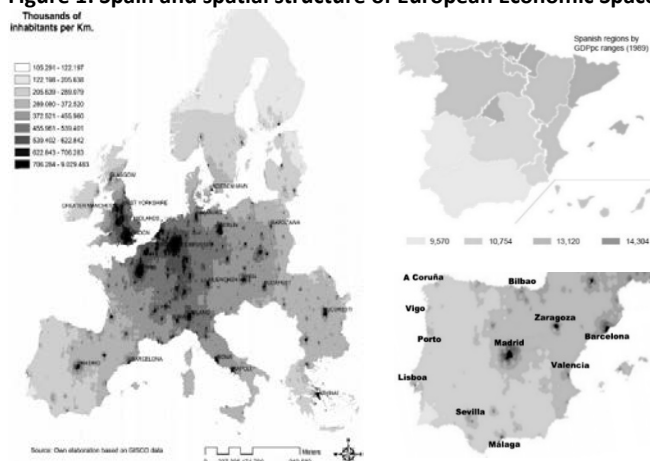
The right side map at the bottom of Figure 1 describes the spatial structure of the Iberian Peninsula. In Spain, it can be seen that there is a clear difference in terms of accessibility to the markets between the North-East quadrant which takes in Basque Country, Madrid and Catalonia and the rest of the peripheral areas in the centre of the peninsula (Castile and Extremadura)

Source: Faíña and López-Rodríguez (2006)

the South in Andalusia and Murcia, and in the Atlantic North-West, corresponding to Galicia and Asturias.

Traditionally, the areas in the North-East quadrant, closest to the rest of Europe and with the greatest market access correspond to the most developed parts of the country, with a large percentage of population and economic activities, and generating the highest levels of growth and per capita income. These regional differences in the development of Spain can be seen in the top right side map of Figure 1.

The accession of Greece, Spain and Portugal to the EU was followed by a change in the Economic and Social Cohesion Policy (European Single Act, 1987), which from 1989 onwards dedicated a significant part of its resources to regions with structural development deficits (known as Objective 1 regions). Countries within the EU experienced a significant convergence in terms of per capita income, although at regional level there are more doubts regarding convergence and the reduction of differences in terms of growth and per capita income.

The traditional approach towards dealing with the adverse effects of remoteness focused on improving access and reducing distance costs by improving transport infrastructures (roads, railways, ports and airports). However, the current growth models have been extended to include the importance of human capital, emphasising the movement of the economy towards services, improving technologies and significantly reducing transport costs, as well as the development of ICTs, eliminating trade barriers and promoting greater European integration, to help soften the adverse effects of remoteness.

In the case of Spain, its peripheral location and size were combined with a major lack of capital provisions at public and private level. The resources provided by the EU's regional policy allowed for an extensive investment programme focusing on

territorial integration and providing access to the markets for Spanish regions (most of which were in peripheral regions), as well as improving environmental infrastructures, education and health (human capital) and the capital and business capacities of the productive system.

The result was an important process of economic development, with cumulative growth rates in per capita income well above the average for the former EU15 in the period 1989-2010. In Spain, this convergence in per capita income also applies to all its regions, including the most peripheral and underdeveloped ones, which grew faster than the EU15 average.

2.3. Economic Growth in Spain

2.3.1. A growth policy heavily based on investment

One of the most relevant features of the growth process in Spain is the fact that it was driven by a major process of investment and accumulation of capital.

The graphics in both sides of Figure 2 show the evolution of the capital stock and the investment effort of the Spanish economy from 1989 onwards. The stock of real (net) capital more than doubled during the period 1989-2010. However, despite starting out with low capital stock volumes, the period with the highest investment effort in terms of the ratio investment/capital stock was not the initial period between the end of the 1980s and early 90s, but instead the booming period of the Spanish economy was from 1997 until 2007, when as a result of the current economic downturn and subsequent recession, the investment effect decreased and the accumulation of capital of the Spanish economy slowed down (FBBVA-Ivie, 2013).

Figure 2: Evolution of the capital stock and investment effort of the Spanish economy (1989-2010)
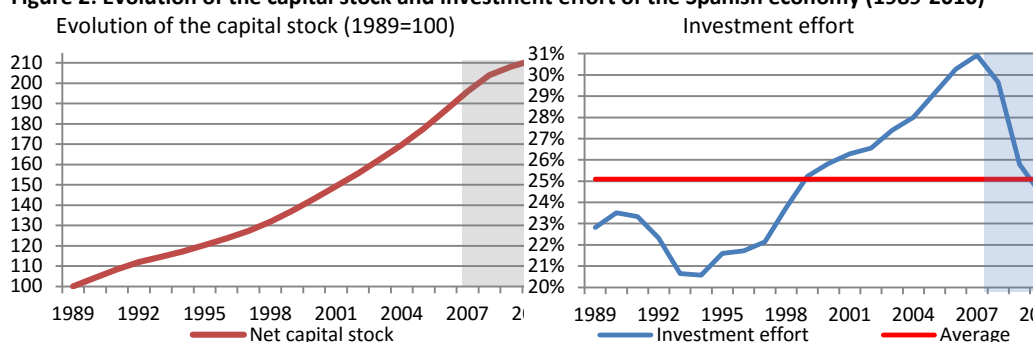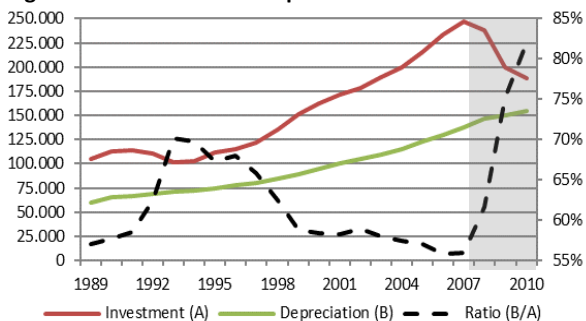

Source: Own elaboration from the database of FBBVA-IVIE, 2013

The drop in income and adjustments with high unemployment rates hinder the sustainability of a model with large stocks of capital, as depreciation starts to represent a very significant proportion of reduced flows of investment (FBBVA-IVIE, 2013). The consequences of the drop in investment were dramatic, and capital

depreciation rose to very significant percentages of the investment (more than 80% in 2010).

As a result of this major process of capital accumulation, the operating conditions of the Spanish economy changed dramatically, and the depreciation of the capital stock began to absorb very significant parts of the total GDP (see figure 3).

Figure 3: Investment and depreciation in M€ constant 2000

Source: Own elaboration from the database of FBBVA-IVIE, 2013

At the initial stages of growth in Spain (including the 1980s and 1990s), the lack of infrastructures and capital provisions were so significant that it was taken as read that the marginal productivity of investments in the renewal and extension of stocks (especially in cases of fixed capital with long useful lives) was very high.

However, the situation changed dramatically in the 2000s, and investments with excessively high forecasts during the boom in growth and the housing bubble aggravated the problem of the loose consideration of the cost efficiency and sustainability of a substantial percentage of the major investments planned in an exponential stage of outlooks for growth in the GDP and the population (immigrants, residents from other countries, tourists, etc.).

2.3.2. The contrast between per capita GDP and productivity

The increase in endowments of productive factors in the Spanish economy led to a significant process of development from 1989. Table 1 shows the reference values for Spain and the EU15 at constant 2000 prices (figures in euros).

Table 4: Productivity and GDP per capita in Spain vs EU15 (thousand euro, constant value 2010)

		1989	1999	2007	2010	ρ 89-99	ρ 99-07	ρ 07-10
EU15	GDP/per employee	44,331	51,588	55,678	55,590	1,52%	0,95%	-0,05%
	GDP/per capita	19,207	22,492	25,573	24,557	1,58%	1,60%	-1,35%
SPAIN	GDP/per employee	36.060	40.071	38.815	41.138	1,05%	-0,40%	0,73%
	GDP/per capita	11.937	14.910	17.671	16.819	2,20%	2,10%	-0,60%
% SPAIN / EU15	GDP/per employee	81,3%	77,7%	69,7%	74,0%			
	GDP/per capita	62,1%	66,3%	69,1%	68,5%			

ρ = cumulative rate of growth, coefficient of time exponential growth function (in differences divided by no. years)
Source: EU15 data from Cambridge Econometrics, Spain data from IVIE.

GDPpc in Spain grew at a cumulative rate greater than 2% and caught up with the EU15 average; the GDPpc ratio increased from 62% in 1989 to 69% in 2007. However, productivity was a serious drawback in the Spanish development and convergence process. Labour productivity (output per worker) was not able to follow the path of GDPpc Spain and the productivity gap between Spain and the

EU15 widened from 20 to 30 percentage points, the comparative level Spain's productivity fell from 81% in 1989 to 70% of EU15 average in 2007. Labour productivity in Spain grew at a 1% cumulative rate during the period 1989-1999, considerably less than GDPpc (2.2%) and well below the 15-member EU average (1.5%). Furthermore, during the growth boom of the period 1999-2007 labour productivity was stagnated in Spain.

A characteristic and somewhat anomalous feature of Spain's growth is the fact that the convergence in terms of per capita income with regard to the EU15 did not go hand-in-hand with convergence in terms of output per worker. This is also an important drawback for the global competitiveness of the Spanish economy which was affected by the productivity decline observed in the European countries with regard to productivity in the most dynamic world economies, especially USA since mid-1990's[6].

Labour productivity only began to recover as a result of the tough readjustments that were made through the devastating effect on employment of the acute and prolonged recession that continues to affect the Spanish economy since last quarter of 2007. The accumulative downturn in per capita income terms in Spain was 1.3%, signifying a major decrease with regard to the average for the EU15 (-0.05%) and a major increase in unemployment, reaching 25% in 2012.

Growth was not uniform over the period, and the growth in per capita income was affected by the crisis of 1992, although from 1994 onwards there was a period of sustained growth until the outbreak of the current crisis in 2008. On the contrary, the growth of labour productivity (output per person in employment) followed a very different and contrary path. It grew significantly in the 1990s, growing rapidly from 1989, and then slowing down from 1995 onwards, and then following a downward trend from 1998 until the outbreak of the current economic crisis. Figure 4 below illustrates these patterns.

The top of Figure 4 shows the trends for per capita income for the country as a whole, differentiating between the less developed Objective 1 regions and the others. During the first few years of the period, the Objective 1 regions converged in terms of per capita income, then decreasing quite significantly during the 1990s, to once again converge during the growth period in the 2000s.

The bottom of Figure 4 shows the trends in productivity of the Spanish regions at constant 2000 prices (euros). Here we can see that there was a significant growth in the first few years, a turning point around 1994, followed by a marked decrease from 1999 onwards, precisely during the process of a significant economic growth from the end of the 1990s, accompanied by a major increase in the population (with high immigration rates) and employment rates that reduced the average labour productivity.

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[6] This fact was broadly in examined literature, see among others European Commission (2007), Timmer, O'Mahony and Van Ark (2007) and Maroto y Rubalcaba (2008).

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Figure 4: GDPpc and Productivity by regions (1989-2010)
GDPpc by Objective 1 and Non Objective 1 regions
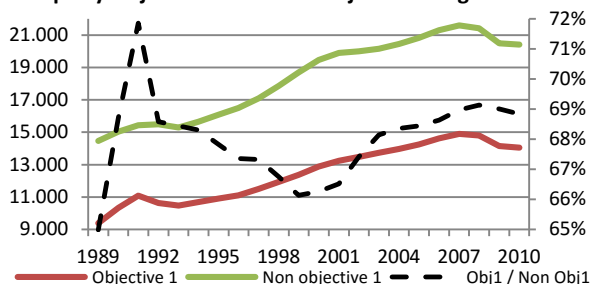
Productivity by Objective 1 and Non Objective 1 regions
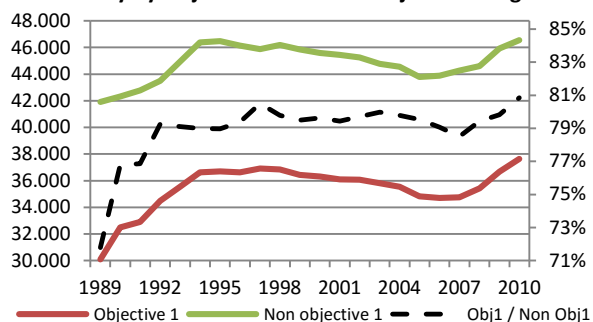
Source: Own elaboration from IVIE dataset.

The contrasting development of growth of per capita income and labour productivity, a feature of the Spanish growth process, can once again be seen in the growth rates of the Objective 1 regions in comparison to those of the more developed regions. Convergence in terms of productivity slowed down during the period of greatest growth, becoming more acute during the major downturn in employment as a result of the current economic crisis. This crisis and the recession from 2007 onwards have led to major adjustments with high job losses, focused on less productive jobs, resulting in a peak in terms of output per worker during the years of the crisis, at the expense of employment.

