ABSTRACT

This paper studies the contribution of the various factors of production, with an especial emphasis on transport infrastructure investments financed by the European Regional Development Fund (ERDF) and the Cohesion Fund (CF), to productivity per employee and Total Factor Productivity in Spain by estimating an extended Solow model (1956). The model is estimated using a data base built for 17 Spanish regions over the period 1989-2010. The results of the estimation show a negative growth rate of TFP in the range of 1.47%-1.60% over the period. This negative trend has been partially offset by the positive contributions made by Research and Development (RD) investments and the ERDF and CF investment in transport infrastructure. The results of our analysis also provide evidence on the stagnation in labour 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 jobs creation leading to a capital widening type of growth process.

Key Words: Regional development, Infrastructures, Capital widening, European Regional Development Fund, Cohesion Fund, Spain, Total Factor Productivity

JEL Classification: R10, R11, R12, R13, R14
1. Introduction

In recent decades, most advanced European countries experienced sustained economic growth based on processes of capital deepening. As many studies pointed out (Jorgenson, 1995; Jorgenson and Kevin, 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).

Overall, the growth process of the Spanish economy in the last decades 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).

This paper studies the contribution of the various factors of production (with an emphasis on transport infrastructure capital) to productivity per employee and Total Factor Productivity in Spain by estimating a Solow model (1956) expanded with infrastructure and human capital. The model estimation is carried out using data-base built for 17 Spanish regions (NUTs II level) over the period 1989-2010. This data-base was compiled putting together different statistical sources (Spanish Institute of National Statistics, INE, EUROSTAT, the Valencian Institute of Economic Research, IVIE,) jointly with the data extracted from European Regional Policy annual reports issued from 1989 until 2010 by the Directorate General of Community Funds of the Spanish Ministry of Economics and Public Finance (in Spanish know as DG Fondos).

The analysis pays special attention to the evolution of TFP over time and the role played by the investment in transport infrastructures carried out by the European Regional Development Fund, ERDF, and the Cohesion Fund, CF. The results of the estimation show a negative growth rate of TFP in the range of 1.47%-1.60 % over the period. This negative trend has been partially offset by the positive contributions made by Research and Development (RD) investments and the ERDF and CF investment in transport infrastructure. The positive contributions of these to last factors are estimated to be in the range of (0.22 – 0.28) and (1.7 – 2.4) percent respectively.

The paper also reports about the capital widening type of growth process followed by the Spanish economy over this period characterized by stagnant labour productivity and a strong jobs creation.

This paper is related to two strands of literature. On the one hand, the one referring to the evaluation of the EU Cohesion Policy and the assessment of its impact on growth and productivity (for recent studies see among others, Crescenzi et al. 2017, Crescenzi and Giua, 2016, 2017, Fratesi and Perucca, 2014, Monastiriotis, 2014, Monastiriotis and Psycharis, 2014, Lopez-Rodriguez and Faiña, 2014, Brandsma et al., 2014, Rodríguez-Pose and Fratesi, 2004). On the other hand, the literature on productivity and particularly the studies dealing with the Spanish case (see among others, Mas and Quesada, 2006, Maroto-Sanchez and Cuadrado-Roura, 2006, Cuadrado-Roura and Maroto-Sanchez, 2010, Cuadrado-Roura and Maroto-Sanchez, 2011, and Escribá and Murgui, 2013).

The rest of the paper is structured as follows: section 2 gives a brief overview on the growth patterns and productivity levels in Spain, section 3 contains the theoretical background, section 4 is devoted to explain the econometric model and the estimation strategy, section 5 details the
different data sources and procedures to compile the ERDF and CF data on transport infrastructure investments, section 6 presents the econometric results and finally section 7 concludes and outlines some policy implications.

2. Growth and productivity in Spain: an overview

The pattern of economic growth in Spain has three distinctive features: 1) A large investment effort considerably higher than in other countries; 2) The investment flows were mainly addressed to business capital; and finally, 3) A strong infrastructure development, mainly environmental, social and transport infrastructures. Unlike most developed European countries, along the 1989-2010 period Spain followed a capital widening type of growth process, where the increase in capital stocks was mainly absorbed by an intense process of jobs creation leading to steadied increases in the employment rates, while the capital/labour ratio and the productivity per employee remained stagnated or even slightly declined.

This process, especially from 1998 onwards, was mainly fuelled by an economic situation low real interest rates and an unlimited access to foreign credit in parallel with a strong boom in non-tradable services and in the real state sector.

The sharp increase in capital stocks and investment effort (see Figure 1) was accompanied by a significant growth in employment (reducing structural unemployment) and the labour force, especially immigrants oriented to sectors such as real state and tourism with a large share of low qualified employees. Consequently, productivity per employee stagnated over the period. The outbreak of the economic crisis in late 2007 and beginning 2008 had a deep impact on the Spanish economy leading to a GDP recession and a massive job destruction. The counterpart of this situation was reflected in important increases in productivity per employee mainly due to the strong adjustments in the business sector (shut down of many firms) and in the labour market (unemployment rate reached a peak of 26.94% at the worse of the crisis).

![Figure 1: Evolution of the capital stock and the investment effort of the Spanish economy (1989-2010)](source)
As figure 1 shows, the increase in capital stocks in the Spanish economy led to a significant process of development from 1989 onwards. Table 1 shows the offers an overview of the GDP per employee and GDP per capita for the initial year of our analysis 1989, the launching of the Euro 1999, the beginning of the crisis and the last year of our analysis compare vis-à-vis with the corresponding values for the EU15 at constant 2000 prices (figures in euros). It also offers the average cumulative growth rates of the above in between these periods.

