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Labour productivity in Spain: 1977–2002

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(Running title: Labour productivity in Spain: 1977–2002)

Abstract

This study examines the evolution of labour productivity across Spanish regions during the period from 1977 to 2002. Applying the kernel technique, we estimate the effects of the transition process on labour productivity and its main sources. We find that Spanish regions experienced a major convergence process in labour productivity mostly driven by human capital in the 1977–1993 period. Conversely, the dynamics of investment in physical capital appear to be neutral with respect to the transition dynamics of labour productivity. Finally, from 1995 to 2002, no dynamic processes seemed to have taken place. Spanish regions exhibit a persistent relative position with established convergence clubs: the human capital effect is less important and the investment in physical capital seems not to have a triggering effect on labour productivity growth.

Keywords: Labour productivity, Employment, Human capital, Physical capital, Spanish regions, Transition to democracy.

JEL Classification: J24, N34, N940, O18, O52, R10

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1. Introduction

In the last three decades two important events have marked Spanish history: the start of the post-Franco era (1977) and entry into the European Community (1986).

Both events entailed important transformations of Spanish society and, above all, of the economic structure of the country. In 1977, the relative weight of the agricultural sector in the Spanish economy was far from negligible. Nowadays, Spain is a modern country with a clearly dominant service sector forming the core of the productive structure (see Table 1).

[Table 1 about here]

The achievement of these results has been made possible by a sequence of different social and economic changes.

As discussed in de la Fuente (2002), a major economic convergence process has taken place across Spanish regions mainly due to the combination of factor accumulation, technological diffusion and the human capital rate effect. The most prominent effect has been a major reduction in regional inequality (measured as output level per employee). The catch-up process allowed Spain to benefit from a growth rate in real GDP terms that was almost always higher than the EU average. However, a striking feature occurs in Spanish development indicators (Table 2). Since 1995, the Spanish economy has experienced a positive growth rate along with a negative labour productivity growth rate (as discussed in Martínez *et al*., 2008).

[Table 2 about here]

This feature seems puzzling. Labour productivity, measured as real GDP per hour worked, is the main source of economic growth (as real GDP growth). Over time, the two values should

evolve alongside each other but this does not appear to be the case for Spain.[1] Productivity gains take place when the production of good and services grows faster than the volume of work dedicated to production. In Spain, the simultaneous existence of a positive growth rate and a negative productive rate (from 1995 on) implies that the volume of work is growing more than production. The persistence of this phenomenon over time indicates that there is no proper justification for this lack of synchronism at this particular stage of the development process.

This paper proposes an empirical study of the evolution of labour productivity across Spanish regions from 1977 to 2002. The idea is to identify similarities or differences in the evolutionary trends of labour productivity across Spanish regions by sector (industry and services) with respect to two of the corresponding determinants (namely, human and physical capital). With the knowledge that a convergence process had taken place across Spanish regions, the purpose is to explore the factors that had triggered this movement and, eventually, the sector that drove it. The importance of finding the causes for this mismatch between growth and productivity is fundamental for the sustainability of the future growth rate and, hence, for designing the right policies to continue fostering growth.

Of the possible methods for suggesting an explanation, we opted to emphasize the historical dimension as the most suitable to understand the present situation. The present situation can be interpreted as being the progressive accumulation of events and dynamic movements of production factors over time. In line with O'Mahnoy and Van Ark (2003), we explore the possibility that the currently poor records for Spanish labour productivity can be the results of a reduced contribution of human capital to the dynamics of labour productivity jointly with a

[1] In the long run, labour productivity is the primary determinant of improvements in the standard of living. In a general standard economic framework, labour productivity is a relatively good proxy for the whole productivity, given that labour makes a major contribution to total production (almost 70% in developed economies). Productivity growth corresponds to a higher GDP growth rate than variation in the hours worked.

lack (or a low rate) of investment in physical capital that has been insufficiently high either to evolve properly with the growth rate of employment or be efficiently adopted in the production process.[2]

In this study, we refer to Spanish regions as the main spatial unit of reference because of the transition dynamics they have undergone. In this contribution we propose a few novelties with respect to other existing studies. In order to exploit the historical dimension we built an original and homogeneous database by gathering data from 1977 onwards. Since the beginning of the post-Franco era, the country has experienced an evolution in its productive structure, and we consider that most of our attention should focus on the evolution of the labour productivity in each of the main sectors of the economy (namely industry and services). Unlike other studies, we propose an analysis of the evolutionary trends of labour productivity across Spanish regions using an indicator (by sector) of productivity per-hour worked accounting for the effects of the progressive reduction in hours worked experienced in Spanish regions. This contribution is also different from previous studies because it proposes an analysis of productivity by sector (i.e. separation between industry and services) for a longer period that spans from 1977 to 2002.[3]

Finally, we apply the kernel technique, specifically the stochastic kernel technique, to achieve better control of the transition movements over time. Stochastic kernel is a non parametric technique. It measures the probability of a region with a given productivity in one year achieving any other level of productivity in another (chosen) year. The major advantage of the nonparametric technique is that it does not assume a priori any specific linear model. A

[2] By looking at the evolution of Spanish labour productivity from 1995 to 2003, Martínez *et al.* (2008) claim that adjustment costs and inefficiencies derived from inappropriate qualification in the labour force can lead to dynamics in which labour productivity can record low or even negative growth rate. In this case, a recovery of positive growth rate of labour productivity passes by a renewal of labour training and human capital accumulation adapted to the new technologies.