However, as we will see later on, the two groups of regions (the most developed and the Objective 1 regions) do not display common growth patterns at internal level. In particular, during the boom in growth from the end of the 1990s until 2007, the growth patterns in terms of increased employment and productivity crisscrossed between regions with very different levels of development, instead configuring a dynamic focused on the bipolarity of a major increase in production, the population and total employment, and a fall in labour productivity compared to more moderate rates of growth together with increases in productivity, although always below the EU15 average.

2.4. Productivity Drivers in Spanish Economy

The contrast between high growth in terms of per capita income and stagnation in terms of labour productivity in the Spanish economy, together with the contrasting development of regional differences in terms of per capita income and output per worker is a surprising phenomenon which is more complex than it might initially appear.

In accounting terms, per capita income (the same as its accumulative growth rate) can be broken down into the product of the productivity per employment and the

share of employment in total population-employment ratio (in the total of the accumulative rates of productivity growth and the occupation ratio).

$$y_{pc} = \frac{Y}{pop_{tot}} = \frac{Y}{pop_{empl}} \cdot \frac{pop_{empl}}{pop_{act}} \cdot \frac{pop_{act}}{pop_{tot}} = \frac{Y}{pop_{empl}} \cdot \frac{pop_{empl}}{pop_{tot}}$$

(15)

$$y_{pc} = Labour\ productivity \cdot Employment - to - Population - ratio$$

The simple breakdown of the per capita income into its two factors of output per worker and employment clearly shows that since entering the EU, Spain has developed significantly with an extensive growth model mainly driven by the enlargement of productive endowments and employment. The growth of per capita income was mainly due to the increase in the employment ratio, and even during the period 1999-2007 employment increased so quickly that it easily compensated for the drop in productivity.

However, the growth process in Spain was associated with significant social and economic progresses, seen in a wide variety of indicators ranging from the increases in female participation in the labour market and a rise in the educational level of the population, to the internationalisation and opening to foreign trade of the economy, and including major investments and high rates of growth for the capital and resources associated with ICT and R&D+I. On the other hand, human capital has played an important role in Spain's TFP, efforts to improve the stock of human capital in Spain over the last few decades has made possible the approach to the average of the OECD countries. This improvement has also strengthened the ability of Spanish companies to learn and absorb new technologies, and has had a significantly beneficial impact on the improvements in productivity (Cubel et al., 2011)

Mas and Quesada (2009) studied the role of ICTs in the slowdown of Spanish productivity. By distinguishing between capital assets related (and not related) to ICTs (software, communication and hardware) in the FBBA-Ivie dataset, a growth accounting exercise was applied to the non-primary sectors of the Spanish market economy. The main findings showed that ICT capital growth rates (9.7% between 1995 and 2004) almost doubled those of total capital, while the ICT intensive cluster (the branches using most intensively ICTs, mainly business services and financial intermediation) experienced an important labour productivity (as well as TFP) growth contributing to partially attenuate the fall in the TFP of the Spanish Economy. However, the negative tendency of productivity remains a major issue in Spain, apart from some other lagging features in the economy (such as small share of ICTs in total investment, productive structure and the lack of technical training and qualifications) and some probable measurement problems, one of the main conclusions reached by Mas and Quesada (2009) is that "in Spain, the (presumably beneficial) full effects of ICT capital on total factor productivity growth are not observable as yet. A late start is probably one of the main reasons for not finding yet clear evidence of a productivity pick up induced by ICT technologies".

Martinez, Rodriguez and Torres (2008) studied the Spanish evidence on a productivity paradox of the new economy in the sense of the famous statement by Robert Solow (New York Times Book Review, July 12th 1987) that "the computer age [was seen] everywhere, except in the productivity statistics". A computable general equilibrium model (with labour and six types of capital assets for calibrating the cost shares of the productive factors) is used to identify the sources of productivity growth in Spain during the late 90's and early 2000's, which are compared with the evidence available for the US and other countries. A negative tendency in TFP is also found for Spain, although an interesting conclusion is reached on the transition process: "the relevant (but potential) benefits of ICT need time to come true [and spill over the whole economy]. Adjustment costs and inefficiencies derived from inappropriate qualifications in the labour force lead to transitional dynamics in which productivity suffers low and even negative growth rates" (Martinez, Rodriguez and Torres, 2008).

An extended Solow growth model was estimated with panel data for the Spanish regions to measure the contribution of different factors of production (with special interest in the stock of private and human capital, as well as the gap of transport infrastructure capital) to the productivity of labour and the temporal evolution of TFP over the period 1989-2010 (Montes-Solla, Faiña, and Lopez-Rodriguez, Forthcoming). Output per worker is explained by means of a Cobb-Douglas production function of the per worker stocks of private and human capital, as well as the transport infrastructure capital weighted by the inverse of a saturation index (the relative lack of capital to reach a convenient provision of transport infrastructure endowment per worker). The latter variable is intended to capture the conditional or moderating effect of infrastructure endowment saturation over the influence of transport infrastructure investments to increase the output per worker[7]. The model is linearized by means of log transformation and the cumulative rate of growth of total factor productivity (TFP) is estimated by means of an exponential function of time (the variable year) jointly with the share of RTD expenditure on regional GDP in each period of time[8].

The results are significant and consistent with the evidence provided in the previous works. The Cobb-Douglas expanded production function provides a suitable tool to explain the output per worker in the Spanish economy and provides accurate estimates of its elasticity to the endowments of productive factors (the

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[7] For this purpose, an index of infrastructure provision is calculated by dividing the capital stock of infrastructure by the geometric mean of the population and the regional area (the square root of the product of the two) and then draws on the increased regional provision of infrastructure (in our database it corresponds to Madrid in 2010) to which the index value 1 terrestrial infrastructure endowment is allocated. For other regions and years, rates below saturation (satindex2) are constructed to capture the relative distance to the reference infrastructure

[8] TFP trend is estimated by means of the expression: $Ln(A \cdot e^{\lambda \cdot t + \mu \cdot \rho_t}) = LnA + \lambda \cdot t + \mu \cdot \rho_t$

stocks of private and human capital and the stock of infrastructure weighted by regional relative distances to saturation along the period). Furthermore, the cumulative rate of growth of TFP is estimated by the coefficient of the year variable and the accelerating variable linked to the regional RTD shares on GDP.

Estimations show that the most influential variables on labour productivity are the stock of private capital per worker (elasticity of 0.51) and human capital per worker (elasticity of 0.46). This is in line with other studies' findings on human capital as one of the most important determining factor of the per capita income, labour productivity and economic growth, as it has clearly direct and indirect effects on these areas. A higher level of education leads to increased labour productivity, and in an environment of market efficiency, greater business incentives to invest in physical and technological capital (Doménech, 2008).

The capital stock per worker in transport infrastructure takes a small but significant positive value (elasticity of 0.02), which corresponds to a saturation index equal to 1 (the case of the best endowed region, Madrid in the year 2010). However, this elasticity increases for other regions and time periods due to the multiplier effect of saturation indexes lower than one[9], as for example in the peripheral regions such as Andalusia and Galicia, where capital infrastructure elasticity values were respectively 0.066 and 0.053 in 1989, 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) providing evidence that public investment in infrastructure has had a positive impact on production and employment in Spain and promoted income convergence among regions, especially since the Spanish accession to the EU. However, turning to the regional redistribution of investments in infrastructures, it has probably had significant efficiency costs.

The time trend of TFP reached an average cumulative decreasing rate of around -0.013, whereas the share of RTD on GDP was a significant driver of total factor productivity (TFP) growth with an estimated coefficient of 0.031. However, the low levels of RTD shares in Spain, despite their rapid growth since the late 90s, were insufficient to overcome the extensive nature of the Spanish economic growth model. Overall, the results for the TFP rate of growth, as a result of both components (time trend and the RTD shares), show that output per worker was lower than their potentially expected values once the amounts of investment are taken into account. Total Factor Productivity (TFP) in Spain experienced a negative rate of growth of around -0.012 (cumulative annual average) confirming the markedly "extensive" nature of the growth process in Spain[10].

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[9] The elasticity of output per worker to the stock of capital in infrastructure endowments, δg, is obtained by dividing the estimated coefficient by the inverse of each region saturation index at each period of time.

[10] Other estimates with different objectives have focused on the interregional variation of TFP with a panel of industry data (Escribá and Murgui, 2011).

2.5. Regional Disparities: Productivity and GDPpc in Spanish Regions

2.5.1. Regional GDPpc levels

The average personal income in Spain grew more rapidly than the UE-15 average, if calculated at constant prices (base year 2000). This convergence process of the Spanish regions along with the UE-15 was much higher in terms of Purchasing Power Standards (PPS), unity measure used by the Cohesion Policy, which triggered the exit of the majority of the Spanish regions from Convergence Objective (known before as Objective 1). Regional disparities in GDP per capita show an increase between years 1989 and 1999, followed by an also important decrease during the period 1999-2007. The outbreak of the current economic crisis in Europe has increased again the economic divergence among the Spanish regions[11].

As can be seen in Table 5 below, Regional disparities in terms of GDP per capita experienced an important increase between 1989 and 1999, next they were reduced to a comparable extent along the growth boom 1999-2007 and finally they increased again in the years of the current economic crisis.

Table 5: GDP per capita in Spain (thousand euro, constant value 2010)

GDP/POP	1989	1999	2007	2010	ρ 89-99	ρ 99-07	ρ 07-10
NUTs 2 Regions							
Range	5.982	10.878	8.841	9.444			
Mean	11.937	14.910	17.671	16.819	2,2%	2,1%	-1,6%
Std. Dev.	2.367	3.167	3.323	3.255	2,9%	0,6%	-0,7%
Variation	19,8%	21,2%	18,8%	19,3%			

Source: Own elaboration from IVIE dataset

Nevertheless, the distribution by relative development ranges of the Spanish regions did not experience much changes throughout the period 1989-2007 In this case, four ranges of development are taken as a reference: 1) The highest one above the average plus ½ of the standard deviation; 2) The mid-high (between the average and the average plus ½of the standard deviation); 3) The mid-low (below the average and the average minus ½of the standard deviation); 4) The lowest one below the average by more than ½of the standard deviation.

The Table 6 shows the distribution of the Spanish regions by ranges of GDPpc along the period 1989-2010. Figure 5 provides their map plots for the years 1989 and 2007 (2010 map did not differ from 2007).

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[11] The process of convergence (measured in constant euro, taking 2000 as the year base) is considerably larger in terms of Purchasing Power Standards (PPS), the metric (unity measure) used in the Cohesion Policy. In the programming period 2007-2013 the Canary Islands, Castile & Leon, and Valencia left the convergence objective as they surpassed the 75% of the EU-15 GDP per capita (Phasing-in regions). On the other hand, Asturias and Murcia left the same objective, surpassing the 75% threshold of EU-27 GDP per capita, as a result of the statistical effect linked to the decrease on the EU average after the accession of the Eastern Countries. In the new programming period 2014-2020, only Extremadura will keep being eligible as a convergence region, though Andalusia, Castile-La Mancha and Galicia will still be aided by a privileged transitory regime.

Table 6: GDPpc Ranges of Spanish regions 1989-2012

Region	1989	1999	2007	2010
Cataluña	1	1	1	1
Madrid	1	1	1	1
Navarra	1	1	1	1
País Vasco	1	1	1	1
La Rioja	2	1	1	1
Baleares	1	1	2	2
Aragón	2	2	1	2
Cantabria	2	2	2	2
Castile y León	2	2	2	2
Asturias	3	3	2	2
Canarias	2	2	3	3
Valencia	2	2	3	3
Galicia	3	3	3	3
Castile-La Mancha	3	3	4	4
Murcia	3	3	3	4
Andalucía	4	4	4	4
Extremadura	4	4	4	4

R	Range borders	1989	1999	2007	2010
4	x−δ	9.570	11.743	14.348	13.565
3	x−1/2δ	10.754	13.327	16.009	15.192
2	x+1/2δ	13.120	16.494	19.332	18.447
1	x+δ	14.304	18.078	20.993	20.074

Source: Own elaboration from data base IVIE (2013). Figures in euros 2000

Figure 5: Map of GDPpc in Spanish regions throughout the period 1989-2010

AN: Andalusia   AR: Aragón   A: Asturias   BI: Balearic Islands   CI: Canary Islands
CA: Cantabria   CM: Castile-La Mancha   CL: Castile-Leon   CAT: Catatonia   V: Valencia
E: Extremadura   G: Galicia   M: Madrid   MU: Murcia   N: Navarra
BC: Basque Country LR: La Rioja
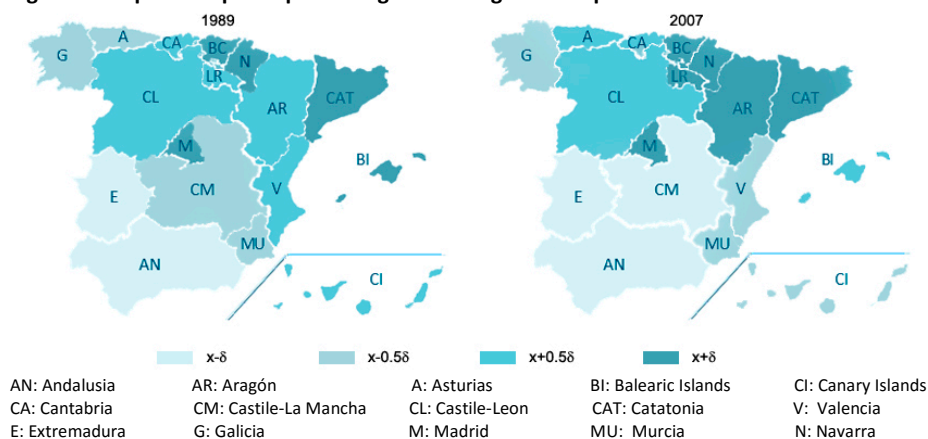
Source: Own elaboration from IVIE dataset

2.5.2. Regional productivity levels

Table 7 below shows the growth in regional differences in output per worker. On the contrary to the pattern for differences in GDPpc, a gradual reduction can be seen in the distance between the highest and lowest regional production values throughout the whole of the period, while the relative variation coefficient decreases in the first stage from 1989-1999, then increasing slightly during the

period 1999-2007 and then finally decreasing once again due to adjustments caused by the current economic downturn.