Table 1: Productivity and GDP per capita in Spain vs EU15 (Thousand euro at constant 2000 prices)

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<td>EU15</td>
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<tr>
<td>GDP/per employee</td>
<td>44,331</td>
<td>51,588</td>
<td>55,678</td>
<td>55,590</td>
<td>1.38%</td>
<td>0.85%</td>
<td>-0.04%</td>
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<td>GDP/per capita</td>
<td>19,207</td>
<td>22,492</td>
<td>25,573</td>
<td>24,557</td>
<td>1.44%</td>
<td>1.43%</td>
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<td>SPAIN</td>
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<td>GDP/per employee</td>
<td>36,464</td>
<td>40,841</td>
<td>39,171</td>
<td>41,845</td>
<td>1.03%</td>
<td>-0.46%</td>
<td>1.65%</td>
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<tr>
<td>Worked hours/per employee</td>
<td>1,753</td>
<td>1,703</td>
<td>1,710</td>
<td>1,710</td>
<td>0.36%</td>
<td>-0.10%</td>
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<tr>
<td>GDP/per capita</td>
<td>11,918</td>
<td>15,077</td>
<td>17,825</td>
<td>16,836</td>
<td>2.14%</td>
<td>1.86%</td>
<td>-1.43%</td>
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<td>% SPAIN/EU15</td>
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<tr>
<td>GDP/per employee</td>
<td>82.25%</td>
<td>79.17%</td>
<td>70.35%</td>
<td>75.27%</td>
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<tr>
<td>GDP/per capita</td>
<td>62.05%</td>
<td>67.03%</td>
<td>69.70%</td>
<td>68.56%</td>
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\(p = \text{cumulative rate of growth}, \; \text{the coefficient of a time exponential growth function (in differences divided by the number of years)}\)

* 1999 data refers to year 2000.

Source: Own elaboration based on Cambridge Econometrics and the database for this paper.

The main features of the growth path in the Spanish economy are apparent when compared to the EU15. Since the mid-90s until 2008, labour productivity in Spain compared to the EU15 fell steadily (from 81.3% in 1989 to 69.7% in 2007). This fact become even more worrying on account of the loss of momentum of EU productivity vis-à-vis with the world most dynamic economies, particularly USA\(^2\). From 2008 onwards, due the impact of the crisis in the labour market labour productivity recovered reaching 75.27%. On the contrary, Spanish GDP per capita experienced a clear convergence process with the EU15.

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\(^2\) This fact was broadly examined in the literature, see among others European Commission (2007), Timmer, O’Mahony and Van Ark (2007) and Maroto and Rubalcaba (2008).
3. Theoretical background

3.1 Growth and Innovation: the trap of low-skills/low-quality equilibrium

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

In relation to human capital as a productive factor (Barro and Lee, 1994), recent studies using the general equilibrium model of new geographical economics have shown that peripherality and low market access pose a significant penalty to the accumulation of highly qualified human capital (Lopez-Rodriguez et al., 2007, Redding and Schott, 2003). This suggests a new channel of influence of transport infrastructure and market access on private investment in the qualification of human capital. Moreover, recent literature highlights that economies of agglomeration operate at “overlapping scales”\textsuperscript{3} and that important concentration forces at work are in metropolitan areas and central regions (Farole et al. 2011). An infrastructure network and

\textsuperscript{3} Geographical Economics models have already highlighted that reductions in transport costs could have adverse effects on the development levels of peripheral regions by intensifying competition from industries in central locations with strong economies of scale.
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.

Current models incorporate other key factors of endogenous growth such as technological progress and RD (Romer, 1986, 1990) and human capital (years of education and skills of the workforce) (Lucas, 1988). Early econometric analysis based on this ‘extended Solow model’ found that RD significantly boosts growth (Lichtenberg, 1992; Coe and Helpman, 1993), whereas evidence also supported the importance of human capital as a growth driver (Mankiw et al., 1992).

Schumpeterian growth models grounded in innovation economics also highlighted the continuous extension of ‘quality ladders’ and ‘product spaces’ (Grossman and Helpman, 1991; Aghion and Howitt, 2007), pointing out that high growth performance stems from constant investment in new products and productive technologies fueled by high rates of return. Redding (1996) integrated both strands of endogenous growth theory grounded on RD investment and human capital accumulation and on the Schumpeterian innovation process as the main sources of the ‘growth engine’. He produced a formal model of endogenous growth focusing on the synergies between human capital and RD investments, as well as capturing the interplay between workers who invest in human capital (developing skills) and firms which invest in quality-augmenting RD.

These self-reinforcing dynamics of human capital and RD investments give 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 referred to as a ‘mosaic of positions relative to the technological/quality ladder hierarchy’ (Farole et al. 2013, Redding 1996).

The economy of a region can be trapped in a disadvantageous equilibrium of low- skills/low-quality falling into low-competitiveness dynamics. Which equilibrium is selected depends entirely upon agents’ expectations, and a sound policy to drive the economy out of the low competitiveness/low-growth trap is needed. 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: 469).

Figure 3 illustrates a growth equilibria game based on the complementarities of individual agents’ strategies. Departing from a disadvantageous equilibrium of low- skills/low-quality (low-competitiveness) firms in the regional economy can choose either to invest in innovation leading to increase quality and productive enhancement or not to carry out these investments remaining with a low competitive profile. On the other hand, workers can choose either to invest in acquiring new skills or remain with their current skills. Moving away from this advantageous equilibrium (getting out of the productivity trap) is difficult since it implies solving a very complicated coordination and incentives problem.
The game has two stable equilibria. One, associated to remain in the low-productivity equilibrium, given by the couple of strategies of no investment in new skills (workers) and no innovation in quality and productivity enhancement (firms). The other, the optimal and preferred one, linked to the high productivity equilibrium is given by the couple of strategies of investment in new skills and innovation in quality and productivity enhancement. The transitional problem to reach the optimal equilibrium lies in the potential losses assumed by the first mover when she carries out her investment. If the second mover does not invest in improving his capabilities to match those required to make successful the first mover strategy, the potential losses of the first mover become realized.