[3] Benito and Ezcurra (2004) consider the period from 1977 to 1999.

preselected parametric model may be too restrictive to fit an unknown regression relationship properly.

After being introduced by Quah (1997), the method of analysis applied in this study has already been adopted, for instance, by Lamo (2000) to study the dynamics of GDP per capita in Spain, and Benito and Ezcurra (2004) to investigate the regional productivity imbalances in the European Union.

This study follows in the wake of Esteban (1994), with findings comparable to those he obtained for aggregate productivity. Our results confirm that there has been a convergence of labour productivity across regions during the period considered (as in Lamo, 2000), but the rate of evolution is different when comparing the period (1977–1986) with the other two (1986–1993 and 1995–2002). These three sub-periods shed light on three important phases of modern Spanish history. The first period (1977–1986) entails the post-Franco years up to entry into the European Economic Community (EEC), the second (1986–1993) the first experience of Spain as a member of the EEC and the third (1995–2002) the progressive integration of Spain into the European Union (EU) after the Maastricht Treaty came into force on November 1st 1993.

From a strictly economic point of view, the three periods represent three important stages of the Spanish economy's internationalization process in most recent times. The first period (1977–1986) matches with the progressive openness of Spain versus the European market, the second (1986–1993) coincides with the advancement of the integration process as well as the economic challenges entailed by fierce international competition and, finally, the third (1995–2002) with the complete integration into the European Union and the adoption of the euro.

Analysis of the sources of productivity during the first sub-period suggests that the dynamics of labour productivity is in keeping with the changes in the employment share and, above all, with the evolutionary path of the human capital (both in services and industry) rather than

investments in physical capital. In a study by Covers (1997), human capital is identified as the factor that has a significant positive effect on the growth of labour productivity in manufacturing sectors across European countries.[4] In this study, we re-examine and qualify better this effect with regard to the Spanish case. Human capital has been the productive factor driving productivity convergence across Spanish regions and such dynamics have lasted as long as the convergence dynamics of human capital across regions has been present.

Recent reforms of the labour market have helped to reduce the unemployment rate. Unfortunately, they led to the consolidation of existing regional inequalities, thus interrupting the convergence process (1995–2002 period). The picture is completed by the neutrality of the effect of the investment in physical capital. As a consequence, the low labour productivity growth in Spain can be associated with a combination of the dynamics of its two main components: a high growth rate of human capital that is poorly supported by proper investments in physical capital. The mismatch between the dynamic movements of these two factors had a major influence at the end of the convergence period that led to negative productivity growth rates. These results are also confirmed by looking at the evolution of an indicator of capital intensity (following Bowden and Turner, 1991). Thus, the source of this negative performance is not precisely the general lack of investment in physical capital (as addressed, for instance, by O'Manhoy and van Ark, 2003), but the lack of investment in the regions that recorded a higher level of growth in human capital.

This study is organized as follows. Section 2 provides a description of data and the method of analysis adopted in this study. Section 3 presents a few descriptive statistics and Section 4 focuses on the study of the dynamics of labour productivity in Spain since 1977. In Section 5

[4] Likewise, Bowden and Turner (1991) conclude that human capital has a determinant role in explaining differences in labour productivity in the UK economy during the recovery period after the Second World War.

we propose an analysis of the transational dynamics of human and physical capital as factors related to labour productivity and, finally, Section 6 concludes.

2. Data and method

To carry out this study we built an original database by aggregating the information of different, but homogenous, sources. The two main sources referred to are CRENOS[5] and Eurostat. Data extracted from these bases are quite similar and quite homogenous for the period analysed.

The period 1977–1993 (that corresponds to the first two sub-periods introduced in Section 1) is fully covered by the database created by CRENOS: data for regional valued added (total as well as for service and industry sectors) are available as factor costs, constant prices (1985=100) and expressed in purchasing power standard (pps). The same database provided information about the total employment (total, in industry and service sectors) for the same period.

Data concerning the period 1995–2002 (the third sub-period) are provided by the Eurostat database. In this database, the value of the regional value added is expressed in constant prices (1995=100) and in euro. Employment is also available by region as total or sector value.