Table 7: Productivity in Spain (thousand euro, constant value 2010)

GDP/EMPL	1989	1999	2007	2010	ρ 89-99	ρ 99-07	ρ 07-10
NUTs 2 Regions							
Range	21.518	19.044	18.300	17.703			
Mean	36.060	40.071	38.815	41.138	1,1%	-0,4%	1,9%
Std. Dev.	5.882	5.061	5.372	5.202	-1,5%	0,7%	-1,1%
Variation	16,3%	12,6%	13,8%	12,6%			

Source: Own elaboration from IVIE dataset

In terms of the variations in the regional structure by productivity ranges, as can be seen in Table 8 below, there have not been any spectacular changes, and the central core of the most developed regions coincides with those that have the highest productivity (Basque Country, Navarra, Madrid and Catalonia). The medium-high level is also characterised by relative stability, comprising Aragón, Cantabria and Castile-Leon. Other regions such as Asturias and La Rioja could also be included in this level, while other major tourism areas such as the Balearic and Canary Islands have some decreases to the medium-low level.

Table 8: Productivity of Spanish regions 1989-2010

Region	1989	1999	2007	2010
Cataluña	1	1	1	1
Madrid	1	1	1	1
Navarra	1	1	1	1
País Vasco	1	1	1	1
La Rioja	2	1	2	2
Baleares	1	1	2	3
Aragón	2	2	2	2
Cantabria	2	2	2	2
Castile y León	2	2	2	2
Asturias	3	2	2	2
Canarias	2	2	3	2
Valencia	2	2	3	3
Galicia	4	4	3	3
Castile-La Mancha	3	4	4	4
Murcia	3	4	4	4
Andalucía	3	3	3	3
Extremadura	4	4	4	4

R	Range borders	1989	1999	2007	2010
4	X−δ	30.177	35.010	33.443	35.936
3	X−1/2δ	33.119	37.540	36.129	38.537
2	X+1/2δ	39.001	42.601	41.500	43.739
1	X+δ	41.942	45.132	44.186	46.339

Source: Own elaboration from data base IVIE (2013). Figures in euros 2000

There is greater movement in the lowest productivity ranges. The lowest position was initially occupied by Extremadura and Galicia, followed by another two convergence regions, Castile-La Mancha and Murcia, which eventually fell to the lower range, while Galicia managed to climb up to the following range. Andalusia is in a stable position in the medium-low range throughout all of the periods, while Valencia descended into this range in 2007.

Figure 6 below show the growth in labour productivity in the Spanish region, classified according to a ranking.
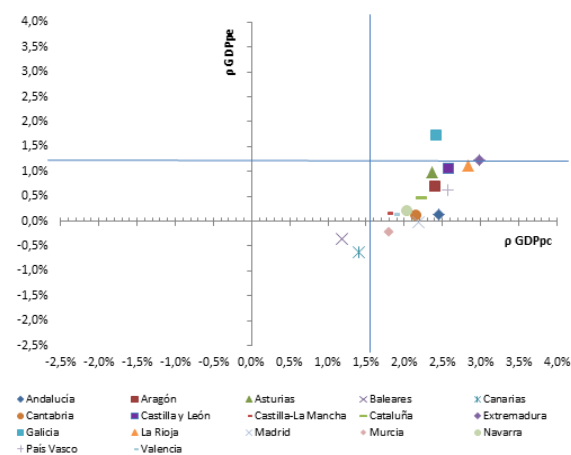
Figure 6: Map of Productivity in Spanish regions (1989-2010)

AN: Andalusia	AR: Aragón	A: Asturias	BI: Balearic Islands	CI: Canary Islands
CA: Cantabria	CM: Castile-La Mancha	CL: Castile-Leon	CAT: Catatonia	V: Valencia
E: Extremadura	G: Galicia	M: Madrid	MU: Murcia	N: Navarra
BC: Basque Country	LR: La Rioja			

Source: Own elaboration from IVIE dataset
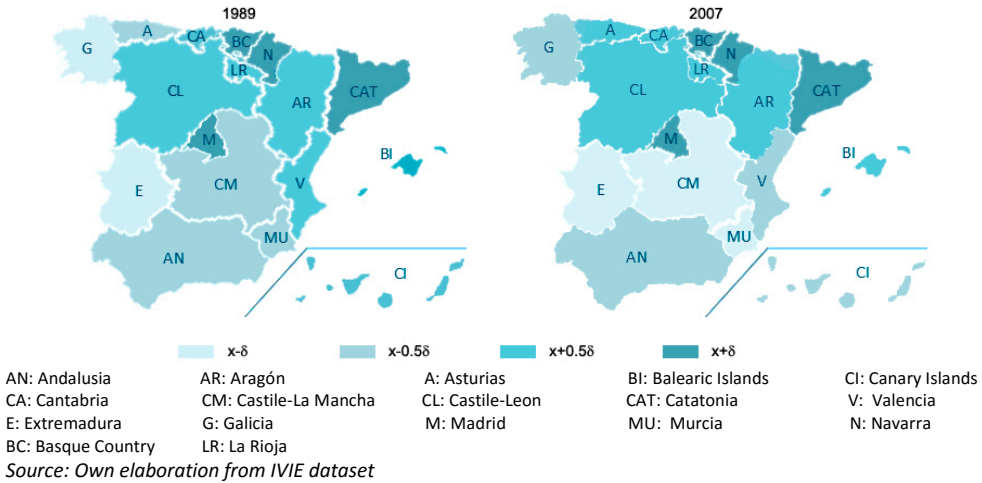
2.5.3. Main patterns of evolution

Overall, the main patterns of growth the set of Spanish regions fit quite well with the evolution of the country as a whole. That means that the main patterns of the growth models of Spanish regions do not significantly differ between convergence regions and the most developed regions. However, there are some specific features in the regional growth patterns that warrant attention.

Figure 7: GDPpe and GDPpc regional growth rate (89-07)

Note: Blue axis in the first quadrant represent the corresponding average rates of growth in EU 15
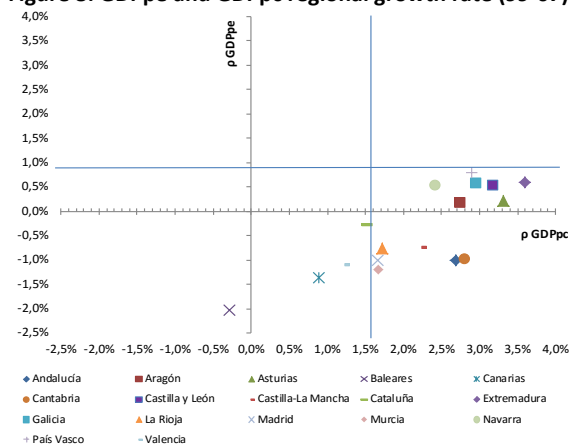*Source: Own elaboration from FBBVA-Ivie database 2013*

Figure 7 shows the patterns of evolution of GDPpc and labour productivity in Spanish regions during the period 1989-2007.

The vertical axis shows the accumulative productivity growth rates, while the horizontal axis shows the rates of growth for per capita income. The straight solid lines in the first quadrant indicate the average values for the EU15 for the whole of the period 1989-2007. Figure 7 shows a very different development model to that of the EU15. Practically all regions grow at high per capita income rates with zero or negative growth in labour productivity. There is a slight positive association between the growth in productivity and per capita income,

41

although it is of little significance.

Figure 8: GDPpe and GDPpc regional growth rate (99-07)

Note: Blue axis in the first quadrant represent the corresponding average rates of growth in EU 15

Source: Own elaboration from FBBVA-Ivie database 2013

Specifically, the convergence regions such as Extremadura and Galicia have grown with productivity increases close to those of the EU, while others such as Andalusia (in a convergence region) and Madrid (in the centre of the most developed regions) have achieved very significant increases in per capita income without any increase in productivity whatsoever. They share this situation with other more developed regions such as Catalonia, Basque Country and Navarra.

This situation can be clearly seen if we consider the period between 1999-2007 separately (Figure 8) when the intense and widespread boom in growth led to development with stagnation (and even a reduction) in productivity in the vast majority of Spanish regions.

2.5.4. Growth models

The main growth models in the Spanish regions are analysed in this section, using the factorisation of the growth rate of per capita income in its two components of labour productivity and employment rate.

Per capita income can be broken down into the product of the productivity per person in employment and the employment component (employment rate). This means that the accumulative growth rates are the coefficients of a time exponential function, and the per capita income growth rate (ρ_{GDPpc}) is the sum of the growth rates for productivity (ρ_{GDPpe}) and the increases in employment (ρ_{roe}).

The following diagrams show a breakdown of the accumulative growth rate (AGR) for the Spanish regions in terms of their productivity and employment factors. The horizontal axis (X) and vertical axis (Y) represents respectively the accumulative growth rate of employment-to-population rate (AGR-EPR) and the accumulative growth rate of productivity (output per worker, AGR-OPW). The blue lines are iso-line of accumulative growth rate (AGR) of GDPpc and the dotted line separates the regions with AGR-OPW (above) from those based on AGR-EPR (below).

**Figure 9: GDPpc regional components (1989-2007)**
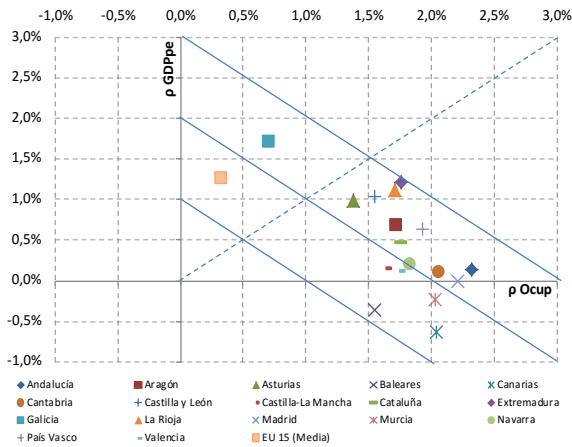
Source: Own elaboration from FBBVA-Ivie database 2013

In the period 1989-2007 (figure 9), all regions experienced growth rates of per capita income based primarily on increasing employment-to-population rate (EPR). The largest differentials between regions are in terms of accumulative growth rate of productivity (AGR-OPW) rather than accumulative growth rate of employment-to-population (AGR-EPR). The large majority of Spanish regions are in the range (-0.5%, 1.5%), which only vary a 2%. Only Andalusia

and Madrid have an employment-to-population rate (EPR) over 2%. Moreover, while Europe's growth is based mainly on improving productivity, Spanish regions have grown based on the increase in the employment-to-population rate (EPR), especially from the late nineties.

Most Spanish regions reached of AGRs of GDPpc greater than 1.5% in the period 1999-2007 (Figure 10), but their productivity performance was not that good. A relatively important group of regions reached a high AGR of GDPpc in the range of (2.5%, 3.5%) with positive AGR-OPW (Basque Country, Navarre, Galicia, Castile-Leon, Aragon, Asturias and Extremadura) they are placed in Northern of Spain except for Extremadura.

Figure 10: GDPpc regional components (1999-2007)
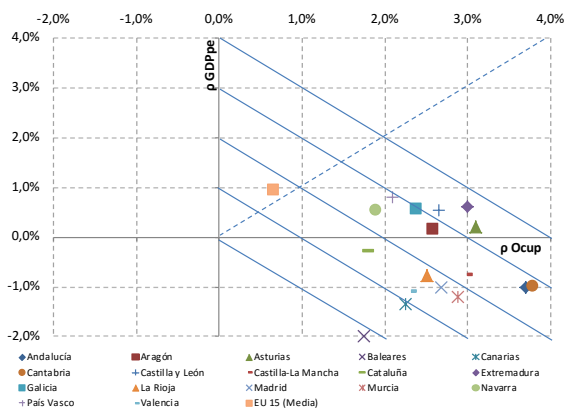
Source: Own elaboration from FBBVA-Ivie database 2013

Andalusia was also an exception; it reached an AGR of GDPpc higher than 2% but experience an AGR-OPW of 1%. Another important group of regions, made up of Castile-La Mancha, La Rioja, Murcia and Madrid, reached an important AGR of GDPpc in the range of 1.5% to 2.5% with negative AGR-OPW rates. Valencia is very close to this group with an AGR of GDPpc approaching 1.5%, and finally, the two touristic regions (Canary and Balearic

Islands) were the worst performers with relatively low AGR of GDPpc and negative AGR-OPW lower than 1%.