There are many reasons which make difficult to match players’ investments in new skills and the specific requirements of firms’ innovation strategies. There is a lot of uncertainty linked to innovation processes both in terms of the results (output) and in the specific requirements which arise when carrying on the different stages of the innovation process. Players trapped in a low-productivity economy do not have much knowledge on how to tackle these uncertainties. The success to the transition towards a high productivity economy needs, on the hand, to spread knowledge and information on the potential activities and capabilities that must be matched by the different players. On the other, credible expectations on the feasibility of achieving a higher productivity economy must be created, as well as an environment of mutual trust among the players. A central role for government policy and development institutions in designing appropriate policy measures to generate trust and coordinate expectations emerges. Rodriguez-Pose and Vilalta-Bufi (2005) in their study on the performance of EU NUTS 1 regions found that the matching between the specific skills required by firms and those offered by workers is one of the key factors to improve regional performance and growth rates.

This approach to equilibrium selection provides new insights into development policy. Subsidies improving human capital accumulation and RD investment stemming from companies, together with improved transport infrastructure and accessibility, may help to induce the right expectations in workers and companies and increase simultaneous investments in RD and in human capital which can lead a region onto a high-skills/high-quality equilibrium and increase competitiveness.
3.2 Capital widening: Growth without productivity gains

The meaning of capital widening becomes apparent once we drop out the central assumption of full employment in growth theory. This is a key assumption to investigate the underpinning causes of growth processes whenever the amount of labour is a binding factor.

On the contrary, when the supply of labour is elastic because unemployment rates remain at high levels during long periods of time, an economy can reach important growth rates by increasing capital accumulation and creating new jobs through capital widening, that is by increasing both the amount of capital and labour inputs in the production function.

From a Price theory perspective, it is a tricky question to explain how this can happen in an unrealistic system of perfectly competitive markets. However, we do not need to solve such a complex theoretical problem for substantially improving our understanding of capital widening processes associated to the empirical research carried out in this paper. Market “imperfections” which are present in real world (like trade unions and other institutional factors) justify the approach followed in this paper.

Growth theory generally assumes full employment because this is the real interesting case for analyzing the role of the main growth drivers (business and public capital, human capital and technological change). This case is characterized by the fact that the full employment assumption imposes an active constraint on growth making impossible of very hard to increase output by increasing the levels of employment. Strictly speaking labour supply is not fully rigid and therefore there is some room for growth driven by labour increases at the cost of unleashing wage increases that must be met by capital investments enhancing labour productivity. This is precisely the true interesting case studied in the growth literature.

If we denote the full employment labour force by \( L_{FE} \) the employment level by \( L_N \) and the level of output by \( Y \), the condition of labour force as an active constraint and a binding growth factor \( L_N = L_{FE} \) implies that output increases \( \Delta Y > 0 \) can only be achieved by raising business capital levels \( \Delta K > 0 \), human capital levels \( \Delta \varphi(s) > 0 \) or by means of improving technology efficiency (captured in the extended Solow model by total factor productivity \( A \)). This means that the only ways to achieve sustained growth is by increasing labour productivity \( (Y / L_N) \) through capital deepening and/or enhanced technology efficiency (Total factor productivity, \( A \)).

However, in the real case of economies suffering from long term structural unemployment, the amount of available labour is not a binding factor of growth and the full employment constraint is no longer active. This case opens the door to a completely different growth dynamics. Steadied growth rates can be kept in the medium run by creating new jobs and increasing both employment levels and capital accumulation.

If the labour constrain is not binding \( L_N \ll L_{FE} \), some kind of capital investment constraint (associated with institutional environment-high salaries in a rigid labour market- or the lack of access to foreign financial markets, etc.) which keeps the economy well below the full employment situation must exist. In some way, this situation can be characterized by a lack of access to capital which hampers capital accumulation, jobs creation and output growth.
A capital widening type of growth process can therefore happen when the capital accumulation and jobs creation go hand in hand. Mathematically (disregarding zero or negative increments):

$$\begin{align*}
\frac{\Delta K}{\Delta L_N} > 1 & \implies K \frac{L_N}{L_N} \text{ increases (some capital deepening occurs)} \\
\frac{\Delta K}{\Delta L_N} = 1 & \implies K \frac{L_N}{L_N} \text{ constant (mere capital widening)} \\
\frac{\Delta K}{\Delta L_N} < 1 & \implies K \frac{L_N}{L_N} \text{ decreases (Capital widening with shrinking Capital/labour ratio)}
\end{align*}$$

The most remarkable conclusion here is that a positive growth process based on a high capital investment and strong jobs creation can take place with stagnating or even decreasing labour productivity and decreasing technological efficiency (TFP).

To illustrate how capital widening leads to per capita GDP growth with stagnating labour productivity it is useful to break down per capita output, $y_{pc}$, into the product of the productivity per employee times the employment ratio (share of employment in total population).

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

In a similar way, the per capita output (or income) growth rate, $g_{y_{pc}}$, can be broken down into the sum of the labour productivity growth rate, $g_{y_{pe}}$, plus the growth rate of the share of employment in total population, $g_{res}$.

$$g_{y_{pc}} = g_{y_{pe}} + g_{res}$$

This is the reason why economies in a low-skills/low-quality equilibrium can achieve substantial growth in the medium run without much quality and competitiveness improvement. Whenever labor supply is elastic (because of steadied long term unemployment rates or migratory inflows), productivity stagnation (or slight decline) can be overcome by jobs creation and increasing employment shares in total population.

4. Econometric model and estimation strategy

The extended Solow model uses an augmented production function (incorporating human capital besides the traditional inputs, labour and capital) which in our case is an appropriate tool for analysing labour productivity and estimating the elasticity values for the different production factors, as well as for estimating the time trend of the technological efficiency, known as total factor productivity. Moreover, the model can be extended to estimate the effects on output and productivity of infrastructures adding a new variable to capture the stocks of public infrastructures.