Statistics on working hours (1977–2002) are obtained by merging the information on weekly worked hours (taken from OIT: Annuario Estadistico del Trabajo) and those included in Carreras (2005).

Regional data on private gross capital formation by sector (1977–1998) are taken from the series *El Stock de capital en España y sus distribución territorial* released by IVIE and

[5] CRENOS is an acronym for Center for North and South Economic Research (http://www.crenos.it/).

Fundación BBVA. Finally, regional data on human capital (1977–2001) come from the statistics *Series de Capital Humano en España* (released by IVIE and Fundación Bancaja).

A highly efficient way of examining variations in labour productivity across regions (at different points in time) is by estimation of univariate kernel density functions.[6] Kernel density is a nonparametric technique that makes it possible to compute the density of a function through the frequency data that appears in a sample. A nonparametric technique is a flexible form of estimation. The main advantage of this technique is that it does not build on a predefined functional form but works in continuous space. Owing to the small sample size, we computed the kernel density function using the Gaussian kernel function with the Silverman bandwidth selection criterion. This technique makes it possible to perform complete statistics by simultaneously accounting for the evolution of one observation (here regions) in association with the dynamics of the remaining components of the sample. Hence, at a glance, we are able simultaneously to control for the transition of the full sample.

The simplest nonparametric density estimate of a distribution of a series is the histogram, but it is not continuous. The kernel density estimator replaces the 'boxes' in a histogram by 'bumps' that are smooth. Smoothing is done by putting less weight on observations that are further from the point being evaluated(x). More technically, the kernel density estimate of a series X at a point x is estimated by

$$f_n(x) = \frac{1}{Nh}\sum_{i=1}^{N} k\left\{\frac{x - X_i}{h}\right\}$$

where N is the number of observations, h is the bandwidth (or smoothing parameter) and $K(\cdot)$ is a kernel function that integrates to 1.

The kernel function $K(\cdot)$ is a weighting function that determines the shape of the bumps.

[6] The univariate kernel density function was computed with Eviews 5.0 software.

We used the Gaussian kernel function that downs weights on points as the distance from x increases. Unlike most kernel functions, this is unbounded on x and each observation is included in the estimation (Härdle, 1990).

Bandwidth h controls the smoothness of the density estimate; the larger the bandwidth, the smoother the estimate. Bandwidth selection is of crucial importance in density estimation. We used the Silverman method: a standard option for the Eviews package.

The stochastic kernel technique is complementary to the previous one and is used to control the transition path of a variable from one status to another. As argued by Lamo (2000), the stochastic kernel involves some technical advantages in the case of a cross-section matrix.

Studying the entire cross-section distribution dynamics encodes the standard approaches and overcomes some of the difficulties; it does not suffer from Galton's fallacy. It does not impose any structure on the data: its robustness does not depend on model specification. It does not require the imposition of any assumption regarding the exterior shape or the moments of the density function from which the data are drawn.

This method – introduced by Quah (1997, 2006) – is highly intuitive. Let λ_t be the probability measures (one each year) associated with the cross-section distribution. A simple way of modelling this dynamic is using the following probability model:

$$\lambda_t = T^*(\lambda_{t-1,} u_t)$$

which is analogous to a first order auto regression model in time series. By ignoring the disturbance and iterating it, it can be written as:

$$\lambda_{t+s} = (T^*)^S \lambda_t$$

As s goes to infinity it is possible to characterize the long-run distribution of the variable across the economies. T* maps probability measures into probability measures, for instance, providing information on whether the variables get closer. T* must be estimated from the

data. Approximating T* by assuming a discrete state-space is misleading because there is no optimal criterion to define a grid. However, it is possible to construct a time-variant transition matrix by fixing the probability vectors (λ_t) to be uniform and identical for each point and defining a time variant grid (S_t). In this way it is possible to generate a sequence of transition probability matrices that will follow the intra-distribution mobility.[7] In order to overcome the problem of the discretization of the interval, a length can be chosen that is small enough for there to be a continuous matrix.

A stochastic kernel can be considered in terms of conditional probability density. Let us consider two density distributions at time t and $t+\tau$. A plot of the stochastic kernel will tell us the probability density $t+\tau$ conditional on the density at time t. The location of the probability mass along the positive sloped diagonal would indicate a high persistence of relative positions of economies (hence low mobility). The graphs presented show a horizontal section (in two dimensions) of the three-dimensional images. The high concentration of circles along the diagonal indicates the presence of convergence clubs. The probability mass under this diagonal indicates an improvement in relative positions (namely the catch-up position) and, if it is parallel to the vertical, there is convergence. Concentration along the negative sloped diagonal would indicate that regions are overtaking each other and, finally, transition probabilities describing horizontal lines would show that the probability of being in any state at period $t + \tau$ is independent of the economy's position at t.