2.5.5. Spanish Regional Puzzle

Regional disparities in Spain have experienced some paradoxical features that have been referred to as "Spanish Regional Puzzle" (Garrido-Yserte and Mancha Navarro, 2010). Spain underwent an overall process of regional convergence in the levels of income per capita and productivity while experienced increasing regional concentration in the aggregate values of production, employment and population.

However, Spanish regional levels of income per capita and labour productivity evolved in opposite ways and so regional disparities (in GDPpc and labour productivity) did, due to the prevailing effect of employment creation in a context of labour productivity stagnation. Most of regional disparities in GDPpc in Spain (almost 85% of the inequality) can be explained by differences in the employment population ratio (Garrido-Yserte and Mancha Navarro, 2010).

The Spanish economy featured a trade-off between the growth of employment and productivity. Broadly speaking the greatest increases in GDPpc tends to occur in the regions with the greatest employment/population ratios, very often associated with decreasing or stagnant productivity (Cuadrado-Roura and Maroto-Sanchez, 2010, Escribá and Murgui, 2013).

A trade-off between employment and productivity has been at work in Spain in the last decades. This phenomenon is characterized by lower productivity growths in the regions with higher employment growth rates. Since the mid-90s, changes in the employment rate have been as a rule higher than variations in the rate of productivity. This feature to a large extent can be considered as a consequence of the "extensive" nature of the Spanish growth model. It was mainly based on large investments efforts to increase capital endowments in public infrastructures, private companies and human capital, without substantial development in the overall performance of productive system. Total factor productivity (TFP) exhibits a decreasing trend over the period, whereas the rapid growth of investments in ICTs related assets and RTDI projects did not deliver productivity improvements in the large majority of economic activities and was not enough to counteract the shrinking tendency of TPF growth. There is some evidence of a "productivity paradox" in Spain, but despite that GDPpc development in Spain was meanly driven by continuous increases in per worker capital endowments (both physical and human capital) and the employment-to-population ratio (EPR).

2.5.6. Regional impact of economic crisis

The evolution of the Spanish regions' GDP in 2012 was characterised by a widespread recession. Spanish Regional Accounts reported the regional distribution of the real growth rate of the Spanish economy estimated at −1.4% for 2012[12]. In
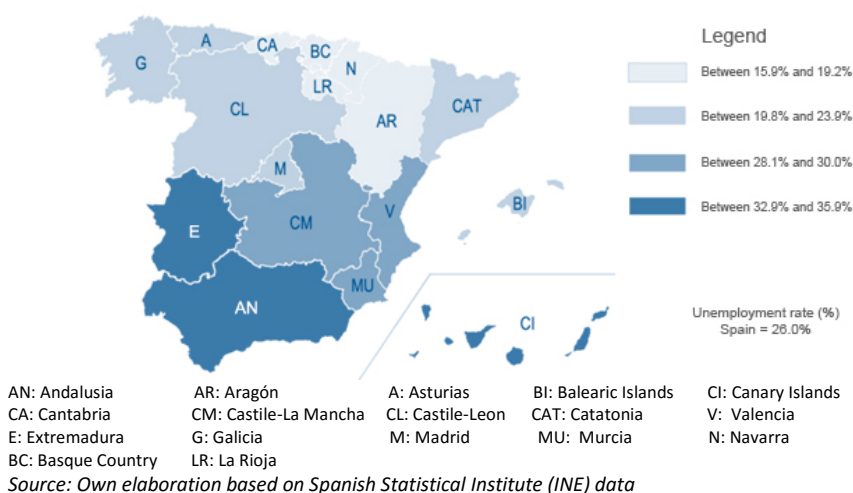
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[12] INE, Quarterly National Accounting of Spain, 28th of February 2013 and INE, Gross Domestic Product by Region, Year 2012 (Spanish Regional Accounts. Base 2008), 21 March 2013.

line with the deep and widespread recession of 2012, employment problems were exacerbated all across Spanish regions and the unemployment rate rose to 26.02% in the whole country[13]. The most significant feature of the economic development in the Spanish regions in 2012 is the deep and widespread recession of GDP and the rise in unemployment rates.

The recession had a profound impact on the Spanish labour market (an average unemployment rate of 21.7%). The more technologically advanced regions (Competitiveness regions, such as Basque Country, Navarra, Madrid and Catalonia) found it easier to deal with the crisis, while some of the convergence, Phasing-out and Phasing-in regions were facing serious problems with unemployment and economic stagnation. Beyond these broad features, it is hard to find a general and systematic pattern.

However, the spatial distribution of the regional rates of GDP growth and unemployment for 2012, are shown in figure 11 below.

Figure 11: Unemployment rate (%) for Spanish regions in 2012

AN: Andalusia	AR: Aragón	A: Asturias	BI: Balearic Islands	CI: Canary Islands
CA: Cantabria	CM: Castile-La Mancha	CL: Castile-Leon	CAT: Catatonia	V: Valencia
E: Extremadura	G: Galicia	M: Madrid	MU: Murcia	N: Navarra
BC: Basque Country	LR: La Rioja			

Source: Own elaboration based on Spanish Statistical Institute (INE) data

Unemployment rates were high (in the range of 15.9%, 19.2%), but well below the Spanish average, in the best performing regions (Basque Country, Navarra, La Rioja and Cantabria), whereas a group of regions (Valencia, Murcia and Castile-La Mancha) placed above the Spanish average (in the range of 28.1%, 30.0%) and finally the worst-performing regions (the Canary Islands, Extremadura and Andalusia) reached unemployment rates well above 30% (in the range of 32.9%, 35.9%).

Regarding the main changes in regional disparities, the ranking of Spanish regions by GDP per capita has not changed significantly over the last few years. On average, the GDP per head in current euros shrank by around 1.6% between 2010

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[13] INE, Economically Active Population Survey (EAPS), 4th Quarter 2012, 24 January 2013.

and 2012, although the per capita GDP of the poorest region (Extremadura) remained approximately equal to half of the richest (Basque Country). In a similar vein, the unemployment rate in Spain increased considerably (by 40%) between 2009 and 2012, but the relative distance between the worst and the best performing regions (Andalusia and Basque Country, respectively) also remained at around 1/2.[14]

In general, the more technologically advanced regions (Competitiveness regions, such as Basque Country, Navarra, Madrid and Catalonia) have not been affected by the crisis as seriously as some convergence, Phasing-out and Phasing-in Southern and Mediterranean regions, which are facing dramatic problems in terms of unemployment and economic stagnation. Overall, regional disparities have remained constant, but unemployment and economic stagnation are widespread and dramatic.

The sovereign debt crisis, the credit crunch and credit spreads, as well as public expenditure cuts and tax increases have given rise to an additional depressive impact in the short run. However, currently it seems that the contraction is touching its bottom at the end of summer 2013. The austerity measures and structural reforms undertaken by the central government are having a bigger impact on those regions whose regional governments have the highest debt and public deficit. These regions have had to make the most severe adjustments, which has naturally affected their situation in the short term. These adjustments have been especially severe in Castile-La Mancha (which reduced its public deficit from 9% GDP in 2011 to 1.5% in 2012), while some others are still facing fiscal adjustment problems (1.96% for Catalonia, 2.02% for Andalusia, and 3.02% for the Region of Murcia).

2.6. Conclusions

The Spanish growth model, based on a process of significant investment and a considerable increase in the capital stock can be classified as an extensive growth model, in which the capital growth leads more to an increase in production and employment than to increases in productivity, both in terms of output per worker and Total Factor Productivity (TFP).

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[14] The evidence of the impact of the crisis on regional differences is unclear. On the one hand, the coefficient of variation in the GDP per capita of the Spanish regions has shown a certain upward trend, from 18.6% in 2008 to 19.8% in 2012 (with the estimated data from the National Statistics Institute). However, the most outstanding feature is the general downturn in all of the regions and in the average from the country (from 23.8 thousand euros to 22.7 between both dates, minus 4.6%). This said, the worst effect of the crisis has been the increase in job losses, with the unemployment rate soaring from 8.6% in 2007 to 26% in 2012 (in the last quarter), rising to more than 30% in Andalusia, the Canary Islands and Extremadura. However, the overall increase in all of the regions meant that the coefficient of variation in the unemployment rates fell from 34.6% to 31.3% during this period.

However, the potential benefits of ICT and RTD investments need time to spill over the whole economy to significantly improve productivity statistics[15]. Increased productivity derived from ICTs and technological change calls for new types of business organisation, education and professional training in order to spread new technical and economic opportunities. The experience of the USA and other countries reveals the importance of bringing flexibility and competitiveness to the markets in order to facilitate the diffusion and beneficial use of ICTs and reduce the time needed for their benefits to spill over the general productivity of the country.

This transitional problem was aggravated in Spain by the boom that occurred after the introduction of the Euro (1999-2008), when low interest rates and widespread access to credit resulted in a housing bubble with extraordinary growth in the construction sector, and an overall rise in salaries that negatively affected the country's productivity and competitiveness.

Since entering the EU, the Spanish economy has achieved GDP growth rates higher than the European average, together with significant increases in its population and high job creation, which has made possible to substantially reduce the unemployment rate and converge towards the higher levels of per capita income of the EU15, which includes its most developed members. However, this process had a negative side in terms of productivity. Labour productivity has been growing very slowly in Spain since 1995, and TFP is negative. Furthermore, the downturn in productivity and the increase in salaries during the boom period of the 2000s led the country to suffer from a loss of competitiveness with regard to EU and non-EU countries (FBBVA, 2006).

The accumulation of capital and the creation of employment were important factors, yet the improvements in productivity were scarce in nearly all sectors. The specialisation of production has not strengthened the presence of innovative activities and those with a high technological content as would be expected from an advanced economy, but instead in traditional and highly cyclical sectors such as construction. Low productivity levels have affected nearly all of the country's activities, despite an increase in capital assets per worker during this period. However, these were much more serious in the construction sector, as during the housing boom a large number of investment projects based their short-term profitability on expectations for the revaluing of the assets and not on productivity.

The pattern of growth of the Spanish economy in the 2000s was fragile and unsustainable in the long term. On the one hand, "the competitiveness of Spain at a global level has placed too much trust in the short-term benefits derived from the arrival of the Euro" (Pérez et al, 2011), while on the other, the risks and imbalances accumulated during the period of expansion and housing boom (a high current account deficit and heavy debt burden) led the Spanish economy to be highly

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[15] This possibility was pointed for Spain by Mas and Quesada (2009) and Martinez, Rodriguez and Torres (2008)

vulnerable to the impact of the international crisis.

An overview of Spain's economic policy in the last few decades would highlight excessive trust in economic integration in the EU, as today it is clear that integration in European markets and the short-term financial benefits of the Euro are not sufficient in order to face up to the challenges of the new economy and intensified competition on a global scale.

The outbreak of the crisis caught the Spanish economy in a vulnerable situation, and the need for adjustments in productivity led to a significant and generalised increase in unemployment in all of the country's regions.

One lesson that has been learned is that in the future, it will be necessary to insist on greater rigor in the selection of investments, in order to guarantee a cost effectiveness and productivity in line with the capital resources.

The major challenges facing Spanish regions are recovery from economic depression and a need to reinforce their supply capabilities to successfully face increased competition resulting from globalization. The recent FBBVA-IVIE (2011) report clearly highlights the main productivity problems that need to be tackled by the Spanish economy: 1) Internal company changes; new growth requires better, bigger and more productive companies, capable of competing in larger markets with higher quality services and products, greater dynamism and internationalization. 2) Redirecting productive specialization; enhancing the largest added-value activities in the service sector, reinforcing productivity in the manufacturing sector and fomenting the production and intensive use of ICT. 3) Promoting the productive use of knowledge, fostering technological or process innovation and business RTDI projects, intensifying the use of human capital, enhancing the use and exploitation of ICT as the basis for competitiveness (Expert Network Report on Spain, 2013).

Chapter 3 - Cohesion policy and transportation

3.1. Introduction

This chapter discusses infrastructural investment policy in the EU, both under the rubric of Cohesion policy and under that of EU transportation policy and, in particular, of investment in trans-European transport network (TEN) infrastructure. There is nothing like a widely accepted conventional wisdom regarding transport infrastructure and regional development policy, nor is there a clear theory for ascertain how much infrastructure helps a region's development chances. The focus of this chapter is on the main conceptual tools for designing and evaluating, usually on a region-by-region basis, the right mix of infrastructure and other development goals in the current state of regional development theory and policy in the EU.