Let us denote regions and years by the subindexes i and t, respectively. The starting point in our framework is the definition of the following augmented Solow (1996) production function:
Where \( Y \) measures the total production of goods and services, \( K_{\text{hum}} \) denotes the level of aggregate human capital, \( K_{\text{biz}} \) denotes the stock of business aggregate capital, \( K_{\text{inf}} \) denotes the stock of public infrastructures, and finally, \( A \) stands for total factor productivity (TFP). The coefficients \((\delta, \delta_K, \delta_g)\) represent the elasticities of output with regard to human capital, business aggregate capital and the stock of transport infrastructures respectively.

Following Barro and Lee (2010), we proxy human capital as the product of the weighted average of the length of each educational attainment level by their corresponding percentage in the working age population (aged 25-64). Mathematically, human capital is given by the following expression:

\[
K_{\text{hum}} = L_t \cdot e^{\phi_t(s)}
\]

where

- \( L_t \) denotes the level of employment for each region and year
- \( \phi_t(s) \), denotes the stock of human capital per employee as the weighted average of the duration of each educational attainment level

Substituting expression (2) in equation (1), we obtain the following expression for the production function:

\[
Y_{it} = A_{it} \cdot (L_t \cdot e^{\phi_t(s)})^{\delta_{it}} \cdot K_{\text{hum}}^{\delta_{it}} \cdot K_{\text{inf}}^{\delta_{it}}
\]

TFP is expressed as follows:

\[
A_{it} = A_0 \cdot e^{(\lambda t + \mu \cdot r_{rd}) + (\gamma \cdot euf)}
\]

Where, \( A_0 \) denotes the starting value for Total Factor Productivity (TFP). The exponential component of \( A \) represents the growth rate of Total Factor Productivity (TFP). The \( t \) variable denotes year and the associated \( \lambda \) coefficient stands for the average cumulative rate of growth of TFP along the time trend. \( r_{rd} \) is the regional share of research and development expenditure (RD) on regional output and the associated coefficient \( \mu \) captures the boosting effect of RD expenditure on the TFP cumulative rate of growth. \( euf \) is the regional share of the annual expenditures in regional infrastructures delivered by the ERDF operational programs and the Cohesion Fund on the stocks of regional infrastructures capital \( K_{\text{inf}} \). In a similar way, the associated \( \gamma \) coefficient captures the boosting effect of ERDF and CF expenditure on the TFP cumulative rate of growth.

Introducing expression (4) in expression (3) leads to the following production function:

\[
4 \text{ Lopez-Rodriguez and Martinez (2017) in a study of the contribution of innovation activities to TFP growth for a sample of EU countries consider both R&D and non-R&D innovation activities as the main drivers of TFP}
\]
Dividing expression (5) by $L_{it}$, the expression (5) is reformulated as output per employee:

$$
Y_{it} = \left( A_0 \cdot e^{t \cdot \mu \cdot rd_{it} + t \cdot \gamma \cdot cuf_{it} \cdot t} \right) \cdot \left( L_{it} \cdot e^{\phi_{it}(s)} \right)^{\delta_t} \cdot K_{bi_{it}}^{\delta_b} \cdot K_{inf_{it}}^{\delta_{inf}}
$$

(5)

Using lower case letters to represent the corresponding per-employee variables, expression (6) can be written as:

$$
y_{it} = \left( \frac{A_0}{L_{it}^{1-\delta_t-\delta_b-\delta_{inf}}} \right) \cdot e^{t \cdot \mu \cdot rd_{it} + t \cdot \gamma \cdot cuf_{it} \cdot t} \cdot e^{\phi_{it}(s) \cdot \delta_t} \cdot k_{bi_{it}}^{\delta_b} \cdot k_{inf_{it}}^{\delta_{inf}}
$$

(6)

Assuming constant returns to scale, $\delta_b + \delta_{inf} = 1$, the expression (7) can be written as follows:

$$
y_{it} = A_0 \cdot e^{t \cdot \mu \cdot rd_{it} + t \cdot \gamma \cdot cuf_{it} \cdot t} \cdot e^{\phi_{it}(s) \cdot \delta_t} \cdot k_{bi_{it}}^{\delta_b} \cdot k_{inf_{it}}^{\delta_{inf}}
$$

(7)

Taking logarithms in expression (8), we obtain the model which will be estimated in the empirical part of the paper:

$$
lny_{it} = lnA_0 + \lambda \cdot t + \mu \cdot rd_{it} \cdot t + \gamma \cdot cuf_{it} \cdot t + \delta_t \cdot \phi_{it}(s) + \delta_b \cdot lnk_{bi_{it}} + \delta_{inf} \cdot lnk_{inf_{it}} + \varepsilon_{it}
$$

(9)

Considering that the effects of infrastructure capital endowments on regional productivity are contingent on the relative endowment levels of each region, we define two alternative measures of capital endowments. For the sake of clarity, the first one gathers the stocks of transport infrastructure capital per employee and will be labelled as $Kinf_{1}$. The second one labelled as $Kinf_{2}$ is a new comparative measure of capital which is built from an index ($satindex$) which for each time period weights regional capital stocks by both regional population and area and express these weighted values as ratios to the best endowed region (the maximum value along the time frame of our period of analysis). This homogenised index is named as saturation index and is mathematically defined in the following way:

$$
satindex_{it} = \frac{K_{a_{it}}^{inf}}{\sqrt{\frac{pop_{it}}{area_{it}}}}
$$

(10)

The economic rationale behind expression (10) is on the one hand (numerator) to take into account differential regional sizes both in population and area (regional capital stocks are weighted by their geometric mean (square root of the regional population times the regional area) and on the other (denominator) to capture the regional transport infrastructures gap with regards to a well-endowed region.

The index varies in the range (0,1] taking the value 1 for the best-endowed region and diminishing as we move towards the worst endowed region.

$Kinf_{2}$ is defined as $satindex_{it}$ times 100 to avoid problems when taking logs in the range (0,1] which leads to negative and cero values. Using $Kinf_{2}$ allows a more accurate analysis of the effect of transport infrastructures endowments on the productivity levels in Spain.
Expression (10) can be defined in terms the saturation index in the following way:

\[ \ln y_{it} = \ln A_t + \lambda \cdot t + \mu \cdot \ln K_{it} + \gamma \cdot \text{euf}_{it} \cdot t + \delta \cdot k_{it} + \delta \cdot \ln K_{infit} + \varepsilon_{it} \]  

\[ 11 \]

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:

The longitudinal combination of time and cross-sectional data (panel data) allows for coping with unobserved heterogeneity and minimises the possibility of estimating errors. We have estimated equations (9) and (11) by fixed effects.

5. Data

We combine several sources of information to gather the data we use in the empirical part of the paper. Mainly four data sources have been used, the Valencian Institute of Economic Research, (Instituto Valenciano de Investigaciones Económicas, IVIE), the Spanish National Statistical Institute, (INE), The Spanish ministry of Education, Culture and Sports (MECD) and the former Spanish Ministry of Economics and Finance (MEF).

IVIE research institute jointly with the BBVA foundation generate quality statistical data on a range of issues related to the Spanish economy and up-to-date information to facilitate decision making. The Institute currently provides twenty-four databases, some of which have been published for over fifteen years, such Capital Stock and Human Capital. We have resort to the Valencian Institute of Economic Research, IVIE for data on Gross Domestic Product (Y), Human capital (Khuman), Business capital (Kbiz) and public capital in transport infrastructures (Kinf).

The variable research and development expenditure (rd) refers to the regional yearly expenditure in research and development activities as a percentage of GDP over the period 1989-2010. These data come from the Spanish National Statistical Institute, (INE).

The per employee human capital variable (ϕit(s)) has been proxied as the average years of education weighted by the percentage of labour force population (aged 25-64) for each educational attainment level. The data for this variable covers the period 1989-2010 and has been taken from IVIE and has been computed from human capital data provided by the Spanish ministry of Education, Culture and Sports.

Regarding the variable of European funds investments in transport infrastructures (erdf) we have used the total expenditure in transport infrastructure projects carried out by European programs. Total expenditure includes European aid plus the co-funding share of the Spanish bodies corresponding to the amount of the investment brought by European funds (European Regional Development Fund -ERDF- and the Cohesion Fund).

These data have been obtained from the European regional policy annual reports issued from 1989 until 2010 by the Directorate General of Community funds of the Spanish ministry of Economic and Public Finance (DG Fondos), the Spanish body in charge of the implementation and supervision of the EU Structural funds. These annual reports deliver detailed information on the investments carried out with the support of the European funding along the time-span
of our empirical exercise which covers the four programming periods since the Spanish adhesion to the EU.

The core of the current regional policy in the EU with programming periods comes from the European Single Act (1987) but it was not until 1989 that the first programming period was launched (1989-1993). Afterwards, within the time frame of our analysis three new programming periods were launched (1994-1999), (2000-2006) and (2007-2013).

In the first programming period (1989-1993) the European regional policy annual reports of DG Fondos were only issued in the former Spanish currency unit (peseta). During the second programming period (1994-1999) the DG Fondos reports were issued both in peseta and ECU (European currency unit). Since the creation of the EURO in 1999 the reports are issued in the new European currency.

All the data in our study have been transformed at constant 2000 euro (expressed in thousands of Euros). Consequently, the amounts of the European programs’ investments in transport infrastructures have also been transformed at constant 2000 euro.

The following steps have been taken to carried out this conversion:

a) For the amounts gathered in the 1989-1994 European regional annual reports, we first apply the annual exchange rates Peseta/ECU (obtained from Eurostat5). Then, the ECU amounts were transformed at constant 2000 euro by applying the conversion factors from euro fixed series euro/ECU (obtained from Eurostat6)

b) For the amounts gathered in the 1995-1999 European regional annual reports they have been transformed at constant 2000 euro by applying the conversion factors from euro fixed series euro/ECU.

c) The amounts gathered in the 2000 European regional annual reports are already expressed at constant 2000 euro.

d) For the amounts gathered in the 2001-2010 European regional annual reports they have been transformed at constant 2000 euro by applying the Spanish Consumer Price Index deflator (CPI deflator) because this index captures more accurately the influence of the price evolution in Spain which systematically featured higher inflation rates than the Euro area.

The transport infrastructure investment data for the period 1989-1993 are directly obtained from the European regional annual reports in the sections devoted to the implementation of the framework of the different ERDF Operational Programs (OPs). In the case of objective 1 regions these sections provide regionalized information on the expenditure on transport infrastructures broken down by region (Autonomous Communities). They include the amounts invested in transport infrastructure projects both by regional bodies and by the Central Administration (multi-regional ones). In the case of objective 2 regions, the corresponding sections of the annual

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5 See Table [ert_bil_conv_a]: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ert_bil_conv_a&lang=en
6 See Table [ert_h_eur_a]: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ert_h_eur_a&lang=en
reports provide information on the investment in transport infrastructures within the ERDF OPs\textsuperscript{7}).

In the 1994-1999 and 2000-2006 programming periods, the amounts invested by the ERDF OPs\textsuperscript{8} in transport infrastructure projects were obtained from the DG Fondos annual reports following the same procedures as in the previous programming period.

A novelty of these periods and the last year of the 1989-1993 programming period is the launching of the Cohesion Fund (CF) in 1993 devoted to finance large projects in the fields of transport (Transport European networks-TEN) and environment (water, energy, waste and other environmental projects). The CF is managed by the Central administration on a project by project basis. To assess and assign the CF expenditure to the different regions, we first computed the amounts of the projects approved by the CF under the transport infrastructure heading (reported in DG Fondos annual reports). Secondly, for multi-regional projects, we computed the regional shares in each of those projects based on the length of the tranches (kilometres of rails and highways) that goes through each region. Finally, to assign the annual expenditures of the CF, the 4-year average duration of each project was taken into account.

Finally, for the period 2007-2010, we had access to the database of DG Fondos (Ministry of Economy and Finance) while the authors of this paper were carrying on their tasks under the Expert Evaluation Network (Faiña et al., 2009, 2010, 2011, 2012, DG Regio, European Commission).

The following table 2 shows the amounts invested in transport infrastructures (at constant 2000 euro) and the shares to the GDP for the ERDF and CF over the different programming periods broken down by objective 1 and objective 2 regions.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EU Funds</td>
<td>EU Funds</td>
<td>EU Funds</td>
<td>EU Funds</td>
<td>EU Funds</td>
</tr>
<tr>
<td>Objective 1</td>
<td>6,373.9</td>
<td>16,320.9</td>
<td>24,487.7</td>
<td>8,662.1</td>
<td>55,844.5</td>
</tr>
<tr>
<td></td>
<td>0.55%</td>
<td>1,02%</td>
<td>1,03%</td>
<td>0.58%</td>
<td></td>
</tr>
<tr>
<td>Objective 2</td>
<td>551.6</td>
<td>3,932.1</td>
<td>8,930.9</td>
<td>836.1</td>
<td>14,250.7</td>
</tr>
<tr>
<td></td>
<td>0.04%</td>
<td>0.24%</td>
<td>0.36%</td>
<td>0.05%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6,925.5</td>
<td>20,253.0</td>
<td>33,418.5</td>
<td>9,498.2</td>
<td>70,095.2</td>
</tr>
<tr>
<td></td>
<td>0.29%</td>
<td>0.62%</td>
<td>0.69%</td>
<td>0.30%</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Cohesion Fund investment in transport infrastructures are added from 1993 onwards
Note 2: A) Objective 1 regions include Andalucía, Asturias, Canarias, Cantabria, Castilla y León, Castilla-La Mancha, Valencia, Extremadura, Galicia and Murcia. In the 1989-1993 and 2007-2013 periods, Cantabria is out of this objective. B) Objective 2 regions include Aragón, Baleares, Cataluña, Madrid, Navarra, País Vasco and La Rioja. In the 1989-1993 and 2007-2013 periods, Cantabria is entered in this objective. C) In the 2013-2020 programming period only Andalucía, Castilla-La Mancha, Extremadura and Galicia remain as objective 1 regions (convergence regions), the rest of them, Asturias, Murcia, Canarias, Castilla y León and Valencia, are included in a transition regime called as Phasing-out and Phasing-in regions.

Source: Own elaboration based on EU Funds annual reports data (DG Fondos)

With the addition of the amount of EU investments in transport infrastructures our database was completed. The database is made of a strongly balanced data panel of 374 observations (no

\textsuperscript{7} A singularity in the 1989-1993 programming period for Objective 2 regions was that OPs had two programming phases, one initial for the period 1989-1991 with a time frame of 3 years, to which subsequent updates were incorporated for the 1992-1993 period (1989 DG Fondos report, pp. 98 and 1991 DG Fondos report, p.256

\textsuperscript{8} In the 2000-2006 programming period, Objective 2 regions OPs were gathered together into the so called single programming documents (SPD)
missing values) which correspond to the 17 Spanish regions observed over the period 1989-2010.

6. Econometric estimation and results

The variables used in the econometric analysis are: $y$ which refers to the regional GDP per employee; the net capital stock is broken down into regional business capital, $k_{biz}$ (defined as non-housing business capital) and regional capital stock of transport infrastructures, ($K_{inf1}$ and $K_{inf2}$). Regional research and development expenditures are as a percentage of regional GDPs, $rd$; ERDF and CF regional investments in transport infrastructures as share of regional transport infrastructure stocks, $euf$; regional human capital, $\varphi(s)$, is calculated as the weighted average of the years of education in each educational attainment level for the working age population (25-64).

Tables 3 and 4 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 3: Summary and description of variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. D.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>374</td>
<td>39291.0</td>
<td>5510.4</td>
<td>25218.1</td>
<td>51827.2</td>
</tr>
<tr>
<td>(GDP per employee)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$rd$</td>
<td>374</td>
<td>.78221</td>
<td>.46834</td>
<td>.09</td>
<td>2.41</td>
</tr>
<tr>
<td>(variable to control for the effect of GDP as an accelerator of TFP growth)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$euf$</td>
<td>374</td>
<td>.02601</td>
<td>.02266</td>
<td>.00000</td>
<td>.11248</td>
</tr>
<tr>
<td>(variable to control the effect of EU funds in infrastructures of TFP growth)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varphi(s)$</td>
<td>374</td>
<td>1.0576</td>
<td>.07724</td>
<td>.82494</td>
<td>1.2258</td>
</tr>
<tr>
<td>(stock of human capital per employee)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K_{biz}$</td>
<td>374</td>
<td>54501.6</td>
<td>9782.3</td>
<td>26148.6</td>
<td>84418.4</td>
</tr>
<tr>
<td>(business capital per employee)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K_{inf1}$</td>
<td>374</td>
<td>8087.9</td>
<td>3250.3</td>
<td>2220.4</td>
<td>17036.8</td>
</tr>
<tr>
<td>(capital stock in transport infrastructure per employee)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K_{inf2}$</td>
<td>374</td>
<td>33.7912</td>
<td>17.0098</td>
<td>7.54389</td>
<td>100.000</td>
</tr>
<tr>
<td>(saturation index of relative distance to the infrastructure of reference)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Own elaboration*

To explore the relationship between the different variables in the model, the correlation matrix in table 4 shows the direction and intensity of the correlation coefficients between all the variables in the model. It can be observed that all the paired correlations between the variables have the expected signs. It is worth highlighting the negative correlation between labour productivity and European investments in transport infrastructures because of EU funds are mainly channelled to backward regions.

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9 Employment data includes both employees and self-employed people
Table 4: Correlation table of variables

<table>
<thead>
<tr>
<th></th>
<th>lny</th>
<th>rd</th>
<th>euf</th>
<th>f(s)</th>
<th>lnKbiz</th>
<th>lnKinf1</th>
<th>lnKinf2</th>
</tr>
</thead>
<tbody>
<tr>
<td>lny</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rd</td>
<td>0.3894</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>euf</td>
<td>-0.2824</td>
<td>0.1601</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f(s)</td>
<td>0.4940</td>
<td>0.8056</td>
<td>0.2884</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnKbiz</td>
<td>0.5416</td>
<td>0.5681</td>
<td>0.1223</td>
<td>0.6136</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnKinf1</td>
<td>0.0121</td>
<td>0.2083</td>
<td>0.1610</td>
<td>0.1047</td>
<td>0.4270</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>lnKinf2</td>
<td>0.5509</td>
<td>0.6722</td>
<td>0.7276</td>
<td>0.4983</td>
<td>0.4983</td>
<td>0.3496</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Source: Own elaboration

Figure 4: Labour productivity in Spain, 1989-2010 (Thousand euro at constant 2000 prices)

Figure 5: Capital per employee in Spain, 1989-2010 (Thousand euro at constant 2000 prices)

Source: Own elaboration

Figures 4 and 5 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.

Figure 6: Human Capital per employee in Spain, 1989-2010

Figure 7: Business capital per employee in Spain, 1989-2010 (Thousand € at constant 2000 prices)

Source: Own elaboration
Figures 6 and 7 show the evolution of business and human capital per employee respectively over the period 1989-2010. The evolutions of business capital show a parallel pattern to the one depicted by labour productivity, whereas human capital follows a positive trend all over the period.

Figure 8: Transport Infrastructure Capital per employee (\(K_{inf1} & K_{inf2} \equiv \text{satindex}\)) in Spain, 1989-2010 (Thousand euro at constant 2000 prices)

Source: Own elaboration

Figure 8 provides a very interesting insight about the pattern followed by transport infrastructure capital stocks per employee. The graph on the left shows how the strong jobs creation occurred in the Spanish economy form 1995 until the outbreak of the last crisis distorts the strong investment effort and the large accumulation of transport infrastructure capital made over this period. Additionally, considering that transport infrastructures are subject to strong scale economies their relative endowments expressed in per employee terms undervalue their effects on labour productivity. Moreover, this measure of transport infrastructure capital per employee does not weight by the size and geographical coverage of transport infrastructures.

To sort out these problems we have defined an index of transport infrastructures (\(\text{satindex}\)) across Spanish regions which weights both regional size and population and compares them in terms of the best endowed region (in our case Madrid in the year 2010).

The graph on the right side of Figure 8 plots the evolution of \(\text{satindex}\) over 1989-2010. Transport infrastructure capital stocks measured in this way provide a more accurate proxy for analysing the effects transport infrastructures on labour productivity.
Finally, figure 9 provides the evolution patterns followed by RD investments over regional GDP (right side of the Figure) and the share of EU investments in transport infrastructures (ERDF and CF programmes) over the transport infrastructures capital stocks. The effort of Spanish economy in terms of RD was very low until the second half of 90s (around 0.5%). Nonetheless it started to grow from the late 90s onwards reaching a value slightly above 1% in 2009. Regarding the share of EU investments in transport infrastructures, it grew until the year 2003 (reaching its maximum close to 0.05%). From this moment onwards, the new EU policy guidelines based on the Lisbon strategy reduced the amounts channelled towards transport infrastructures.

Table 5 next 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, lnKinf1, whereas the second, (model B), uses a more helpful variable, the LnKinf2, based on the index we built (satindex) to capture regional distances to the adequate reference level of infrastructure endowments.

<table>
<thead>
<tr>
<th></th>
<th>Model A</th>
<th>Model B</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>5.069*** (0.000)</td>
<td>4.440*** (0.000)</td>
</tr>
<tr>
<td></td>
<td>(14.20)</td>
<td>(11.98)</td>
</tr>
<tr>
<td>t</td>
<td>-0.0147*** (0.000)</td>
<td>-0.0160*** (0.000)</td>
</tr>
<tr>
<td></td>
<td>(-7.70)</td>
<td>(-7.28)</td>
</tr>
<tr>
<td>rd</td>
<td>0.00284*** (0.000)</td>
<td>0.00223*** (0.001)</td>
</tr>
<tr>
<td></td>
<td>(4.69)</td>
<td>(3.43)</td>
</tr>
<tr>
<td>euf</td>
<td>0.0174 * (0.053)</td>
<td>0.0247** (0.010)</td>
</tr>
<tr>
<td></td>
<td>(1.95)</td>
<td>(2.58)</td>
</tr>
<tr>
<td>φ(s)</td>
<td>0.538*** (0.000)</td>
<td>0.518*** (0.000)</td>
</tr>
<tr>
<td></td>
<td>(3.70)</td>
<td>(3.33)</td>
</tr>
<tr>
<td>lnKinf2</td>
<td>0.351*** (0.000)</td>
<td>0.511*** (0.000)</td>
</tr>
<tr>
<td></td>
<td>(9.15)</td>
<td>(15.32)</td>
</tr>
<tr>
<td>lnKinf1</td>
<td>0.140*** (0.000)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(7.57)</td>
<td></td>
</tr>
<tr>
<td>lnKinf2</td>
<td></td>
<td>0.0488* (0.025)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.25)</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td>Estimation method</td>
<td>Fixed effects</td>
<td>Fixed effects</td>
</tr>
</tbody>
</table>
Model A, corresponding to equation (9), shows that the variables with the greatest influence on productivity per employee in Spain over our period of analysis, 1989-2010, are business capital (0.351) and human capital (0.538). The coefficient of transport infrastructure capital is positive and statistically significant with a value 0.140.

Our preferred estimates correspond to equation (11), model B, because of the inclusion of a more accurate measure of transport infrastructure capital based on the index we have defined in expression (10). The results of the estimated model also show positive and statistically significant coefficients for business capital (0.511), human capital (0.518) and transport infrastructures capital, $K_{inf2}$, (0.0488). The estimated coefficient on the average contribution of transport infrastructure to labour productivity in model B is much lower than the one estimated for model A. This estimation fits better with the real effects of transport infrastructures on labour productivity. The estimated coefficient for business capital in model B is higher than the previously estimated in model A and also fits better with the empirical growth literature.

An interesting result in both models is that the investments in RD and transport infrastructure supported by ERDF and CF boost the growth of TFP. The “rd” coefficient is positive and statistically significant with an estimated value in the range 0.00223 (Model B) and 0.00284 (Model A) which means that its implied contribution\(^{10}\) to the annual TFP growth rate is the range of 0.0228 (Model B) and 0.0290 (Model A). The “euf” coefficient is also positive and statistically significant with an estimated value in the range of 0.0174 (Model A) and 0.0247 (Model B) meaning that the share of ERDF and CF expenditure on the stocks of transport infrastructures have an implied contribution\(^{11}\) to the annual TFP growth rate in the range of 0.0056 (Model B) and 0.0080 (Model A). The main reason for this positive contribution of transport infrastructures to TFP growth comes from the idiosyncratic features of the Spanish economy in the period. Most Spanish regions were lagging behind at the beginning of our period of analysis with major transport infrastructures deficiencies. Transport infrastructures gaps were largely narrowed over during the 90s and 2000s with the important help from ERDF and CF investments.

It is worth remarking that RD investments have a greater impact on the efficiency levels of the Spanish economy and TFP growth than the investments associated to ERDF and CF supporting

*Note: Table shows t statistics in sub-parentheses and the associated p-values in sup-parentheses*

\(^{*}\) p < 0.05, \(^{**}\) p < 0.01, \(^{***}\) p < 0.001

Source: Own elaboration

<table>
<thead>
<tr>
<th>Time dummies</th>
<th>Yes</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual average contribution to TFP growth:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rd</td>
<td>0.0290</td>
<td>0.0228</td>
</tr>
<tr>
<td>euf</td>
<td>0.0056</td>
<td>0.0080</td>
</tr>
<tr>
<td>Within R-squared</td>
<td>0.5773</td>
<td>0.5152</td>
</tr>
<tr>
<td>Between R-squared</td>
<td>0.2070</td>
<td>0.5561</td>
</tr>
<tr>
<td>Overall R-squared</td>
<td>0.2598</td>
<td>0.5489</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>79.89</td>
<td>62.16</td>
</tr>
<tr>
<td>Prob &gt; F</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
the deployment of transport infrastructures in Spain. Despite of these positive contributions, the growth rate of TFP in the period is negative and statistical significant with an average cumulative rate ($\lambda$) of -0.0147.

These results are in line with previous studies. When transport infrastructure is weighed by relative saturation indices or by the impact on commercial and on interregional traffic flows, it is found to exert a positive effect on development (Álvarez and Blázquez, 2014; Álvarez-Ayuso and Delgado-Rodríguez, 2012). De la Fuente (2010) shows evidence that public investment in infrastructure had a positive impact on production and employment in Spain. However, he also notes that this process could involve a significant cost in terms of efficiency. Mas and Quesada (2006) using a panel data model with sectoral information also found a downward trend of total factor productivity (TFP) in Spain in the early 2000s. More recently, Escribá and Murgui (2011) found similar patterns although their estimates are based on the interregional variation in TFP.

7. Conclusions and policy implications

Since late 80s, Spain started an intense growth process with around 2% average cumulative growth rate, until the outbreak of 2007 (last quarter of the year) crisis. During this period, Spanish per capita GDP growth outperformed average EU15 countries and created an outstanding amount of jobs (more than 5.7 million from 1999-2007)\(^{12}\) being able to reduce high structural unemployment rates, leading the economy to almost full employment for the first time in decades.

It is worth mentioning that this growth process in Spain was associated with significant social and economic progresses, that can be seen in a wide variety of indicators ranging from the increases in female participation rates in the labour market and the rise in the educational level of the population to the internationalisation and opening to foreign trade of the economy, as well as major investments and high rates of growth for the capital and resources associated with ICT and RD.

However, this paper shows evidence on the capital widening type of growth process experienced by the Spanish economy over 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 jobs creation and strong employment growth without triggering any significant increases in labour productivity. Labour productivity remained stagnated or even slightly decline from 1996 until the beginning of the last crisis. Additionally, our estimated results show a persistent decline in TFP at an average cumulative growth rate in the range of -1.60 %, -1.47%.

Our analysis also shows that the capital/employee ratio remained constant throughout most of the period under analysis in most Spanish regions despite the large investment efforts. However, this intense process of capital accumulation allowed to largely bridge the accessibility gaps among most Spanish regions.

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\(^{12}\) Growing from 16.7 to 22.3 million of jobs, representing a total growth of 34.1%.
It is worth highlighting that both efforts in RD and transport infrastructure expenditure exerted a significant smoothing effect on the negative trend of TFP growth. However, despite of this, these investments were unable to reverse the negative trend in TFP growth.

From a policy perspective, a major drawback of the Spanish economy was not to take advantage of the good economic conditions along the prosperity wave to start much earlier the efforts to set up an effective system of innovation. That would have implied important efforts in the fields of technology and RD commercialization (well beyond that of the services provided by the so called offices for technology transfer, OTRIs), fostering entrepreneurial innovation culture and a better matching between labour market skills and the specific requirements of innovative firms. In sum, a sound regional economic policy is needed to facilitate the transition from a low-skills/low-quality equilibrium (low regional competitiveness) to the optimal one high-skills/high-quality (high regional competitiveness) equilibrium.

A fruitful research avenue along the lines of this paper includes a review of the historical Spanish series, region by region, looking for differential patterns of growth and the impact of transport 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.

References


selected regions (from 1989-1993 programming period to the present) Galicia Case Study”, DG REGIO, European Commission (Online available at the EU Commission website in this link).