To compute the stochastic kernel estimations (whose results are presented from Figure 2 on) we apply a routine created by Taesem Lee (2006) for Matlab, where the kernel bivariate

[7] The hub of circles corresponds to a peak, then to a high density concentration point in a three-dimensional graph.

density is obtained using a normal function and the bandwidth was chosen optimally according to the Simonoff procedure.

3. A few descriptive statistics

There is a general consensus in considering human capital (meaning the share of employment with a higher education degree) to be the most important factor impacting upon the evolution of labour productivity in Spain (see, for instance, de la Fuente (2002)).

This hypothesis is backed by the concomitance of three important circumstances. In the mid-1970s, a liberalization process took place in the Spanish labour market. Yet, between 1975 and 1985, Spain experienced a wave of job destruction induced by the economic changes. In 1986, the employment rate started growing at a rapid pace and between 1991 and 1996 Spain again suffered a period of job destruction until 1996. From 1996 onwards, employment has risen sharply. As far as the distribution of employment across the four largest sectors (agriculture, industry, construction and services) is concerned, employment in industry and in construction never dominate the other sectors' levels of employment. This implies that Spain moved directly from agriculture to services without passing through the pure industrial phase (Moluquer de Motes and Llonch, 2005).

During these years, the Spanish government implemented two important reforms. In 1984, part-time contracts were introduced to foster job creation. The second important reform of the labour market came into force in 1994. It introduced the possibility of exploiting part-time contracts in a more flexible way by allowing fewer limitations on the maximum number of working hours (Moluquer de Motes and Llonch, 2005). This new type of contract reduced the average length of the working day. This was due to a major increase in the number of part-

time workers, with the service sector experiencing the biggest reduction (Sanso Frago *et al*., 2004)

[Table 3 about here]

In the 1990s, as shown in Tables 3–7, Spain recorded a peculiar demographic growth rate in relation to the European average. The growth of its active population, driven by the entry of many young cohorts, women and foreign workers into the labour market, was much higher than in for European neighbours and explains why its labour market was much more dynamic. The final circumstance was the specialization of Spanish economies in labour-intensive activities and relatively cheap labour. Firms thus had the opportunity to hire an abundant, young labour force.

[Table 4 about here]

[Table 5 about here]

[Table 6 about here]

[Table 7 about here]

In Spain, many unemployed people found jobs during the last decade (Table 8); many of these people worked in low-skilled jobs and were, therefore, low-paid. It is quite possible that the entry of those workers into the labour market created such an effect.

[Table 8 about here]

As expected from analysis of these stylized facts, there is a clear trend of negative (when statistically significant) correlation between labour productivity and the share of employment both in services and in industry. This is precisely what is shown in Table 9. The expected negative correlation is statistically significant in recent times in industry while in services

they are statistically significant both in the transition period (1977–1986) and in the final period (1995–2002).

[Table 9 about here]

These results are confirmed by the kernel statistics. The univariate kernel referring to the distribution of employment across sectors (Figure 1) indicates a progressive reduction in the share of employment in industry and an increase in services (as in Moluquer de Motes *et al*., 2005). The shape of the kernel function in industry was more uniform in 2002 than it was in 1977, while that of services maintains major polarization to the left of the distribution. The inequality across regions in terms of the share of employment in services persists over time. This factor uncovers an underpinning asymmetry in the two sectors. Therefore, one could reasonably expect such a difference to have driven, to some extent, the difference in the evolutionary paths of employment in the two sectors across regions.

These results are comparable with the findings of Esteban (1994, 1996), Martínez Serrano (2004) and Lamo (2000). They all support the idea that labour mobility was mostly responsible for the convergence process until 1985, while nowadays it plays no role. However, our analysis refines this outcome: this dynamic holds for the industry sector, while in services there is no clear-cut pattern that can be taken as reference.

[Figure 1 about here]

3. Labour productivity: industry and services

Recently, the study of labour productivity has become the focus of major interest due to one important factor: US productivity is growing at a rapid rate while Europe is failing to reap the same productivity gains as the US.