Investment projects in transport and public infrastructure (telecommunications, energy, water, sanitation, etc.) play an important role in European regional development policy, so much so that they have been financed by the European Regional Development Fund (ERDF) and the Cohesion Fund (CF).

In the wake of the EC enlargement to the less developed south European countries (Greece, Spain and Portugal), the Single European Act (1986) predisposed an investment policy aimed at reducing regional disparities and encouraging growth in the less developed areas (see Chapter 1). In 1993, upon completion of the European internal market, a Cohesion Fund (CF) was created as a new instrument of Cohesion policy, to support investments in large infrastructure projects in the fields of environment and transport.

Praised by some and criticised by others, the role of investment in infrastructure and transport projects has evolved within Cohesion policy with a shrinking share in total financial endowments; nevertheless, it still maintains considerable importance in less developed regions and has been reinforced in the Trans-European Transport Network (TEN-T).

3.2. Cohesion Policy and Transport Infrastructure Networks

Cohesion policy is the most important framework for solving the problem of an insufficient infrastructure in less developed countries, most of which were situated in the periphery of southern Europe. Given the fairly peripheral and isolated situation of Spain and Portugal, on the one hand, and Greece, on the other, investment in transportation infrastructure could initially be carried out without worrying too much about connecting these member states' infrastructure with that of other member states. However, the unification of the European internal market and the enlargement to Central and East European countries (CEECs) reinforced the need for a common transport policy and firmly placed TEN-T among the top priorities aimed at connecting European territories with one another. Transport policy and trans-European networks, which were formally not included within the framework of Cohesion policy, received greater impulse after enlargement, partially compensating for the reduced role of transport infrastructure in the new Cohesion policy 2020 financial perspectives.

Since 1989, Cohesion policy has developed into one of the main spending priorities of the European budget doubling in real terms and turning this policy into the main spending item (see Chapter 1). Currently the resources dedicated to Cohesion policy have decreased slightly (from EUR 347 billion in 2007-13 to EUR 325 billion in 2014-20) stabilizing around 34% of total funding in the 2014-20 Multiannual Financial Framework (MFF). This funding is channelled through the so-called European Structural and Investment Funds (ESIF). The European Regional Development Fund (ERDF, representing a 56% of the total) and the Cohesion Fund (CF, reaching a 19%) are responsible for financing infrastructure investments, being the latter entirely devoted to Trans-European Network (TEN) and environmental infrastructure. Finally, the European Social Fund (ESF) focused in employment and social inclusion represents around a 25% of ESIF funding.

Cohesion policy, financed under the Heading 1b in MFF (Economic, social and territorial cohesion), will channel the largest part of EU investment towards supporting SMEs, R&D and innovation (RDI), education, employment and social inclusion, the environment and the low carbon economy, as well as towards developing infrastructure networks (transport, energy and digital connections).

Table 9 below shows the key priorities supported by ESIFs with the information available at the time the 6th Report on Social and Economic Cohesion Policy was issued (once the Commission had received all 28 Partnership Agreements (PAs) and around 150 operational programmes (OPs)).

R&D and Innovation (RDI), Information and Communication Technologies and SME support are the most reinforced policies, jointly with the shift to low carbon economy. Overall, these priorities increase by more than 21% with regard to the previous period 2007-13, the largest part coming from the ERDF and the Cohesion Fund.

Table 9: Key Priorities and Funding in Cohesion Policy and Trans-European Networks for the 2014-2020 period

Table 9.A: Economic, social and territorial cohesion. Heading 1a in MFF (EUR billion)

Key priorities in Operational Programmes of Cohesion policy	EUR billion	% Cohesion policy	% EU MFF	% Increase 2007-13
Research and Innovation, Digital Agenda, Support for SME plus low carbon economy policy	100.0	28.4%	9.2%	21%
Research and Innovation, Digital Agenda and support for SME	73.3	20.8%	6.8%	-
Shift to a low-carbon economy (energy efficiency and renewable energies).	26.7	7.6%	2.5%	-
Transport and Energy Network Infrastructure	59.0	16.8%	5.5%	-21%
Total	159.0	45.2%	14.7%	

Table 9.B: Connecting Europe Facility and Trans-European Network (TEN)

Total Funding breakdown by headings of EU MFF	EUR billion	% Cohesion policy	% EU MFF	% Increase 2007-13
Trans-European Networks	26.3	-	2,4%	300%
Heading 1a in MFF: Competitiveness for growth and jobs	15.0	-	1,4%	-
Heading 1b in MFF: Economic, social and territorial cohesion	11.3	3,2%	1,0%	-

Note: MFF = Multiannual Financial Framework; CEF = Connecting Europe Facility
Source: 6th Report on Social and Economic Cohesion Policy

On the contrary, the funding for transport and energy network infrastructure suffers a 21% comparative decrease with regard to the previous period of 2007–2013. This implies a significant shift of funding priorities in the Cohesion policy of the current programming period, that the European Commission (EC) has assessed as an "encouraging" change in accordance with the new EU aim to increase competitiveness and enhance growth capabilities.

Certainly the MFF 2014-2020 increased EU investment in RDI in Cohesion policy (the heading 1b in MFF) and also augmented by 30% the funding for Horizon 2020 within the European RDI policy (under Heading 1a, Competitiveness for growth and jobs, in MFF). However, in the field of common transport policy, the new Connecting Europe Facility (CEF) will boost TEN by tripling the budget for infrastructure investments (mostly in transport, TEN-T) in the 2014–2020 period to EUR 26 Billion. Table 9.B above offers the breakdown of this funding coming partially, EUR 11.3 billion, from the heading 1a in MFF (Competitiveness for growth and jobs) and also, EUR 15 billion, ring-fenced in the Cohesion Fund (heading 1b, Cohesion policy, in MFF).

Overall, investment in non-environmental infrastructure networks (mainly transport) represents more than 21% of Cohesion policy resources, equivalent to 6.9% of total EU Budget for 2014-2020, with 5.5% corresponding to investments financed through ERDF and CF under Cohesion policy heading and the remaining 1.4% falling under common transport policy allocations in first Heading (1A) in MFF.

The funding assigned to the CEF is intended to serve as 'seed capital' to launch further investment by Member States (by 5 times) and induce large investment from companies (by 20 times more if leverage from innovative financial instruments functions properly). Commercial and interregional traffic using road network capital use to have positive effects on private sector productivity making thus important to rise private funding for enhancing infrastructure investment (Alvarez and Blazquez, 2014),

Table 10: Cohesion policy funding by broad policy area in EU-15 and acceding countries
Table 10.A: Cohesion policy funding by broad policy area in EU-15. 1989-2013

% of total	Less developed regions and Cohesion Fund				Other regions			
	89-93	94-99	00-06	07-13	89-93	94-99	00-06	07-13
Business support (including RTDI)	31.5	33.0	28.0	34.4	48.1	31.1	29.2	33.8
Infrastructure (Transport, Energy, Telecom, Social Infrastructure)	36.3	26.1	30.9	23.2	5.2	1.5	13.4	13.2
Human Capital (Labour Market, Education, Social Inclusion, etc.)	20.6	24.7	24.5	22.3	39.0	56.8	45.8	34.6
Environment	1.6	14.3	14.0	15.4	7.6	9.8	8.6	14.2
Other	9.7	1.9	0.8	0.4	0.0	0.8	1.1	0.3
Technical assistance	0.4	0.0	1.8	4.3	0.0	0.0	1.8	3.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 10.B: Cohesion policy funding by broad policy area in acceding countries 2004-2013

% of total	EU-10	EU-12
	2004–2006	2007–2013
Business support (including RTDI)	14.2	25.6
Infrastructure (Transport, Energy, Telecom, Social Infrastructure)	41.5	36.1
Human Capital (Labour Market, Education, Social Inclusion, etc.)	14.8	12.5
Environment	27.3	20.8
Other	0.1	0.0
Technical assistance	2.1	5.0
Total	**100.0**	**100.0**

Source: 6th Report on Social and Economic Cohesion Policy. pp. 206-207. based on Structural Funds Annual Reports and DG REGIO calculations

Table 10 provides the breakdown of Cohesion policy funding by broad policy area in EU-15 and acceding countries. Cohesion policy spending in infrastructure (transport – the main area of spend – but also energy, telecommunications and social infrastructure) over time has consistently concentrated in the less developed regions, with declining pattern over subsequent programming periods. With the enlargement, Central-Eastern European countries occupied the largest area of less developed regions with the highest priority given to endowments in non-environmental infrastructures.

In general, the share of funding allocated to non-environmental infrastructure in less developedEU-15 (the largest part corresponding to transport networks) amounted to 36% in the 1989-1993 period, falling to 23% (25.6% in acceding countries) in the 2007-2013 period as transport networks were gradually built.

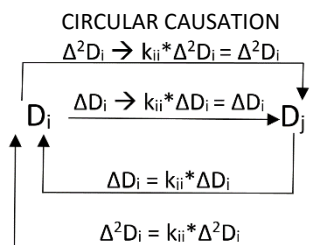## 3.3. Growth Models and Development policy

3.3.1. Growth and Development synergies

Regional Operational Programs in Objective-1/Convergence regions typically included an assessment of the internal coherence of the development strategy by analyzing the interrelationships between their different goals. In a simple way, this analysis of synergies is represented in Table 11 below, its rows show the influence of each goal on the others, a plus denoting a significant push effect. Accordingly, its columns show the pull effect each goal receives from the other (sensitivity). The margins of the table provide indices of influence and sensitivity of different development goals (computed as the share of positive relationships over the total without considering the relationship of each goal with itself).

Table 11: Influence and sensibility, circular causation and leverage effect

INFLUENCE SENSIBILITY	1	2	3	4	5	Total Influence (K_{ij})
D1: RDI: Innovation and R&D		+	+	+	o	**0.6**
D2. ICTs Information Communication Technology	+		+	+	o	**0.6**
D3. SME support	+	+		+	o	**0.6**
D4. HC: Education and Human Capital	+	+	+		o	**0.6**
D5. Network infrastructure (Transport, Energy, telecom)	+	+	+	+		**0.8**
Total Sensitivity (k_{ji})	**0.8**	**0.8**	**0.8**	**0**	**0.8**	

Source: Own elaboration

CIRCULAR CAUSATION

$$\Delta^2 D_i \rightarrow k_{ii} * \Delta^2 D_i = \Delta^2 D_i$$

$$D_i \quad \frac{\Delta D_i \rightarrow k_{ii} * \Delta D_i = \Delta D_i}{} \quad D_j$$

$$\Delta D_i = k_{ii} * \Delta D_i$$

$$\Delta^2 D_i = k_{ii} * \Delta^2 D_i$$

An increase in the endowment of a growth factor D_i (RDI, SME Support, Information and Communication, Technologies, Research and Innovation, Education or Human Capital) positively influences other factors (push effect), and in turn these positively influence the former (sensitivity), pulling it (pull effect) and generating a new effect of the second order.

LEVERAGE EFFECT OF INCREASING A GROWTH FACTOR D_J

$$\Delta^1 D_i \qquad\qquad \rightarrow \Delta^1 D_j = k_{ij} \cdot \Delta^1 D_i \rightarrow \Delta^2 D_i = k_{ji} \cdot \Delta^1 D_j = k_{ij} \cdot k_{ji} \cdot \Delta^1 D_i$$

$$\Delta^2 D_i = k_{ij} \cdot k_{ji} \cdot \Delta^1 D_i \qquad \rightarrow \Delta^2 D_j = k_{ji} \cdot \Delta^2 D_i \rightarrow \Delta^3 D_i = k^2_{ij} \cdot k_{ji} \cdot \Delta^1 D_i$$

$$\Delta^3 D_i = k^2_{ij} \cdot k_{ji} \cdot \Delta^1 D_i$$

...

$$\Delta^t D_i = k^{t-1}_{ij} \cdot k_{ji} \cdot \Delta^1 D_i$$

Leverage effect produced by circular causality : $\dfrac{k_{ji}}{1 - k_{ij}}$

Positive interactions between the push and pull effects of the different goals' policy measures, through a mutually reinforcing process of circular causality, give rise to a sustained increase in the rate of growth. Consequently, those goals which simultaneously possess high influence and high sensitivity, constitute the core of a region development strategy. This is the case with the core growth goals of R&D and innovation (RDI), Information and Communication Technologies (ICTs), SME support, Education and Human Capital (HC).

Investments to bridge the infrastructure gap are highly influential on the strategic core of growth drivers (RDI, SMEs, ICTs, and HC) and effectively promote growth and development by unleashing leverage interactions among those other growth drivers. However, Infrastructure is not sensitive to the pull effect of improved RDI, ICTs or HC and this limits its role as a factor of growth. Investment in infrastructure can choke development, when it is insufficient, but does not spontaneously keep up with investment or development in other areas.

However, in a world of rapid change and technological evolution, the level of 'adequate endowments' of infrastructure should be redefined almost continuously not only because they are highly influential on core development goals, but also because investment decisions on RDI, ICTs and HC are taken by forward looking agents. Entrepreneurs and workers must have coherent expectations to simultaneously invest in technological and human capital at rates large enough to keep up the growth momentum. The expected impact of infrastructure endowments an increased market accessibility use to influence the formation of expectations regarding the profitability of investment in RDI and Human Capital.

3.3.2. Cohesion Policy and Growth Models

From a political point of view, the structural support provided for the new Cohesion policy was part of an implicit agreement to overcome the fears that less competitive countries would suffer adverse economic effects due to the intense competition from most developed areas once all border barriers were removed in a single European market.

From an economic point of view, drawing from the original Solow model (1956) different types of growth models were put forward, providing explanations of the roles played by different growth drivers and obtaining empirical evidence on them. Solow's model is based on a "production function" linking the GDP output with the supply of production factors, labour and capital, jointly with a technological factor of productive efficiency, known as total factor productivity (TFP). Solow found out empirically that labour and capital inputs not completely explain GDP growth and that a part of it (Solow's residual) must be attributed to technological progress.

Current models incorporate other key factors of endogenous growth like technological progress and RDI (Romer, 1986, 1990) and human capital (years of

education and skills of the workforce) (Lucas, 1988). Early econometric analysis based on this kind of "extended Solow model" found that RDI significantly boosts growth (Lichtenberg, 1992; Coe and Helpman, 1993), whereas evidence also supported the important role of human capital as a growth driver (Mankiw et al., 1992, and Barro, 1991).

On the other hand, Schumpeterian growth models, grounded in innovation economics, highlighted the continuous extension of "quality ladders" and "product spaces" (Grossman and Helpman, 1991; Aghion and Howitt, 1992, 2005), pointing out that high growth performance steams from ongoing investments in new products and productive technologies fueled by their high rates of return.

An early paper by Redding (1996) integrates both strands of endogenous growth theory grounded on RDI investments and human capital accumulation, as well as on the Schumpeterian innovation process as the main sources of the "growth engine". Redding (1996) presents a formal model of endogenous growth focusing on the synergies between human capital and RDI investments as well as capturing the interplay in which workers invest in human capital (developing skills), while firms invest in quality-augmenting RDI.

Self-reinforcing dynamics of human capital and RDI investments are synergetic devices giving rise to multiple growth equilibria which can be interpreted as the 'high-skills/high-quality' and 'low-skills/low-quality' positions described in empirical work and also referred to as a "mosaic of positions relative to the technological/quality ladder hierarchy" (Farole et al. 2013).

The economy of a region can be trapped in a disadvantageous equilibrium of low-skills/low-quality falling into low-competitiveness/low-growth (stagnation or even decline). 'Which equilibrium is selected depends entirely upon agents' expectations, and a potential role emerges for government policy and development institutions in designing appropriate policy measures to coordinate expectations and drive the economy out of the low competitiveness/low-growth trap. In Redding's words: 'introducing strategic complementarities and indivisibilities in investments allows multiple equilibriums to arise, which themselves may provide an additional explanation for differing rates of economic growth'. (Redding, 1996: p. 469).

This approach of equilibrium selection provides new insights into development policy. Subsidies improving human capital accumulation and RDI investment stemming from companies, jointly with improved transport infrastructure and accesibility may induce right expectations in workers and companies and increase simultaneous investment in RDI and in Human Capital that can project a region onto a self-reinforcing positive growth path.
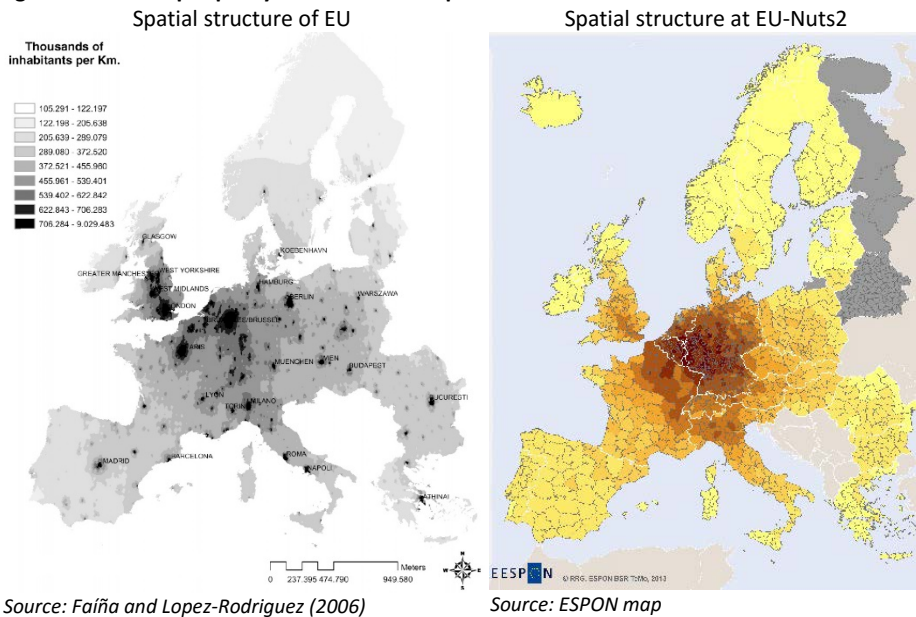
3.4. Spatial Structure and Agglomeration

3.4.1. Spatial Structure and Market Potential

In the first half of the 20th century, an analogy with the physical laws of gravitation was used to explain the decay of demand from distant locations by weighting their demand by the inverse of the distance (Reilly, 1931), this pave the way for drawing up the concepts of market and population potentials. Market potential is an index, which summarizes the influence of whole set of population settlements and economical activities, weighing its volume by the inverse of the distance. The maps of market potential (Harris, 1954, Keeble et al. 1982) are a useful way to summarise the vast information regarding settlements in space by using the simple structure of a map with peaks and valleys of population and economic potential which is useful in territorial planning and in the development of infrastructure networks.

Despite its practical use, the classic concept of potential put forward by Harris was criticised for not taking economic decisions and the usual forces of supply and demand which operate in the market into consideration.

Figure 12: Centre-periphery structure in Europe

Spatial structure of EU

Source: Faíña and Lopez-Rodriguez (2006)

Spatial structure at EU-Nuts2

Source: ESPON map

The spatial structure of the EU is characterised by a centre-periphery pattern, whereby the population and economic activities concentrate in the central regions (London, Paris, and Ruhr) with a progressive reduction dependant on the regional degree of accessibility to markets. The most central areas in the EU (see Figure 01) extends over 20% of the surface, but metropolitan regions host 59% of the EU population, offer 62% of all jobs and produce 67% of the Union's GDP..

3.4.2. Agglomeration economies and urban hierarchy

The tendency towards the concentration of economic activities has been known for decades and urban type processes take advantage of "agglomeration economies". Other specific agglomeration advantages affect sectors or industries such as industrial districts or firm clusters.

The three large sources of urban agglomeration economies, which drive the productivity and growth of cities, are essentially the 'Marshallian trinity' (after the economist Alfred Marshall): 1) knowledge spillovers, a technological externality spreading skills, knowledge and know-how, 2) large labour and skills markets allowing efficient and secure matching processes between firms' needs and workers' skills, and 3) economies which are external to the firm, but internal to the industry, stemming from indivisibilities and scale economies by sharing large cost inputs (transport and social infrastructures and others) among a great number of users and stakeholders.

In conclusion, agglomerations, and particularly the size of the market, offer ample advantages for the qualification of employees and the strengthening of human capital in productive activities, as well as for firms' investments in RDI and high-quality products.

3.4.3. New Economic Geography and spatial structure trend

The developments of the New Economic Geography (NGE) focus on the accumulative mechanisms (circular causation) which result from product differentiation and economies of scale in production (increasing returns). It is mainly focused on "monetary economies", which are transmitted through the price system. Technological and knowledge externalities, which are characteristics of the urban economy, are more difficult to model, but it does not mean that they are less important in practice.

Despite that, the introduction of differentiated products and increasing returns in general spatial equilibrium models, New Economic Geography (Krugman, 1991, 1992, Fujita and Thisse, 1996) is an important progress, which enables the analysis of the spatial distribution of economic activities within the conceptual framework of supply and demand in the market economy.

The physical analogy to explain the decay of demand from distant locations (Reilly, 1931) can be translated in market behaviour terms by considering distance as a cost putting a brake on buyer-demand. The concept of "demand cones" (Lösh, 1940), shown in Figure 13, allows both to compute market potentials (the volume of the demand cones) and to define the average operational radius of market areas (the distance which makes demand from distant locations almost negligible).

Figure 13: Demand cones and Market areas: the decay of demand with distance
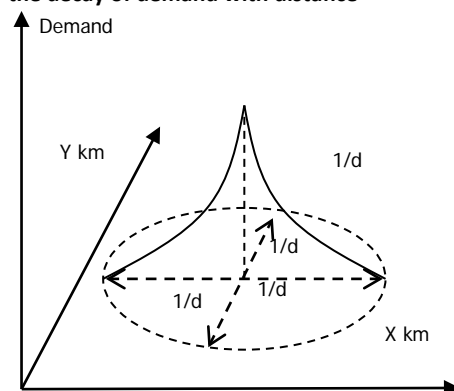
Source: Own elaboration based on the concept of demand cones (Lösh. 1940)

The NEG can be also thought as a conceptual framework for determining the average operational radius of market areas and the market access of different regions. NEG is based on a trade-off between concentration forces of economic activity, which are encouraged by product differentiation (quality based competitiveness) and increasing returns (economies of scale) in large central areas facilitated by low transport cost, and the forces of dispersion, which originate from product homogeneity (price or low cost competitiveness) and high transport costs.

Low transport costs allow quality differentiated products from large central areas to reach far away regions at affordable prices. Increased demand from distant locations reinforces economies of scale and further reductions in unit production costs in large central areas and, in that way, generates "backward linkages" in a circular causation process feeding growth and GDP concentration in large central areas.

The building of the single market and the elimination of border barriers, as well as the technological improvement of transport reduced transport costs. The initial concern of a strong concentration made worse by the single market, does not seem to have been confirmed. There is a clear central peripheral pattern in the European spatial structure, but a concentration as strong as expected as a result of transport cost reduction, technological improvement of communication and economic integration has not yet appeared, except for the greater performance of large cities and metropolitan areas.

There is a significant asymmetry in the predictive value of NEG models (Head and Mayer, 2004) in what regards spatial dynamics and income disparities. NEG predictions on spatial dynamics (computer simulations) point to unstability and breaking points in tendencies, which do not fit with the stability of spatial patterns and urban hierarchy exhibited by empirical data. On the contrary, whenever a centre-periphery spatial structure exists, inequalities in salaries and income between central and peripheral areas fit well with available evidence and can be explained by Market Access differences (the so-called "nominal wage equation" express this relationship). However, this relationship cannot be considered as deterministic and there are remarkable exceptions as it is the case with Scandinavian countries which have been able to overcome to a large extend the main handicaps of peripheral areas.

The NGE offers much more than possible explanations for the distribution and concentration of economic activity in space, offers a framework of analysis suitable for application to the study and evaluation of many different situations with different problems, which require specific combinations (tailor-made) of "policy measures".

3.5. Accessibility

Transport infrastructure reduce the problem of distance in time and cost, improving accessibility to the market both in general, as well as a network connecting the central structure principals.

3.5.1. Transport infrastructures and accessibility

Authors such as Hansen (1959) and Weibull (1976) made a model of the concept of accessibility in the middle of the 20th century. Accessibility is defined as opportunities of potential access from a place by means of a monetary cost and space-time.

In the last decades, accessibility has been the central concept of numerous studies in the area of transport infrastructure. Accessibility is a useful tool both for the planning of the economic development strategy in the long term and to explain good practices (Geurs et al., 2012) of regional and urban development. Several studies relating territorial accessibility to job markets exist (Reggiani et al, 2011), and from this point of view studies regarding accessibility and company location, are of key importance.

Recent studies tackle the theme of accessibility in the European area according to different types of infrastructure. On the one hand, the impact of the urban population's access to the high-speed rail and road network within a given travel time in Spain was studied using a methodology of network analysis in a Geographic Information System (GIS) environment (Monzón et al., 2013). On the other hand, accessibility was studied in Germany (Bentlage et al., 2013) by means of analysing potential opportunities opened by physical networks (rail, road, and airplane networks) as well as through connectedness within the firms' network (non-physical networks).

Finally, the study on digital accessibility through the Internet in Europe (Tranos et al., 2013) focused on potentials for virtual interaction using a methodology of spatial interaction models and network analysis.