Blanchard (2004) argues that in the US, labour productivity is higher because the average person works more, while in the EU there has been a constant reduction in the number of hours worked. Prescott (2004) estimates that the role of income taxes accounts for almost all the differences in labour participation ratios across European countries and the US. The same problem is discussed in O'Mahony and van Ark (2003), who point out that the lack of investment in the EU, along with some specific labour market reforms, have affected productivity performances. Reforms aimed at improving the flexibility of the market have deliberately been the creation of jobs (such as part-time jobs or temporary contracts) mostly in job-intensive sectors, allowing more unskilled and inexperienced workers to enter the workforce. The combination of all these factors (along with a general reduction in the average hours worked) has decreased the output per worker. Moreover, the rigidity of the European capital market has made investment in physical capital (especially in new technology) less attractive, and hence prevents firms from taking advantage, for instance, of information technologies.[8]

4.1 Descriptive statistics on labour productivity in Spain

Martinez Serrano (2004) proposes a decomposition of the different factors affecting the changes in labour productivity (considered productivity per hour worked) in Spain. He provides a study that concentrates on Spanish regions in order to evaluate to what extent each of these are affected by the sluggish productivity. Similar to Esteban (1994), Martinez Serrano detects a convergence of labour productivity across regions, mostly due to labour mobility. Looking at different sub-periods from 1965 to 1998, the trend towards the convergence of labour productivity is principally produced by labour mobility, while an interpretation of the role of physical capital is less clear. In general, the mobility factor in

[8] This is the same kind of conclusion as that reached in a study by Dew-Becker and Gordon (2006).

Spain was responsible for the convergences experienced from 1965 to 1975 and 1975 to 1985 but it has played no role in more recent years.[9]

We provide empirical evidence of the trend towards convergence in terms of labour productivity by ranking Spanish regions by their value of labour productivity in 1977 and 2002.

The data are shown in Table 10. Unfortunately, the two series are not mutually comparable because they were computed according to different sources. However, convergence is indicated by two details: from 1977 to 2002, the order of the classification varies along with the reduction in the standard deviation (more than 10% of the average value in 1977 to less than 10% in 2002).

[Table 10 about here]

Once we had accounted for the existence of the convergence trend, our first exercise consisted of identifying the contribution of the industry and service sectors to labour productivity growth. Productivity per hour worked was selected as an indicator of labour productivity and it was computed as the ratio between the value added (at constant prices) and the product between the total employment and the average hours worked.[10] In this way we are able to control for possible regional effects due to a difference in working time.

[Table 11 about here]

The previous table (Table 11) presents the results of the correlation coefficient (and their statistical significance) for total labour productivity, labour productivity in services and in industry for the three sub-periods identified in Section 1. The aim of this exercise is to determine the possible association between the variations in productivity in different sectors.

[9] If labour productivity is associated with other factors, such as, for instance, human capital, a convergence process can be targeted either by mobility of highly qualified workers or by improving the regional endowments of human capital.

[10] Since 1994 the statistics for hours worked by region have been published by the Instituto Nacional de Estadistica (INE). Statistics for hours worked from 1977 to 1994 have been calculated on the basis of data included in Carreras (2005).

Of course, the simple nature of this exercise prevents us from making any suggestions about the causality among the different variables, but it does provide some interesting insights.

There is a clear positive and statistically significant correlation between the growth rate of total labour productivity and labour productivity in services during the first sub-period. This finding confirms the conclusions addressed in a study by Moluquer de Motes *et al*. (2005), in which the authors show that during its development, Spain moved directly from being an agricultural to a service economy without passing through the pure industrial phase. This relation was reinforced in the second period when the growth in labour productivity in industry also resulted as positive and statistically significant. This result is not surprising if we associate it with Spain's entry into the European Community (1986), which triggered a general and strong improvement in productivity in Spain.

4.2 Dynamics of regional labour productivity in Spain

To study the dynamics of regional labour productivity, we compute the kernel density for total labour productivity, labour productivity in industry and in services in 1977 and 2002, the beginning and the end of the period we are considering (Figure 1). In 1977, all the kernel densities exhibited a somewhat unequal level of labour productivity across Spanish regions. In industry, there was a clear polarization at the centre of the distribution (around value 8), while in services there appears to have been a double-peak estimation; the high peak is on the right side of the distribution and the other is at the extreme left. In other words, in 1977, the service sector in Spain was characterized by major inequality, with most of the regions polarized around the lower level of the distribution. Twenty-five years later, the kernel functions reveal that a convergence process across regions has taken place. The corresponding functions for industry and services are more uniformly distributed than in 1977, even though some residual peaks still persist.

Next, the three sub-periods as previously described are considered: 1977–1986, 1986–1993 and 1995–2002. We computed the stochastic kernel according to the method described above. Figure 2 presents the contour plots of the different kernels. By definition, the x-axes always correspond to the earliest year of each period (i.e. 1977, 1986 or 1995) while the y-axes correspond to the most recent year (i.e. 1986, 1993 or 2002) (Figures 3 and 4).

In the first period, labour productivity in Spanish regions experienced major convergence mostly due to a major convergence in the industry sector. In the second period (1986–1993) the convergence process was principally driven by services while regions consolidated the productivity they had achieved in the industry sector. Conversely, in the third period, the concentration peak[11] lies on the main diagonal (or parallel to it), which implies that the productivity trend in each region was mostly independent and there is persistence of relative positions (both in industry and services).

These results support those proposed by Esteban (1994) and Martinez Serrano (2004) and add some further insights.

[Figure 2 about here]
[Figure 3 about here]

The major convergence in industry in the first sub-period was a consequence of the restructuring process of the productive system fostered by the tendency to transform into an open market economy. The main effect was a more equal spread of industrial activities across regions and, then, a corresponding reduction in polarized distribution in the 1970s. It was only after having completed this redistribution process that productivity in industry exerted a statistically significant impact on the total level of productivity. Conversely, the convergence in services seems to have been delayed. Services are activities with major territorial linkages

[11] Peaks in density distributions correspond to high probabilities.

and are mostly non-tradable goods. The convergence phase coincided with Spain's entry into the European Economic Community (EEC). It was mostly boosted by the need to meet the standard requirements fixed by the EEC, which entailed a process of making services more dynamic across the Spanish territory. Once this major association had been obtained, our next step was to study whether the same kind of dynamics could also be found in the evolutionary path of factors (such as employment and physical capital) that are expected to influence labour productivity.

[Figure 4 about here]

5. Human and physical capital

An analysis of European labour productivity growth from 1950 to 2006 assessed that its evolution was mostly driven by a technology imitation process (above all in the beginning), changes in labour force contribution (either composition and hours worked) and capital intensity (van Ark *et al*., 2008). Certainly, labour productivity growth can be broken down into capital deepening, labour quality growth and total factor productivity growth. When total factor productivity growth is nonexistent, growth can be driven by investment in existing technologies and hiring more workers (Jorgenson *et al*., 2008).

In the economic literature (see, for instance, Bowden and Turner (1991) or Corvers (1997)), a standard approach to define labour productivity assumes a Cobb–Douglas function as the aggregate production function of a region, for instance. In this form, the regional output (intended as GDP) is computed as a product of a weighted combination of different production factors, namely employment, physical capital and human capital. In this type of setting, labour productivity (per hour worked) is obtained as the ratio between the regional output and the product of the regional employment by the total hours worked (yearly) by employees.

Then, the productivity of labour increases when the labour force acquires new skills (investment in human capital). The productivity of physical capital increases with the quantity and the quality of capital. The complementarity between human capital and physical capital is often essential to yield improvements in efficiency.

In the light of the previous findings and in order to pinpoint the factors influencing the dynamics of labour productivity in Spain, next we analyse separately the transition dynamics of employment, physical and human capital in services and industry. Then, we will compare them with the dynamics of labour productivity by sector.

5.1 Human capital

Human capital is generally considered to be one of the engines of economic growth and productivity. It is one of the mechanisms that fosters convergence between regions or countries. Boldrin and Canova (2001) widely discuss the dynamic causation: education and training (of workers) raise labour productivity and help to create a more skilled labour force. The increase in labour productivity (especially in poor regions) attracts private investments, fosters job creation and increases the level of GDP per capita in the long run.

From the 1940s to 1970s the educational level of the Spanish population fell due to a decreasing proportion of people receiving primary education. In the 1940s, there was a clear tendency to neglect compulsory elementary education and foster higher education. This policy has had long-term effects since it is now widely admitted in the human capital literature that the economic impact of elementary education is much stronger than higher education.[12] This policy also led to important regional differences in education levels in Spain; these were only recently reduced by internal migration flows. Regions hosting less immigration (such as

[12] A similar pattern is also discussed in Alonso *et al.* (2008).

Andalusia and Extremadura) experienced minor changes in the stock of human capital, while others such as Catalonia enjoyed major positive effects from migration (Nuñez, 2005).

Currently, if the Spanish level of education is compared with that of other EU countries, its human capital is unequally composed. There is still a large number of people with a higher education degree although the average level of education remains low.

To analyse the transition dynamics of human capital in Spain, we use the stochastic kernel instrument and apply it to the evolution of the employment share with high–medium degrees in industry and services. We focus on the stock of human capital in every Spanish region for the three usual sub-periods (1977–1986, 1986–1993 and 1995–2001) (Figure 5). We use data published by the IVIE (Instituto Valenciano de Investigaciones Economicas) and compute the corresponding share of skilled employment. Similar to Corvers (1997), we measure human capital as the employment shares of intermediate (*estudios medios)* and highly (*estudios anteriores al superior and superiores)* educated workers. Then, we carry out the standard stochastic kernel exercise and plot the corresponding contour.

According to our results, the stock of human capital has grown impressively both in industry and services, in which the first period corresponds to a transition dynamic featuring a catch-up process (hence, redistribution of the share of human capital across regions) among regions (the concentration peak lies on the negative diagonal), while in recent years a convergence process is still active.

Once again the transition dynamics of this productivity factor across regions is similar in both of the sectors.

The movement of human capital in industry and services was so important (in the first part of the period considered) that it drove (in industry) or reinforced (in services) the process of converging labour productivity across Spanish regions. However, in recent years, the

magnitude of this effect has smoothed along with the imprint produced on the convergence movement, allowing for consolidation of the existing inequalities (in labour productivity) across regions.

Once the dynamics of all the selected factors have been analysed, we are able to draw a fairly clear conclusion. From 1977 to 1993, Spanish regions experienced a convergence process in labour productivity both in industry and in services that has been exhausted in recent years. By comparing the regional transition dynamics of labour productivity with that of its principal factors, we are able to detect a strong association between the convergence of labour productivity across Spanish regions with that of the share of employment and the stock of human capital.

[Figure 5 about here]

5.2 Physical capital

The complementarity between human capital and physical capital is essential for economic growth (Boldrin and Canova, 2001), and thus productivity. In recent years, the growth rate of GFCF (gross fixed capital formation) per unit of employment (excluding construction) has been significantly high in Spain with respect to other EU countries (see Table 12). This confirms a certain effort deployed by Spanish entrepreneurs to better the available technology to (finally) improve productivity

[Table 12 about here]

A highly crucial point is to assess whether these investments either helped to fill the gap across regions (in terms of productivity) or enhanced polarization.

We replicate the stochastic kernel exercise with data on private investment (provided by the Fundación BBVA, Banco Bilbao Vizcaya Argentaria).

We consider the formation of private capital stock in industry and services in the following three available sub-periods: 1977–1986, 1986–1993 and 1994–1998 (Figure 6). Throughout the period, private investment has been heavily polarized both in services and industry. The transition dynamics in industry show a single peak along the main diagonal, hence a regional dynamic that mostly reinforces the given positions. In services, the shape of the kernel distribution emphasizes the existence of a double-peak function that persists over time, since the transition dynamics show that the two peaks always settle along the main diagonal.

[Figure 6 about here]

[Figure 7 about here]

By comparing the transition dynamics of physical capital with those of productivity, it is possible to conclude that the evolution of the investment in physical capital follows the same path in industry and services but is quite independent from the evolution of labour productivity across Spanish regions. Put differently, the convergence process experienced by labour productivity in the sub-periods 1977–1986 and 1986-1993 cannot be found in the transition dynamics of physical capital as its source. The evolution of labour productivity across regions seems to be independent of the evolution of physical capital. This dissociation could entail some consequences as discussed in O'Mahony and van Ark (2003) for the sustainability of labour productivity and growth tendency in the long run.

A complementary test on capital intensity helps to qualify better the neutrality of physical capital for labour productivity growth, above all in the last sub-period. To this end, and in the spirit of Bowden and Turner (1991) and Covers (1997), we compute an indicator of capital

intensity (measured by gross capital formation per unit of human capital) and study the dynamics over time with the stochastic kernel technique.

One established result in the literature (see, Bowden and Turner (1991) or Cover (1997)) determines that labour productivity is supported by a strong and positive correlation with capital intensity. The channel passes through the complementary interaction between the capital intensity growth and the share of the intermediate–skilled labour (i.e. human capital). Whenever the two factors growth positively at comparable rates, human capital produces a positive effect on labour productivity via technology adoption.

The comparison of the dynamics of capital intensity (Figure 7), gross capital formation and human capital reveal that capital intensity changes in the first two sub-periods (1977–1986) and (1986–1993) are virtually driven by the dynamics of human capital (the graphs are almost the same), and this effect appears also in the dynamics of labour productivity (see for instance Figure 3).

The dynamics of the capital intensity indicator for Spanish regions (Figure 7) clearly identify that the problem of productivity slowdown - in recent years- has been driven by the lack of diffusion of the technological effect of investments in physical capital. The catch-up process in human capital still in place across Spanish regions is not large enough to overcome the neutrality effect of the dynamics of physical capital.[13] Hence, for the last sub-period (1995–2002) the dynamics of labour productivity and capital intensity are identical (and then the positive correlation between labour productivity and capital intensity is verified) and they confirm the consolidation of convergence clubs (see Figures 3 and 7). Therefore, the kind of mismatch between the evolution of human and physical capital breaks down the dynamics of economic and productivity growth that took place in Spain up to the beginning of the 1990s.

Further empirical evidence also complements this last statement. In Section 1, we mentioned the existence of an apparent puzzle concerning Spanish labour productivity. The mismatch

[13] For instance, because of the inclusion of a high share of temporary and not skilled workers.

between the evolution of the two factors influencing labour productivity presents a way of interpreting the puzzle. The convergence process of labour productivity entailed a process of redistributing resources across Spanish regions. The regional human capital catch-up process fuels convergence. Yet, the dynamic of investment in physical capital did not occur in parallel with that of human capital. Considering the complementarity between physical and human capital (such as that presented in a Cobb–Douglas function of aggregate production), both need to grow simultaneously to guarantee positive returns in the output (namely, labour productivity). From this viewpoint, the Spanish mismatch may not simply be due to the general lack of investment in physical capital but to the lack (or low rate) of investment in productive activities in the regions that have experienced a sustained rate of human capital growth.

In this respect, the following tables (Tables 13-16) draw an interesting picture by looking at the ranking of regions according to the formation of physical and human capital.

With regard to the series corresponding to the formation of gross physical capital (both in services and industry) in 1977 and 1998, the two classifications are basically identical, whereas interesting variations appear when those of human capital are compared. Some regions, such as the Valencian Community, Cantabria, Castile-la-Mancha, La Rioja and the Region of Murcia, quite substantially improved the proportion of human capital in their areas (both in service and industry) but without a corresponding increase in the formation of gross capital. In contrast, regions such as Catalonia literally worsened their position in comparison to the rest of Spain.

[Table 13 about here]

[Table 14 about here]

[Table 15 about here]

[Table 16 about here]

6. Conclusions

We have presented a study of the evolution of labour productivity across Spanish regions from 1977 to 2002. As an indicator of productivity, we selected productivity per hour worked in preference to the common productivity per unit of employment as it takes into account the effects of the reduction in working time. Applying the kernel technique, we focused on the transition dynamics of labour productivity and its determinants in industry and services. In both sectors, labour productivity across Spanish regions displays a convergence process in the 1977–1993 sub-period that was principally driven by the movement of human capital.

Moreover, during the period 1977–1986, the convergence dynamics across regions mostly took place in industry, while in the 1986–1993 period the same happened to services.

Our results are comparable with those of other existing studies (Esteban, 1994; de la Fuente 2002; Martínez Serrano, 2004), but we are better able to qualify the contribution of the two largest sectors (industry and services) to the changes in the total labour productivity.

With regard to these outcomes, a simple interpretation of the recent Spanish puzzle between the positive rate of GDP growth and negative labour productivity rates is arrived at spontaneously. Traditionally, by a simple exercise of national accounting, GDP per capita can be broken down into labour productivity (per hour worked), total hours worked, participation rate and proportion of adult population able to work. Then, GDP per capita is an increasing function of each variable taken separately. As a consequence, it is straightforward to see that an increase in productivity leads to an increase in GDP per capita provided that the variations in the other variables do not totally offset the productivity gains. However, the contrary is also true: a negative growth rate of labour productivity can also lead to a positive GDP growth rate whenever there is a positive growth of total hours worked, or of the participation rate as well as of the employment share. Empirical evidence and the results of this study support the

interpretation that the Spanish case fits this last hypothesis quite well: Spanish economic growth has not always been driven by labour productivity growth. In this sense, these results are backed by some of the conclusions of the book edited by Reig Martínez (2007).

The historical perspective makes it possible to determine that the current situation is the result of the unexpected results of the development process from 1977 on which boosted the convergence process in the industry and service sectors. Now, the convergence process in labour productivity seems stable and some corrections can be introduced by targeting a few selected objectives. Investments in physical capital need to be triggered, especially, in the group of regions that recorded the highest growth rate in human capital.

The new information technologies also deserve attention. In this sense, the contribution by Martínez *et al*. (2008) is insightful. As occurred in the US and leading European countries (such as Germany, for instance), the big potential for recovering sustained positive productivity growth rates has been the witnessing of a wide adoption of the information and communication technologies (ICT) jointly with an appropriate qualification in the labour force. Fostering productivity by the adoption or accumulation of physical capital is one of the conclusions that also applies to other EU countries (Maudos *et al*., 2008). Therefore, from a strictly policy point of view, it could be a valuable policy that fosters labour training and human capital accumulation to adapt them to the new technology adoption at plant level. In this sense, as discussed in Pereita (2005), it could be an interesting strategy to support policies to implement widespread firm-sponsored training programmes as taught by the German experience, when those programmes are addressed especially at low-educated workers. The current rigidities in Spanish labour market make these programmes accessible only to qualified workers because they are more productive, but leaving aside a large portion of the workforce.

The kernel technique (like all non-parametric techniques) is fairly data demanding. Extending the period of analysis could further refine the results of this study. At the same time, it could

also be interesting to increase the number of sectors in order to gather more detailed information about the causes of the productivity trend. Extending this analysis to include migration flows could also be an important issue for providing more detailed insights into the composition of the current workforce and the potential evolutionary path of labour productivity. Other additional results could be obtained by providing a more precise analysis of the importance of the kinds of abilities skilled workers possess.

Finally, it might also be worth doing the same exercise for a few other European countries (always considering their regional composition), and then comparing them in order to investigate the possible differences or similarities between the sources of productivity within the members of the European Union.

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