Transport accessibility on a regional scale in Europe has been computed by the first ESPON (2006) programme. The following map shows the strong spatial association between road accessibility and peripheral areas in the European Union. It can be seen that approximately 60% of European Union territory has an index inferior to the median, located in the periphery (see Figure 14)

Figure 14: Core and periphery areas
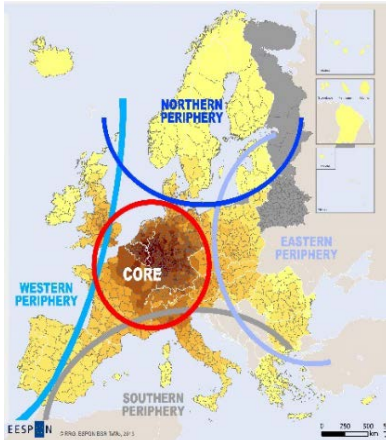
Source: Own elaboration from ESPON map

Recent literature has studied the effects of transport infrastructure over economic activity using measures of accessibility potential (López et al., 2009; Gutiérrez et al., 2010; Condeço-Melhorado et al., 2011). The effects of improved accessibility to the transport network on the regional specialisation of European regions' industrial sector were shown by Mora and Moreno (2013). The economies of regions with a high cost of accessibility (high amount of time or low access potential) should have a higher level of specialisation in one or various industrial sectors than regions with lower costs of accessibility.

The access potential to the network of transport infrastructure, affect the distribution and regional specialisation of industrial economic activity in Europe. However, European policy measures are of great importance given that the spatial distribution of activities is not maintained without changes in the long run (Rietveld and Vickerman, 2004).

In the case of the Dutch region of Noord-Brabant, where the city of Eindhoven is situated (Condeço-Melhorado et al., 2014), empirical evidence is supplied (as well as a monetary estimation) of flooding effects on the location of industrial activities created by transport infrastructure. In the case of Spain empirical evidence support a positive effect of high capacity roads infrastructure to private production, which is greater when spillover effects from adjacent regions are taken into account. Negative spillover effects do not seem to be supported by the Spanish evidence (Alvarez-Ayuso and Delgado-Rodriguez, 2012).

3.5.2. Substitution effects in transport networks

The TEN-T integrates different measures of transport by means of a complex central interregional network, which promotes the use of different modes of transport in order to interconnect the regions.

The environmental objectives of the European transport policy were to reduce CO_2 emissions and to encourage the use of transport means less dependent on petrol (Givoni, 2007), introducing in this manner a new complexity in the relationship between the HS train and other means of transport.

Studies on the effects of substitution between air travel and high-speed train lines (HSR) in international journeys within the EU (Dobruszkes et al., 2014) conclude that both means of transport compete in short to mid length journeys but that they may become supplementary/complementary in mid to long length journeys. The

high speed train substitutes aerial lines for short distances as it operates from city centres, which reduces users' time and CO2 emissions (Givoni, 2007) but encourages intermodality as it is a useful connection to long distance aerial services. In this way, time spent on short distance flights in currently congested airports could be saved and assigned to long distance travel. This approach implies a need for new solutions of flight connection offers, the geographic replanning of high-speed train routes and the adaptation of schedules amongst others (Givoni and Banister, 2006).

3.5.3. The new Europe 2020 Strategy and the TEN-T Network effects

The Trans European Transport Network (TEN-T) is comprised of a global network of roads, railways, rivers, ports and airports on the inside of European countries as well as a main network at the European level, structuring the domestic market.

The high-speed rail lines network (HSL) has expanded continuously. Low speeds and low frequencies of trains in central and eastern member states limit their appeal compared to car travel.

Figure 15: Corredores RTE-T
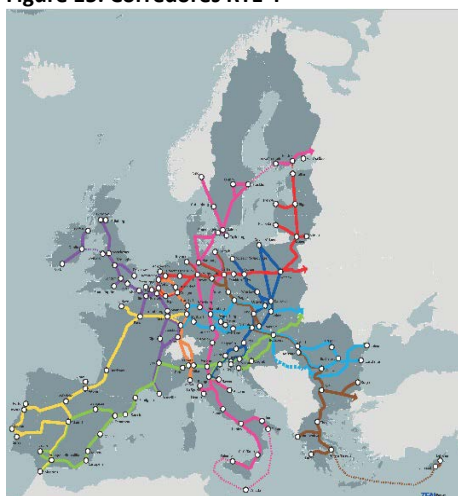
Source: European Commission Report (2013)

The TEN-T (EC, 2010) consists of two layers: a core network to be completed by 2030 and a comprehensive network, which feeds into the core network and is to be completed by 2050. The core network will facilitate the flow of goods and people around the EU. It involves connecting 94 main European ports to rail and road links, 38 key airports with rail connections into major cities, 15,000 km of railway lines upgraded to high speed and 35 cross-border projects to reduce bottlenecks.

New transport infrastructure policy is aimed at developing nine major corridors forming the backbone for transportation in the domestic market and implementing high performance East–West connections.

3.6. Peripheral areas

3.6.1. Will peripheral areas ever be reach?

The strategic complementarity model between the accumulation of human capital and RDI investments, as well as the trap of low qualification and low quality equilibriums (Redding, 1996) are of increased importance in peripheral areas due to the existence of synergies between the degree of regions' centrality and the

hierarchy in the range-size of cities and the levels of human capital and firms investment in RDI and high quality products.

Redding and Schott (2003) developed an NEG model consisting of two types of work, unqualified and qualified, which results from employees' decision to invest in their education. Peripheral regions compensate their competitive disadvantages by paying lower salaries and specializing in low quality undifferentiated products. On the contrary, central regions further specialize in high quality differentiated products exhibiting increasing returns to scale, being able to have greatest intensity in qualified work and pay higher salaries. This structure of incentives is harmful for peripheral areas, where lower salaries and less demand of highly qualified labour generate a penalty to the investment of human capital, which makes peripheral areas prone to fall in weak growth and competitiveness trap getting stuck in low qualification/low quality equilibriums[16].

Regions with geographic proximity to knowledge have advantages at their disposal to generate innovation. Since the mid-nineties of the 20th century, activity in innovation has extended geographically but tended to concentrate in central areas and in metropolitan cities and areas in the vertex of urban concentration hierarchy in the centre of Europe. Farole, Rodriguez-Pose and Storper (2011) express this in a clear way: "the link between innovation and agglomeration tends to be self-reinforcing: innovative activities lean towards agglomeration; and the greater the economic agglomeration, the greater the potential for innovation, for knowledge spillovers and for higher levels of economic growth".

Since the 80s, EU integration has generated an important convergence in the development levels of member countries. Nevertheless, regional disparities within each country tend to increase (Rodríguez-Pose, 1999; Puga, 2002, Farole et al. 2013). In Europe as well as in the whole world, central cities and cities of the largest size tend to reach higher and more stable rates of growth compared to areas with lower agglomeration levels (Kanbur and Venables, 2005).

3.6.2. Infrastructures and growth enhancing regional policies

The traditional focus of growth models studies negative effects of the distance focusing on improved access and the reduction of travel costs by means of transport infrastructure modernisation (roads, railways, ports and airports).

The lack of connection and accessibility to large market centres can limit the investment of human capital and RDI. Difficult connections and reduced accessibility to peripheral areas (the same can be said for integration deficiencies and the connections between different centres and close areas) generate a complex circle of mutually reinforcing interactions which tend to depress the

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[16] To a large extent, empirical evidence in the EU supports a spatial structure in salaries positively correlated with market access and the education level of the population (Lopez-Rodriguez et al., 2007)

economy and push it towards equilibriums of low quality/low qualification. The role of infrastructure is also extended to changes in expectations, which induce economic agents to invest in the improvement of their capabilities (knowledge, technology, new products and processes quality).

Regarding the role of infrastructure as a growth factor in the 1980s, authors such as Aschauer (1989) and Munnell (1990) introduced capital endowments in infrastructure within extended growth models. Mixed results were obtained in more developed countries. In general, the impact of growth in transport infrastructure investment is contingent upon the existence of development bottlenecks, which result from a scarcity of infrastructure. When transport infrastructures are weighed by their relative saturation indexes or by their impact on commercial and on interregional traffic flows they exert a positive effect on development (Delgado and Alvarez-Ayuso, 2004).

In the first development stages of lagging regions, a relatively solid reason exists to support adequate endowments to transport infrastructure. Less developed regions may find it difficult to increase public capital due to their low income levels and, as a result, overcoming a lack of infrastructure endowments could take too long in less developed regions, hindering their growth rates as a consequence of public capital stock shortages which may depress the return on private investment, hampering economic growth. For example, peripheral, lagging regions might lack sufficient financial capacity to develop good transport infrastructure to increase accessibility and connect the region with large market areas.

The improvement of transport infrastructure networks increases peripheral regions' accessibility, reducing transport costs and increasing competition from central areas. It can be said that highways and modern infrastructures have two-way effects: they bring the market closer and also intensify the competition of high concentration centres. Nevertheless, improved accessibility also opens new perspectives and opportunities in peripheral areas, which could result in new expectations and investments in human capital and firms' RDI driving the economy out of the low competitiveness/low growth trap.

There is no definite theory or one single solution as each situation is different and should be treated as such. Designing policy measures for less developed peripheral regions in order to build capabilities and expectations, which have the potential to drive the economy out of the low-skills/low-quality trap, enhancing growth and competitiveness is a challenging task. An analysis of a region's development problems and features is always needed. However, in light of the growth models and spatial positions commented on above, some recommendations can be issued regarding transport infrastructure networks and connections.

Peripheral and sparsely populated areas have a handicap in reaching high-skills/high-quality growth equilibriums, due to their low accessibility and poor connections to access technological knowledge and know-how. Transport

infrastructure improvement can help or even be a necessary condition for enhancing growth and development, but many other handicaps must be met in order to effectively increase growth and competitive performance in peripheral areas. Good connections and reasonable market accessibility require the implementation of allied measures to reinforce regional absorptive capabilities and innovation systems, as well as business internationalization to participate in open innovation partnerships throughout the world and gain range and penetration in international markets (overcoming the narrowness of local markets).

Farole, Rodriguez-Pose and Storper (2011) point out that capital and top-level cities usually are in the best position to successfully implement such policies and also give some guidelines for different types of territories.

For regions adjacent to core metro regions and secondary metro regions, the main recommendations include the promotion of integration with core metro areas and the improvement of their own agglomeration potential. For less developed peripheral regions infrastructure connectivity is recommended in order to link with leading regions, and for relatively sparsely populated rural and peripheral regions increasing connectedness to metropolitan regions is recommended in order to enable knowledge transfer and opportunity recognition.

3.6.3. Innovation, distance and knowledge networks

In a world of ample connectivity resulting from the technological revolution in ICT and transport, the flow of information and open innovation has considerably increased through complex networks and collaboration consortia. However, interpersonal face to face communication and the "Buzz" of cities (Storper and Venables, 2004) are becoming increasingly important. Confidence and ease of negotiation in complex situations are difficult to generate from a distance and strong distance-decay effects exist (Audretsch and Feldman, 2004).

Collaboration networks play a crucial role as carriers of knowledge spillovers and as a means of access to knowledge outside the region. Spatial proximity between the different agents (universities, research centres and companies) is important in order to generate collaboration networks of interregional knowledge. Studies carried out for Europe (Hoekman, Frenken and Van Oort, 2008) in sectors of technological innovation (biotechnology and semi- conductors) demonstrate the importance of networks as well as of proximity in order to align the different objectives of the agents involved in solving complex problems.

In terms of scientific-technological knowledge, European peripheral regions have an approximately average level of academic papers but when the moment arrives to commercialise and convert this knowledge into patents, their results are significantly below those of Central European regions. Different aspects depending on the sector under study exist, but in general, a central-peripheral pattern is

appreciated at a regional level, especially in the event of having to negotiate complex themes such as the development and commercial exploitation of academic paper results by companies.

Figure 16: Distribution of papers and patents in semiconductor sector

Academic Papers (1988-2004)   **Patents (1988-2004)**
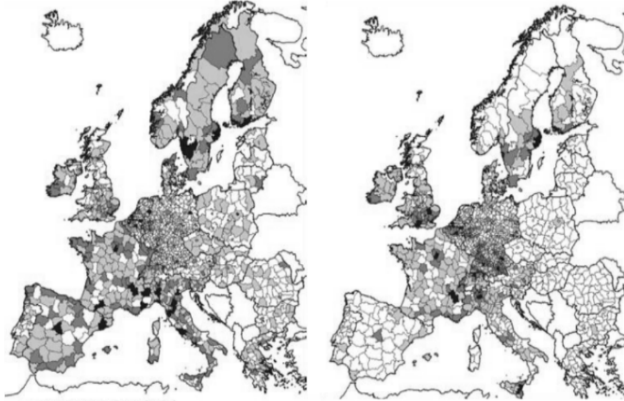
Source: Frank Van Oort (2010)

Figure 16 depicts the regional distribution of papers and patents in the semiconductor sector in Europe. It can be observed that within this sector, which has a higher level of maturity than biotechnology, patents have a much higher spatial concentration level than papers. This could be due to each region's individual characteristics or population formation, the excellence of their universities or the presence of technological firms but could also be a result of the central position of the region, which gives it better market access. This aspect of centrality is important as the low applicability of patents in comparison to papers is observed even in extremely active areas such as Sweden and Denmark.

This means that we cannot yet consider that progress in transport and communication technologies has countervailed the adverse influences of distance (a phenomenon called as "the death of distance"). Accessibility still plays a decisive role in facilitating the creation of collaboration and trust based networks as well as the mobility of people and face-to-face communications. All these factors remain important aspects to be taken into consideration in the valuation of infrastructure and development policy (Rietveldand Vickerman, 2004).

Conclusions and Contributions of the Thesis

Conclusions

Los resultados del capítulo 1 muestran evidencia empírica sobre la naturaleza "extensiva" (capital widening) del fuerte proceso de crecimiento experimentado por la economía española durante el periodo 1989-2010. Este crecimiento económico se basa en grandes inversiones y una fuerte trayectoria de acumulación de capital, pero estos aumentos de capital fueron absorbidas principalmente por gran creación y un fuerte crecimiento del empleo (tanto en trabajadores como en población ocupada). La evidencia empírica apoya de manera firme la existencia de un simple proceso de ampliación del capital sin que ello genere un aumento significativo de la productividad por trabajador o una mejora en la PTF, lo que sí ocurriría en un proceso de profundización de capital. Contrariamente, existe evidencia de una disminución constante de la PTF a una tasa acumulativa promedio de más del 1%.

Cabe destacar que los esfuerzos en el gasto de I+D han sido un importante motor del incremento de la PTF. Sin embargo, a pesar de su rápido crecimiento desde finales de los años 90, los niveles de gasto en I+D siguen siendo bajos e insuficientes para revertir la tendencia negativa de la PTF. Esto confirma una vez más el carácter extensivo y el simple proceso de ampliación del capital del fuerte crecimiento experimentado por la economía española desde finales de los 90 hasta el estallido de la actual crisis económica.

Las inversiones realizadas en infraestructuras han demostrado ser de gran importancia para las regiones menos desarrolladas de España, porque no contaban con una infraestructura de transporte mínima para poder mejorar su actividad económica y capital humano. Sin embargo, una vez que la región alcanza un nivel mínimo adecuado de acceso al mercado, el impacto de las infraestructuras sobre el crecimiento de la productividad se reduce significativamente. Esto se debe a la naturaleza de las infraestructuras de transporte, ya que genera un impacto positivo en la productividad en los otros factores productivos pero sin embargo, este impacto no es recíproco.

Una futura vía de investigación en la línea de este trabajo incluye una revisión de la serie histórica, región por región, en busca de patrones de crecimiento e impacto de las infraestructuras en la mejora del acceso al mercado y la reducción de los problemas de la perificidad. Otra futura vía de investigación sería el análisis de las diferencias temporales de cada región mediante modelos VAR.

Los resultados del capítulo 2 muestran que el modelo de crecimiento español, basado en un fuerte proceso de inversión y un gran aumento del capital, se puede clasificar como "extensivo". Este proceso de crecimiento del capital conduce más a un aumento en la producción y el empleo que a los aumentos en la productividad, tanto en términos de productividad del trabajo como de la productividad total de los factores (PTF).

Sin embargo, los beneficios potenciales de las inversiones en TIC e I+D necesitan un tiempo para trasladarse a la economía real y mejorar significativamente la productividad. El aumento de la productividad derivado de las TIC y el cambio tecnológico requiere nuevas formas de organización empresarial, mejoras educativas y una formación profesional continua con el fin de difundir las nuevas oportunidades técnicas y económicas. La experiencia de los EE.UU. y otros países pone de manifiesto la importancia que supone la flexibilidad y la competitividad de los mercados para facilitar la difusión y los beneficios de las TIC y reducir el tiempo necesario para que sus beneficios se trasladen a la productividad general del país.

Este problema de transferencia se agravó en España debido la gran fase expansiva que se produjo después del ingreso en el euro (1999-2008), ya que las bajas tasas de interés y un amplio acceso al crédito dieron como resultado una burbuja inmobiliaria, un crecimiento excesivo del sector de la construcción y un aumento general de los salarios, que afectaron negativamente a la productividad y competitividad del país.

Desde la entrada en la UE, la economía española ha logrado tasas de crecimiento del PIB superior a la media europea, que junto con un aumento significativo de la población activa y una alta creación de empleo, redujo sustancialmente la tasa de desempleo e hizo converger hacia los niveles más altos de ingresos per cápita de la UE-15. Sin embargo, este proceso tuvo un lado negativo en términos de productividad, ya que se estancó la productividad del trabajo desde 1995 y se produjo una reducción de la PTF, lo que supuso una pérdida de competitividad en casi todos los sectores del país respecto a la UE y a las economías más desarrolladas.

La especialización productiva de la economía española en la década de los 2000 ha tenido una fuerte presencia de sectores tradicionales y altamente cíclicos, como la construcción, en vez de centrarse en actividades innovadoras y de alto contenido tecnológico como cabría esperar de una economía avanzada. La existencia de un aumento muy fuerte del capital por trabajador durante el auge inmobiliario, especialmente en el sector construcción, generó un gran número de proyectos de inversión con rentabilidad a corto plazo en función de las expectativas de revalorización de los activos y no de su productividad. Este patrón de crecimiento era frágil e insostenible en el largo plazo, debido a la excesiva confianza en los beneficios generados a corto plazo por la entrada en el euro y a los desequilibrios financieros acumulados (alto déficit por cuenta corriente y elevado peso de la deuda) que lo han hecho altamente vulnerable a los efectos de la crisis internacional.

Una lección aprendida de cara al futuro es la necesidad de un mayor rigor en la selección de las inversiones con el fin de garantizar su rentabilidad y productividad de acuerdo con los recursos de capital. Los grandes retos de las regiones españolas son la recuperación de la crisis económica y la necesidad de reforzar sus capacidades de oferta para afrontar con éxito la creciente competencia derivada de

la globalización. Para ello, la economía española debe abordar: 1) cambios internos en la empresa: se requieren mejores empresas, más grandes, más productivas y con productos y servicios de alta calidad capaces de competir en mercados globales; 2) la reorientación de la especialización productiva: apuesta por actividades de alto valor añadido en el sector servicios que refuerce la productividad del sector industrial y fomente la producción y el uso intensivo de las TIC; 3) Promover el uso productivo del conocimiento, fomentando el proceso de innovación tecnológico y los proyectos de I+D+i empresarial, que son intensivos en capital humano de alta cualificación y mejora el uso de las TIC como base para la competitividad.

Los resultados del capítulo 3 muestran que la política de cohesión fue el instrumento principal para resolver el problema de escasez de infraestructuras en los países menos desarrollados de la periferia sur de Europa, a través del Fondo Europeo de Desarrollo Regional (FEDER) y el Fondo de Cohesión (FC), este último enfocado completamente en la Red Transeuropea de Transporte (RTE-T) y en la infraestructura ambiental.

A pesar del cambio en las prioridades de financiación de la política de cohesión en el periodo actual, orientadas al aumento de la competitividad empresarial y la mejora de la capacidad de crecimiento, las inversiones en infraestructuras contenidas dentro de la política común de transportes seguirán teniendo un gran peso. El MFF (Multiannual Financial Framework) de la UE para el período 2014-2020, con las inversiones en infraestructura no ambiental (sobre todo de transporte, la RTE-T), representa más del 21% de los recursos de la política de cohesión (6,9% del total del presupuesto de la UE para este período).

Las inversiones orientadas a reducir la brecha de infraestructuras son muy importantes para fomentar y potenciar el desarrollo de los motores de crecimiento (I+D, Pymes, TICs, y Capital Humano), pero esta influencia no es recíproca, lo que limita el papel de la infraestructura como factor de crecimiento. Pese a todo, en un mundo de rápidos cambios y evolución tecnológica, es necesario redefinir casi continuamente el nivel mínimo de dotación de infraestructuras que promuevan un desarrollo eficaz de los motores de crecimiento para generar mejores decisiones de inversión a futuro de los agentes.

Los empresarios y los trabajadores deben tener expectativas coherentes para invertir simultáneamente en capital tecnológico y humano a tasas adecuadas para mantener el impulso de crecimiento. La economía de una región se puede ver atrapada en un equilibrio desfavorable de bajas cualificaciones y baja calidad lo que lleva a la economía a caer en una trampa de baja competitividad y bajo crecimiento (estancamiento o incluso declive). Las políticas de desarrollo apropiadas (en capital humano, I+D, innovación y empresas) pueden crear estímulos y mejorar las expectativas de los agentes (trabajadores y empresas) que impulse a la economía fuera de esta trampa de la bajo crecimiento con un equilibrio de mayor cualificación laboral, innovación y calidad en las empresas.

Hacer que una región periférica salga de la trampa de competitividad no es una tarea fácil ya que no existe una única solución, cada situación y cada región tiene sus propias características que necesitan de un análisis detallado, pero se pueden emitir algunas recomendaciones con respecto a las redes de infraestructuras de transporte y conexiones.

Las zonas periféricas y poco pobladas con baja accesibilidad tienen una clara desventaja para acceder al conocimiento tecnológico y fundamental. Para conseguir que salgan de la trampa de competitividad es necesario la mejora de la infraestructura de transporte que fomente una mejor conexión y accesibilidad al mercado, pero también son necesarias otras medidas de estímulo (apoyo a la I+D, mejoras empresariales,…) que refuercen las capacidades de la región en el mercado internacional y poder superar la estrechez del mercado local.

A nivel científico-tecnológico, las regiones periféricas europeas han convergido a la media en cuestión de documentos académicos pero a la hora de comercializar los resultados y convertir este conocimiento en las patentes y transferencia, sus resultados son significativamente inferiores a los de las regiones de Europa Central. Ello es porque las redes de colaboración de las regiones centrales, entendidas como la proximidad espacial entre los diferentes agentes (universidades, centros de investigación y empresas), desempeñan un papel crucial como impulsores y medio de acceso al conocimiento fuera de la región, en sectores de innovación tecnológica (biotecnología y semiconductores) con el fin de alinear los diferentes objetivos de los agentes implicados en la solución problemas complejos.

Esto significa que los avances en el transporte y las tecnologías de la comunicación todavía no compensan la desventaja de la perificidad. La accesibilidad todavía juega un papel decisivo en la el fomento de la colaboración, la movilidad de las personas y las redes basadas en la confianza. Estos factores siguen siendo aspectos importantes que deben tenerse en cuenta en la valoración de la infraestructura y el desarrollo de políticas de cohesión.

Contributions

Seminar presentations:

Chapter 1:

1. *The role of transport infrastructures and human capital as drivers of economic development in peripheral regions in Spain, 1990-2008*. Seminars of Politic Economy. Chair: Professor John Bachtler (Director and Head of EPRC), University of Strathclyde in Glasgow, European Policies Research Centre. August 14th, 2013.

2. *The role of transport infrastructures and human capital as drivers of economic development in peripheral regions in Spain, 1990-2008*. III Doctoral Seminar. Chair: Professor Frank Van Oort (Utrecht University), University of A Coruña, Faculty of Economics and Business. November 20th, 2013.

Conference presentations:

Chapter 1:

1. *Drivers of growth in Spanish peripheral regions 1990-2008: what role for infrastructures and human capital?*. XXXIX International Conference on Regional Science. Spanish Regional Science Association (AECR). University of Oviedo (Spain). November 21st-22nd, 2013.

2. *Regional development and public infrastructures*. VI Workshop in honour of Geoffrey J.D. Hewings. Galician Regional Science Association (AGCR). University of Santiago de Compostela (Spain). June 9th-10th, 2015.

3. *Regional development and public infrastructures: the case of Spanish regions*. 8th Summer Conference in Regional Science. German Speaking Section of the European Regional Science Association (ERSA). University of Kiel (Germany). July 2nd-3rd, 2015.

4. XLI International Conference on Regional Science, Spanish Regional Science Association (AECR). Universitat Rovira i Virgili, Reus (Spain). November 19th-20th, 2015.

Chapter 2:

1. *Extensive Growth and the Productivity Paradox in Spanish Regions*. XL International Conference on Regional Science, Spanish Regional Science Association (AECR), University of Zaragoza (Spain), 19th-20th November, 2014.

2. *Development and structural change for the Spanish regions*. VI Workshop in honour of Geoffrey J.D. Hewings. Galician Regional Science Association (AGCR). University of Santiago de Compostela (Spain). June 9th-10th, 2015.

Publications:

Chapter 1:

Regional development in Spain 1989-2010: capital widening and productivity stagnation (Paulino Montes-Solla, Andrés Faiña and Jesus Lopez-Rodríguez) (forthcoming), **IVIE Working Papers serie EC**.

Chapter 2:

Regional development and structural change: the productivity paradox of Spanish peripheral regions (Andrés Faiña, Jesus Lopez-Rodríguez and Paulino Montes-Solla), in Regional Upgrading in Southern Europe: Spatial Disparities and Human Capital (Eds: Madalena Fonseca and Ugo Fratesi), in press 2015, **Springer Verlag**.

Chapter 3:

Cohesion policy and transportation (Andrés Faiña, Jesus Lopez-Rodríguez and Paulino Montes-Solla), in Handbook on Cohesion Policy in the EU (Edits. Simona Piattoni and Laura Polverari), in press 2015, **Edward Elgar Publishing Ltd.**

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Figures:

Tables:

Graphs: