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Estimating the Long-Term Economic Impacts of the Spanish Universities on the National Economy

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Estimating the Long-Term Economic Impacts of the Spanish Universities on the National Economy*

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Abstract

Universities are institutions whose activities have important economic and social impacts on their nearest surroundings. Most studies of the economic impact of universities analyze exclusively the impacts on the demand side, the effects on output, income and employment deriving from the universities' activity and their associated spending. This paper focuses on the universities' effects on the supply side of the economy, and analyzes the long term impacts of the universities on their local economy. Taking as a case study the Spanish University System, it proposes a methodology for estimating the effects of university activity on the Spanish economy in terms of its contribution to the increase of human capital, of salaries, of occupation, of technological capital and, finally, to the increase of income and the growth of the economy for the period 1989-2010. These effects are quantitatively important and their impact on GDP of Spain is non-negligible.

Keywords: Universities, long term economic impacts, human capital, technological capital, economic growth.

JEL Codes: I23, I25.

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1. Introduction

The activities of the universities produce several economic and social impacts on their nearest surroundings. These impacts are mainly external market benefits (McMahon, 2009). In the last two decades, many studies have studied the economic impacts of universities' activities on their local economy of many countries of the OECD¹. These studies focus on quantifying the short term impacts generated by university activity on employment and demand in local firms through their own spending or that induced in other agents. However, these studies do not take into account some of the universities' long term socioeconomic contributions, such as the increase in the society's endowments of human and technological resources which as well as generating economic growth facilitate the transformation of productive structures.

The teaching activity of universities increases the human capital available in the economy, embodied in its graduates, which has a crucial economic impact when it is used productively. The increase in the university-educated population increases the number of employed persons, as university graduates have higher rates of activity and employment, and a frequency of unemployment and length of unemployment lower than the average for the active population. University graduates are more productive workers due to their better skills, and obtain higher salaries than occupied people with lower educational levels. These impacts on employment, productivity and salaries are more important than those occurring on the demand side because their effects are much longer-lasting.

Equally, the R&D activities of the universities generate scientific and technological knowledge which is utilized by the productive system, and also have an impact on technological capital. In sum, the universities have positive effects on the accumulation of human capital and technological capital and therefore generate positive impacts on income and the growth of the economy that increase economic and social wellbeing.

Although the literature recognizes the positive effects of universities' teaching and research activities on economic development, the available studies do not provide homogeneous indicators to quantify these long term economic effects on the local economies. This article proposes a methodology for analyzing and quantifying the long term impacts of universities on the supply side of the economy and applies it to the case of the Spanish University System (SUS), a system composed by 81 universities involving around 1.6 million of students. The paper responds to questions like: What is the value of the human capital generated in its universities? Do the universities make a significant contribution to the generation of technological capital? What is the impact on the rates

¹ Drucker and Golstein (2007) present an excellent summary of this type of studies.

of activity and of unemployment? What is their contribution to Spain's long term economic growth?²

This paper is organized as follows. The Section 2 briefly outlines the literature on economic impacts of the universities activity. Section 3 describes our models used to estimate the long-term economic impacts of the Spanish University System, the results of which are presented in Section 4. Finally, the Section 5 concludes.

2. Contributions of Universities to the Economy: The Literature

The first studies of the economic impact of universities began to appear from 1980 in The United States, Canada and, more occasionally, Europe. They all present a common approach based on one central idea: since the everyday activities of universities have positive effects on the local economy, they attempt to quantify the impacts of teaching and research activities on the variables traditionally used to measure regional economic development. As well as the impacts attributable to universities' current spending on staff and infrastructures, studies (Drucker and Goldstein, 2007) of the effects of universities on economic development have focused on the following types of impacts: knowledge creation, creation of human capital, transfer of existing technical knowledge, technological innovation, capital investment, leadership, creation of infrastructures for the production of knowledge and, finally, influence on the economy.

Studies of the economic impact of a university³ estimate the direct and indirect effects of university spending, investment and employment on their regions using a fairly homogeneous methodology: input-output models and estimation of Keynesian multipliers. These are known as short term demand side economic impact studies, and quantify the effect of university activity expenditure on income and employment in the economy, disaggregating the calculations into their direct, indirect and induced components. This approach does not take into account many important social benefits since it omits the positive externalities of university education (OECD, 2001; Grossman, 2005; Lange and Topel, 2006) and focuses its attention on the effects of the expenditure, and not on

² Some of these questions are included in the multidimensional rank of indicators used by *U-Multirank* to compare the performance of higher education institutions. See van Vught and Ziegele (2011). The *U-Multirank* includes dimensions like teaching and learning, research, knowledge transfer, international orientation and regional engagement.

³ These studies use an input-output model of the IMPLAN (IMpact analysis for PLANning) type to estimate the effects of the university on the economy of the state (with multipliers of the SAM, *Social Accounting Matrices*, type). The methodology used was designed by the *American Council of Education* (ACE) which in 1968 drew up a detailed guide to measuring the economic benefits of colleges and universities to their local communities. The first reports were based on the pioneering study by Caffrey and Isaacs (1971).

the long term impacts on the supply of resources of the economies. It does not therefore recognize the importance of universities' long term contributions on the supply side.

The economic literature finds a positive relationship between greater education of the individual and greater activity, occupation and income (OECD 2009). Similarly a positive effect of education on economic growth has been verified (Glaeser and Saiz 2003; Moretti 2004). Additionally, the virtuous circle of university education implies that economic growth can be attributed in large measure to scientific and technological improvements associated with increases in labor productivity.⁴

Some studies find that the contribution of universities' research and technological development to economic development increases over time (Goldstein and Renault, 2004; O'Shea *et al.*, 2005; Varga, 2009). Anselin, Varga and Acs (1997) provided empirical evidence of the degree of spatial diffusion between university research and high technology innovations in the United States. The study by Sudmant (2009) on the economic impact of The University of British Columbia (UBC) incorporates concepts adapted from the literature on the economy of education, knowledge and innovations and economic growth. The central idea is that the economic impacts of universities are different from those attributable to other organizations because as well as the "static impact" (the traditional one) on the economy, the universities also have a "dynamic impact" that increases the productive capacity of the economy.

The studies show that the competitiveness of the economy is determined by the degree of productive utilization of its capital, human resources and natural resources. The "Forum for the Future of Higher Education", coordinated by Porter (2007) at Harvard University, highlights this relationship between the economic prosperity of the regions and the health of their university institutions. The universities contribute to economic development through various sources of influence: as employers and buyers, developing the real estate market, improving the qualifications of the occupied population, increasing technological capital, advising firms and creating business networks, transforming technology and incubating firms.

There are few studies of the economic impact of universities' activity in Spain and those carried out before 2008 quantify only the short term demand side economic effects of the universities. Recently, the study of Pastor and Pérez (dirs.) (2008) analyze the economic impacts of the University of the Basque Country, both on the demand side and the long term effects on the supply side on the economy of the Basque Country. This line of research has continued with Pastor and Pérez (2009) for the public system of universities of the Valencia Region and, more recently, with the studies by Pastor and

⁴ However, Wolf (2003) argues that high private returns to education are not matched by high or consistent social returns.

Peraita (2010, 2011 and 2012) which use the methodology of the earlier studies to analyze the socioeconomic contribution of some universities to their regional economies.

The approach of these studies is that reflected in this paper and consists of estimating the long-term economic impacts of the Spanish University System to the national economy, on the basis of the existing empirical evidence on the universities' diverse forms of contribution to economic and social development.

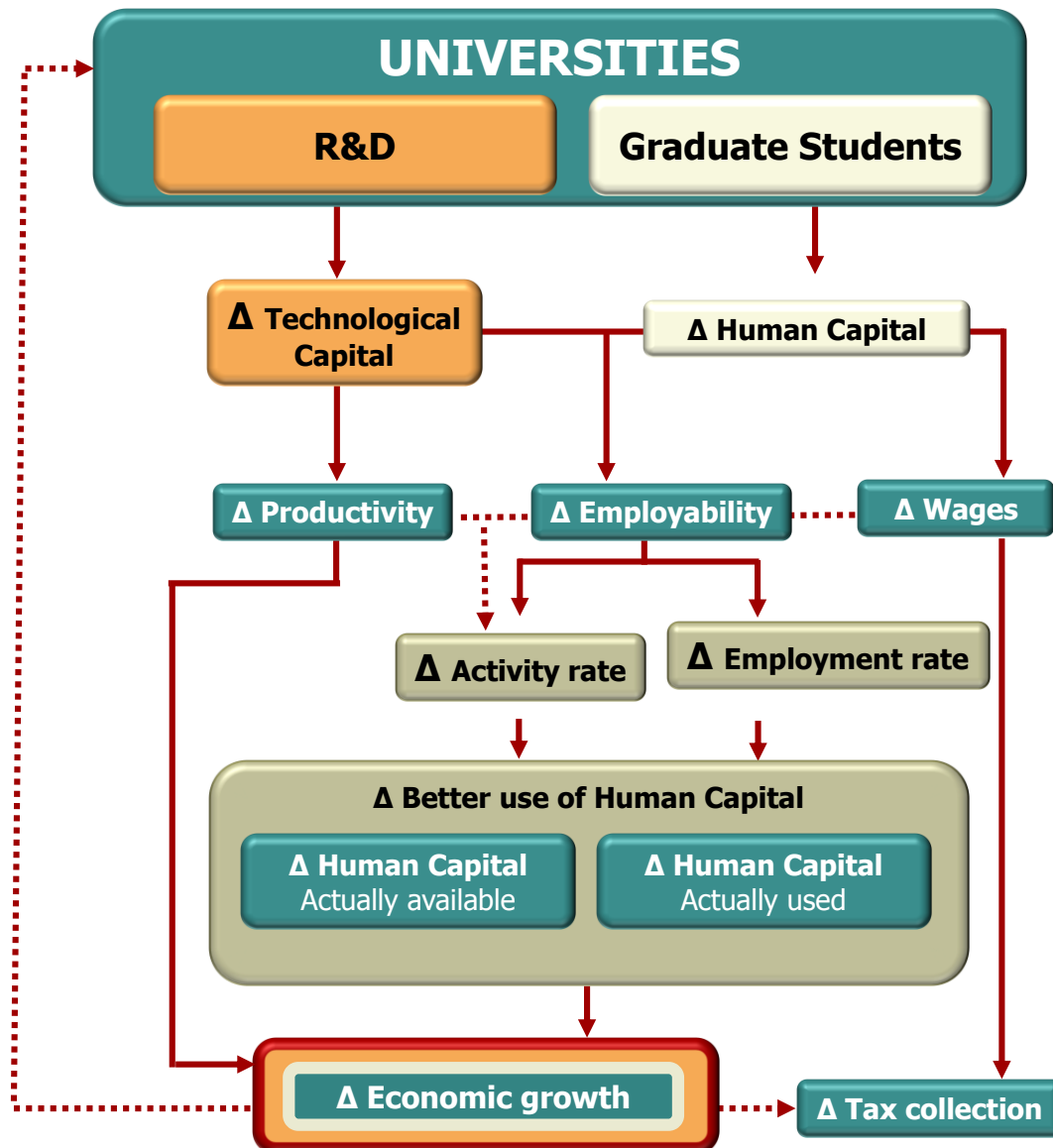
3. Methodology for estimating the Long-Term Economic Impacts of university activity

This section presents methodological proposals for measuring the long-term impacts of universities on the supply of resources in the economy. They are applied to the case of the impacts of the Spanish University System (SUS) on the economy of Spain. The SUS's supply side impacts are estimated using a *counterfactual scenario*, i.e. a hypothetical situation in which the SUS does not exist.

Figure 1 shows some of the impacts of SUS activity from a long term perspective and considers the effects produced on the supply side. The figure offers a simplified version of universities relationship with its economy and shows that the university's supply side contributions are heterogeneous and present a longer period of maturation than the economic impacts of spending by the university and its associated agents. These impacts evaluate two types of effects; first, those of SUS activity on the endowments of resources available (employment, human capital, technological capital, etc.) and, second, the subsequent effects deriving from this increase in available resources (economic growth, improvement in income, tax revenue, etc.) which are long-lasting, and hence are of greater potential importance for the Spanish economy.

The generation of human capital by the SUS through the formation of university graduates is the most important, and certainly the most visible, direct contribution to Spanish economy. To measure human capital we use the synthetic indicator of average years of education of the population. In fact, we compute the impact of the SUS on the increase in human capital as the difference between the average years of education of the working age population of Spain and the counterfactual average years of education, i.e. those that would have been achieved had the SUS not existed, and therefore had not formed university graduates. Thus, the average years of education of the working age population of Spain is the quotient between the years of education achieved by the total population and the number of individuals in the population.

Figure 1. The Contribution of Universities to Economic Growth



In consequence, the counterfactual years of education series (those that the population of Spain aged 16-65 years would have if the SUS had not formed university graduates) are calculated considering that had the SUS not existed those leaving education would have attained the educational level prior to university (completed secondary education).

Insofar as the SUS raises individuals' educational levels, its teaching activity could be conceived in simplified form as a productive process in which different types of inputs are combined to obtain an output, the human capital acquired by the students. Let us suppose that the teaching activity of the SUS consists of "transforming" individuals who enter the university with a post compulsory secondary educational level (S)

and a certain earning capacity (w_S) into individuals with a university education (U) and with a higher earning capacity (w_U), being $w_U > w_S$.

The present value of the increase in salaries over a working lifetime deriving from the university qualification is an economic measure of the value of the human capital generated by the SUS (Serrano and Pastor 2002). To calculate the economic value of human capital two educational levels are considered: post compulsory secondary, and university. We will assume that the retirement age is 65 years. The economic value of human capital in each period is obtained by imputing to each university graduate the increase in wealth human capital that he/she obtains from graduating.

That is to say, the increase in the present value of the salaries that each graduate will receive for having completed university studies over a post compulsory secondary education level. Aggregating for the whole set of graduates of the SUS in each year we obtain the economic value of the human capital generated annually by the Spanish universities. The long term evolution of an individual's earnings is a function of the level of education he/she has reached:

$$w_{e,t} = w_{e,t-1}(1 - g) \quad (1)$$

where w is the individual earnings, the subindex e indicates the educational level attained and g is the real long term growth rate of earnings. Therefore, the updated value of the earnings over a working lifetime will be equal to:

$$h_{e,t} = \sum_{T=0}^{T=WL} \frac{w_{e,t+T}}{(1+r)^T} \quad (2)$$

where r is the real long term interest rate used to adjust future income to the present, and WL is the duration of each individual's working life starting from the period t in which he/she obtains his/her university graduation. Therefore, the investment in human capital made by an individual by undertaking university studies is the increase in his/her income over his/her working lifetime, as a consequence of going from the higher level of secondary education (S) to a university education (U):

$$i_{e0} = h_{e0} - h_{e-1,0} \quad (3)$$

The economic value of the human capital generated by the SUS in period t (YH_t) is the sum of all the individual investments made by its university graduates linked to the changes in educational level produced during period t :

$$YH_0 = \sum i_{e0} \quad (4)$$

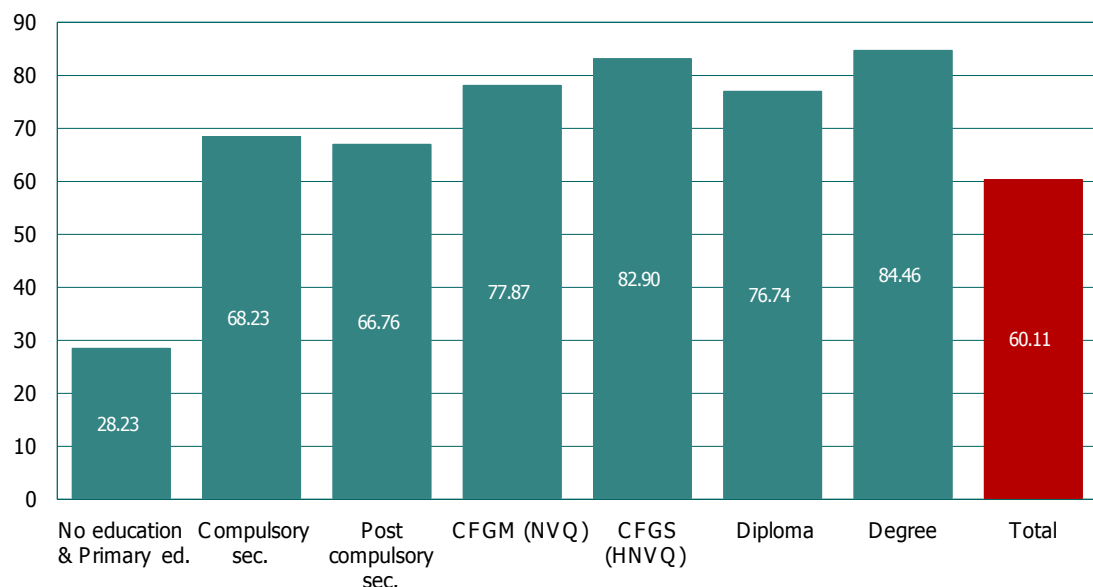
To perform these calculations the same assumptions are made as to the level of education that the individual would have attained had he/she not entered university. That is to say that, just as in calculating the counterfactual years of education, we assume that the individuals who did not study at university have completed post compulsory secondary education. As was indicated before, the result of these estimates is presented below in 4.1 subsection.

The next paragraphs are devoted to quantifying the impact of the SUS, through the generation of human capital, on the increase of the activity rate and the employment rate in Spain; in sum, on the increase of the occupied population, on the increase of the utilization of human capital.

Figure 2 presents the activity rates of individuals according to their level of education and it shows Individuals with a higher level of education, and especially university graduates, tend to have greater participation in the labor market.

To calculate the contribution of the SUS we construct a counterfactual scenario in which we discount the positive effect on the activity rate of having a university qualification. The comparison of this counterfactual activity rate with the real activity rate provides a measure of the contribution of the SUS.

Figure 2. Activity rate by levels of education completed
Spain. 2011 (percentage)



HNvQ is higher grade of vocational training and NVQ is regular vocational training

Source: INE and own preparation.

In the construction of the counterfactual rate the effect of the educational level on the activity rate is isolated from the rest of individuals' characteristics which also influence their probability of participating in the labor market. The counterfactual activity rate is calculated by estimating a conventional probit model of determinants of participation in the labor market including regional fixed effects (see model 1 in Table 1). The data are taken from the *Spanish Labor Force Survey* of 2011 (the sources of the remaining data are in Table 3). The greatest effect on the probability of being active is associated with long cycle university studies, which increase the probability of participating in the labor market by 25.8%.

Table 1. Estimation of labor activity and occupation

	(1) Labor activity		(2) Occupation	
	Parameters	Marginal effect on probability	Parameters	Marginal effect on probability
Constant	-0.049		-0.622	
Woman	-0.466 **	-0.174	-0.164 **	-0.058
Age 25-34	1.199 **	0.359	0.762 **	0.228
Age 35-44	1.217 **	0.369	0.918 **	0.268
Age 45-54	1.028 **	0.320	0.993 **	0.278
Age 55+	-0.426 **	-0.163	0.779 **	0.251
No education	-0.605 **	-0.237	-0.425 **	-0.159
Compulsory Secondary	0.354 **	0.129	0.220 **	0.075
Post compulsory Sec.	0.424 **	0.151	0.437 **	0.142
HNVQ	0.674 **	0.219	0.627 **	0.185
Diploma	0.682 **	0.221	0.764 **	0.216
Graduate	0.818 **	0.258	0.789 **	0.224
Spanish	-0.178 **	-0.065	0.311 **	0.115
Number of observations	144,451		144,451	
Log-Likelihood	-16,533,243		-28,300,000	

Note: ** significant at 1%; *significant at 5%.

Equations include regional fixed effects taking Madrid as reference.

HNVQ is higher grade of vocational training

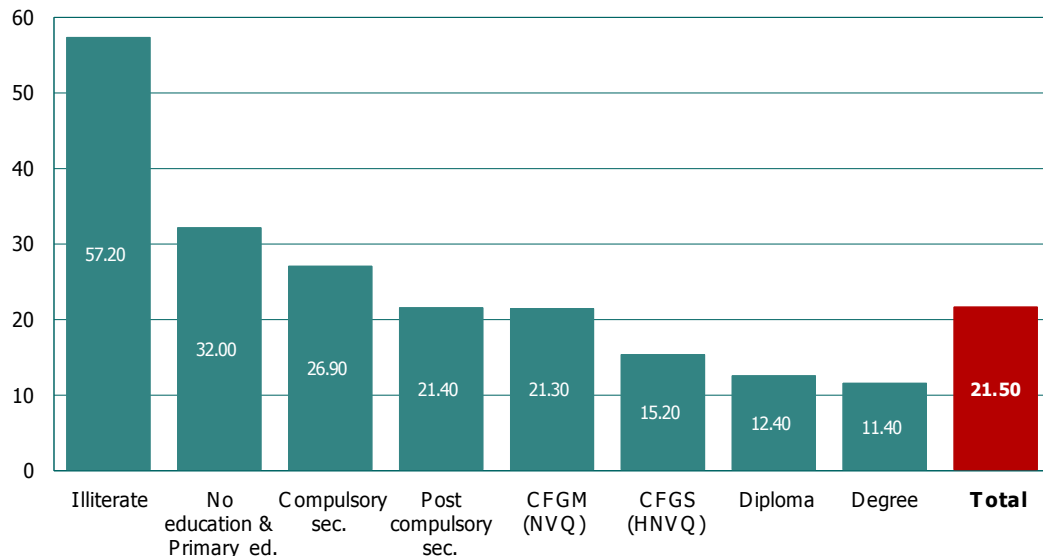
Source: INE and own preparation.

Once the effect on the activity rate of holding a university qualification has been computed, the next step is to measure how much the SUS has contributed to the increase in the activity rate through the formation of university graduates. For this we will consider the information on the number of graduates with short cycle and long cycle degrees from the Spanish universities and compute the counterfactual activity rate which discounts the contribution of the SUS.

However, not all the human capital effectively available is utilized, since part of it is wasted, being linked to unemployed persons. It is therefore important to estimate the *human capital effectively utilized* (that of occupied persons). In this sense, Figure 3

shows another conventional relationship: the higher the level of individuals' education, the lower their probability of unemployment. Thus, in 2011 the unemployment rates of university graduates were 80% lower than those of illiterates and 64.4% lower than those with no education or with only primary education.

Figure 3. Unemployment rate by levels of education
Spain, 2011 (percentage)



HNVQ is higher grade of vocational training and NVQ is regular vocational training

Source: INE and own preparation.

Therefore, once the contribution of the SUS to the reduction in the unemployment rate in Spain has been quantified, its impact on total employment in the Spanish economy can finally be estimated. Model (2) in Table 1 uses the same data as the model (1) and presents a two stage model (Heckman) of the determinants of employment in the Spanish economy. The estimations are used to calculate Spain's *counterfactual unemployment rate* which incorporates the effect of holding a university qualification on the unemployment rate, and two models are estimated. The results of the estimations indicate that education has a positive and statistically significant effect on the probability of employment when all other personal characteristics are similar. According to these results, the increase in the probability of employment as a consequence of continuing from post compulsory secondary education to a long cycle university degree is 2.9%.

Using these results we compute the counterfactual series of Spain's unemployed population, in which the effect on the real unemployment rate as a consequence of having completed a university education is discounted. The quotient between this counterfactual unemployed population series and the active population constitutes the counter-

factual unemployment rate, i.e. the rate resulting from the case where the individuals with a university education had not received such education. Consequently, the greater probability of being occupied of university graduates obviously has a positive impact on the total unemployment rate of the population.

The third long-term impact of the activity of the universities that intend to measure in this paper is the one that occurs on the technological capital of the economy. Universities' research and technological development (R&D) represents a substantial part (27.8%) of the expenditure and income generated by the SUS.

The OECD (2002) defines R&D spending as all creative work carried out on a systematic basis, with the aim of increasing the stock of knowledge and the use of that stock to devise new applications. Using this definition it is possible to quantify the SUS's contribution to the generation of technological capital in Spain by means of the spending on R&D. Technological capital is obtained from the accumulation of the flows of payments to personnel, of inputs and of investments in equipment and installations necessary for carrying out R&D activities.

To estimate the series of technological capital stock generated by the SUS, as done by Puente and Pérez (2004), the inventory method is used according to the expression:

$$KT_{i,t} = (1-d) KT_{i,t-1} + I_{i,t-q} \quad (5)$$

where $KT_{i,t}$ is the capital stock of period t , d is the rate of depreciation and I is the rate of investment in period t . Following Pakes and Schankerman (1984), the effects of investment in R&D are assumed to be incorporated into the technological stock with a delay of one year, so that the results of the R&D activities are not immediate ($q=1$). The capital stock is estimated as described below:

$$KT_{i,t} = \frac{I_{i,t-0}}{g+\delta} \quad (6)$$

g being the rate of growth of investment in R&D.

The literature focuses on the improvements in the productivity of the factors employed and the accumulation of physical, human, technological and organizational capital as two of the major sources of the economic growth. Now, the rest of the section presents the estimation procedure of the sources of growth of the Spanish economy and to the proportion that can be attributed to the SUS. We use the growth accounting proposed by Solow (1957) to estimate the contribution of the SUS to the economic growth of Spain.

Thus, we assume four productive factors and an expanded production function where production (Y) in period t depends on the state of technology (A), the capital employed (K), accumulated technological capital (KT) and the labor employed ($AET = L \cdot AS$), which is the product of the number of people employed (L) and their average years of education (AS). The impact of the Spanish universities on the growth of the Spanish economy is therefore produced through the three effects noted above: the *quantity effect* (on L), the *quality effect* (on AS), and the *technological capital effect* (on KT). The expanded production function is:

$$Y_t = A_t K_t^\alpha AET_t^\beta KT_t^\lambda = A_t K_t^\alpha (L_t AS_t)^\beta KT_t^\lambda \quad (7)$$

Taking logarithms (variables in lower case) and first differences (d) with respect to time, equation (7) is written:

$$dy_t = da_t + \alpha dk_t + \beta das_t + \lambda dkt_t \quad (8)$$

This expression permits decomposition of the growth of GDP (dy_t) into the contribution of capital (αdk_t), the contribution of the total quantity of labor ($\beta daet_t$), the contribution of technological capital (λdkt_t) and, finally, the contribution of total factor productivity (da_t).

Total labor growth (AET) is expressed as the weighted mean of the total labor growth associated with the existence of the SUS (AET^{SUS}) and the counterfactual economic growth that would be observed if the SUS did not exist (AET^{CF}) according to the following expression:

$$\widehat{AET}_t = [\theta \widehat{AET}_t^{SUS} + (1 - \theta) \widehat{AET}_t^{CF}] \quad (9)$$

where the circumflex symbol above the variables denotes rates of variation, θ is the proportion of the total years of education generated by the SUS, and $(1 - \theta)$ is the proportion of the rest of the years of education in the total. Given that the total labor AET is the product of the average years of education and the number of occupied persons, equation (9) can be written thus:

$$\widehat{AET}_t = [\theta (\widehat{AS}_t^{SUS} + \widehat{L}_t^{SUS}) + (1 - \theta) (\widehat{AS}_t^{CF} + \widehat{L}_t^{CF})] \quad (10)$$

Equation (10) can be expressed by proxying the rate of variation by logarithmic differences:

$$\widehat{daet}_t = [\theta (\widehat{das}_t^{SUS} + \widehat{dl}_t^{SUS}) + (1 - \theta) (\widehat{das}_t^{CF} + \widehat{dl}_t^{CF})] \quad (11)$$

Similarly, according to equation (5), the growth of technological capital can be expressed as:

$$\widehat{dkt}_t = [\psi \widehat{dkt}_t^{SUS} + (1 - \psi) \widehat{dkt}_t^{CF}] \quad (12)$$

Where dkt_t^{SUS} is the growth of technological capital associated with the SUS's investments in R&D, dkt_t^{CF} is the growth of technological capital of the rest of Spain if the SUS did not exist, ψ is the proportion of technological capital generated by the SUS in Spain and $(1-\psi)$ is the proportion of the rest of Spain's technological capital which has not been generated by the SUS.

KT_{t-1}^{SUS} , KT_{t-1}^{CF} and KT_{t-1} , being respectively the technological capital of the SUS, the technological capital of the rest of Spain, and the total technological capital in the initial year, we find that $\psi = KT_{t-1}^{SUS}/KT_{t-1}$ and $(1-\psi) = KT_{t-1}^{CF}/KT_{t-1}$. According to equations (11) and (12), the decomposition of growth in equation (8) can be expressed as:

$$\begin{aligned} \widehat{dy}_t = & \widehat{da}_t + \alpha \widehat{dk}_t + \beta [\theta (\widehat{das}_t^{SUS} + \widehat{dl}_t^{SUS}) + (1 - \theta) (\widehat{das}_t^{CF} + \widehat{l}_t^{CF})] \\ & + \lambda [\psi \widehat{dkt}_t^{SUS} + (1 - \psi) \widehat{dkt}_t^{CF}] \end{aligned} \quad (13)$$

This equation (13) decomposes the growth of GDP (dy_t) into the contribution of capital (αdk_t), the contribution of the total quantity of labor (βdae_t), the contribution of technological capital (λdkt_t) and, finally, the contribution of total factor productivity (da_t).

The important thing about this equation (13) is that it associates each of the sources of growth of Spain's GDP with the SUS. Thus, $(\beta \theta das_t^{SUS})$ measures the part of the growth associated with the improvements in quality of the labor factor associated with the SUS via the human capital generated, $(\beta \theta dl_t^{SUS})$ measures the part of growth associated with the increase in the quantity of occupied persons associated with the SUS via increases in the activity rate and occupation rate and, finally, $(\lambda \psi dkt_t^{SUS})$ measures the part of growth associated with the increase in technological capital generated by the SUS.

4. Results for the Spanish University System

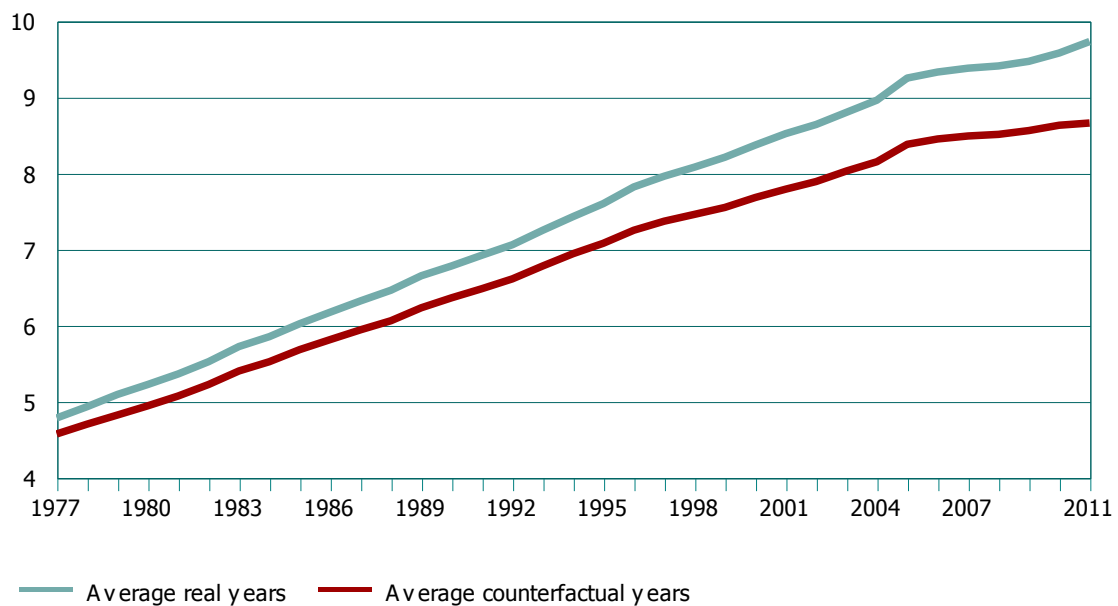
The section contains four subsections that present the results of the estimations of the long-term impacts of the Spanish University System on their national economy. Thus, the first subsection estimates the SUS's contribution to the generation of human capital. The second analyzes the indirect contribution of the SUS, via the human capital

generated, to the increase in the rates of activity and occupation. The third estimates the generation of technological capital through R&D activities. Finally, the fourth subsection estimates the contribution of the SUS to the growth of the Spanish economy.

4.1. Human Capital

Figure 4 presents the real and counterfactual average years of education for the working age population of Spain. The real average years of education of the population aged 16-65 years were 9.73 and without the contribution of the SUS they would have been 8.66 years. This means that the human capital generated directly by the Spanish universities was 1.07 years of education per person of working age. In other terms, in 2011, 11% of the average endowment of human capital of the population was generated directly by the SUS.

Figure 4. Real and counterfactual average years of education
Working age population. Spain. 1977-2011



Source: INE and own preparation.

To calculate the value of the human capital, we consider for each age group the increase in salary earnings when an individual passes from post compulsory secondary education to university level. Additionally, assumptions have to be made as to the growth of real salaries and of future real interest rates. Table 2 presents the *wealth human capital* for the secondary and university levels of education in three alternative scenarios: one neutral (scenario I), one pessimistic (scenario II) and one optimistic (scenario III).

Table 2. Wealth human capital per individual and value of university output
(thousands of euros of 2011)

	Secondary post compulsory ¹	Tertiary short cycle ²	Tertiary long cycle ³
Scenario I ($g=0\%$, $r=0\%$)	981.7	1,269.4	1,611.7
Scenario II ($g=2\%$, $r=2.5\%$)	854.9	1,100.3	1,391.5
Scenario III ($g=2.5\%$, $r=2\%$)	1,131.5	1,469.7	1,872.8

¹ Secondary Education II and Vocational Training, middle and higher grade

² University diplomas and engineering technicians.

³ Graduates, higher engineers and doctors.

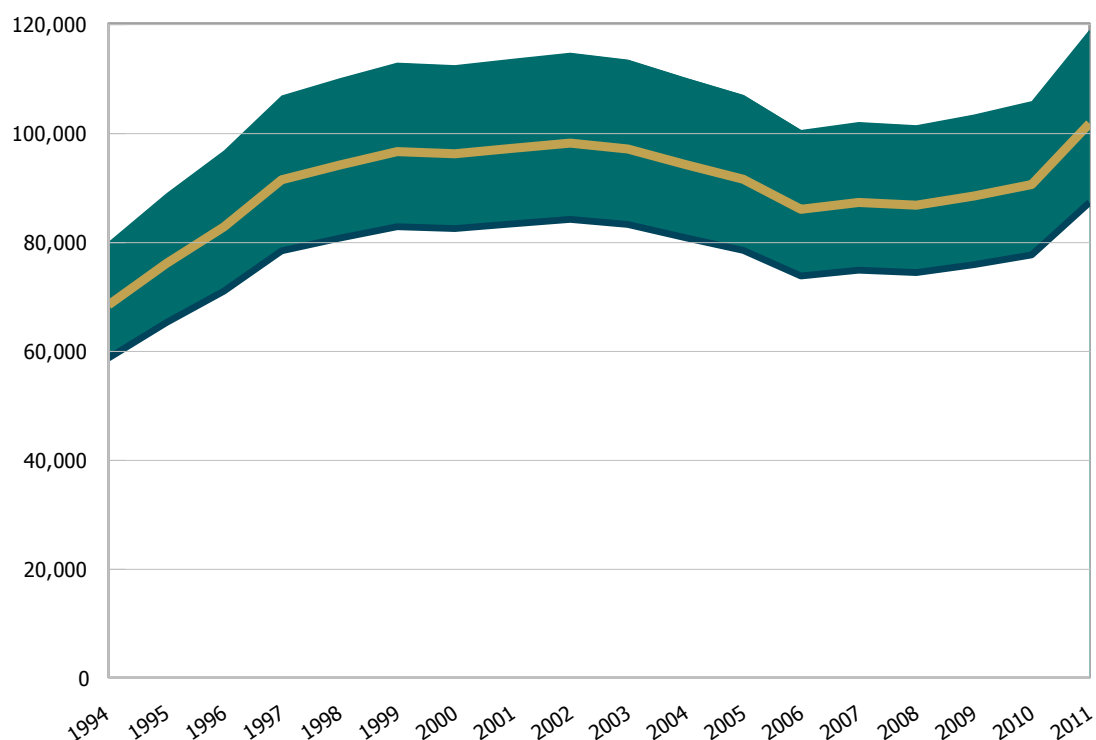
Note: g is the rate of growth of real salaries and r is the real interest rate.

Source: INE and own preparation.

As can be observed, the adoption of different assumptions notably influences the level of *wealth human capital* of each educational level, though not their relative positions. In the neutral scenario (scenario I), the present value of salary income (wealth human capital) of an individual with post compulsory secondary education is nearly one million euros (981,704 euros), that of a short cycle university graduate nearly 1.3 million euros and that of a long cycle university graduate over 1.6 million euros. Thus, going from post compulsory secondary education to a long cycle university education implies an increase of 630,000 euros (536,600 euros in the pessimistic scenario and 741,300 euros in the optimistic scenario).

Then last calculation to obtain the value of the human capital generated by the SUS consists of combining the foregoing results with the number of university graduates in each academic year. Figure 5 presents the results for each of the assumptions considered. According to the neutral scenario (scenario I), the *output* generated by the whole SUS in 2011 was 101,663 million euros. The value of the *output* varies between 87,150 million euros according to the most pessimistic scenario (scenario II) and 118,885 million euros under the optimistic scenario (scenario III).

Figure 5. Economic value of the output of the SUS
Alternative scenarios. 1994-2011 (thousands of euros of 2011)

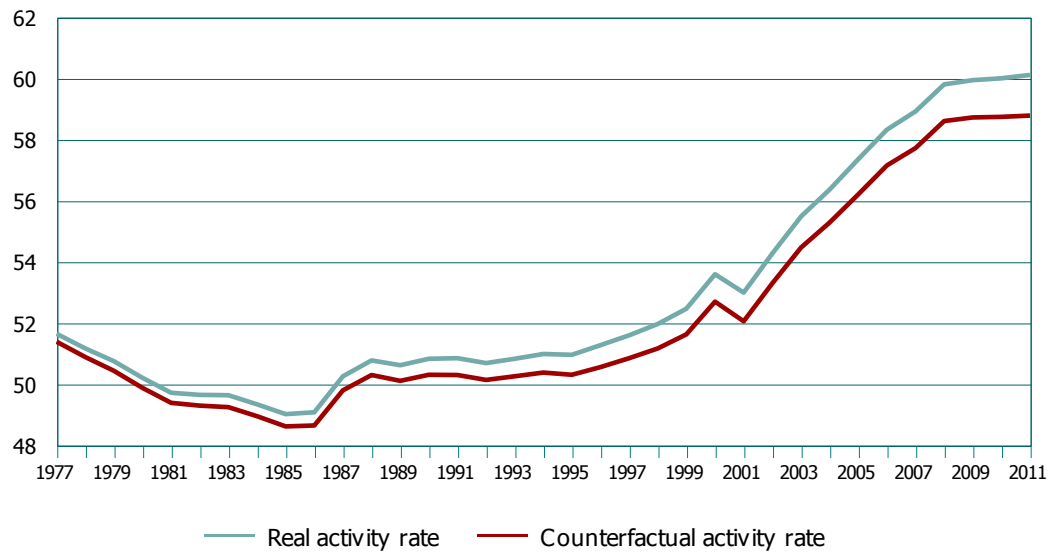


Note: Scenario I ($g=0\%$, $r=0\%$); Scenario II ($g=2\%$, $r=2.5\%$); Scenario III ($g=2.5\%$, $r=2\%$)
Source: INE, Ministry of Education, and own preparation.

4.2. Activity Rate and Employment

Based on the estimates presented in Model (1) of Table 1, the Figure 6 shows the evolution of the activity rate and the counterfactual rate. In 2011 the activity rate was 60.11%. However, if Spanish university graduates had not studied in the SUS and had the same behavior with regard to their participation in the labor market as individuals with post compulsory secondary education, the activity rate in Spain would have been 58.78% (1.33 percentage points lower).

Figure 6. Real and counterfactual activity rate
Spain. 1977-2011 (percentage)



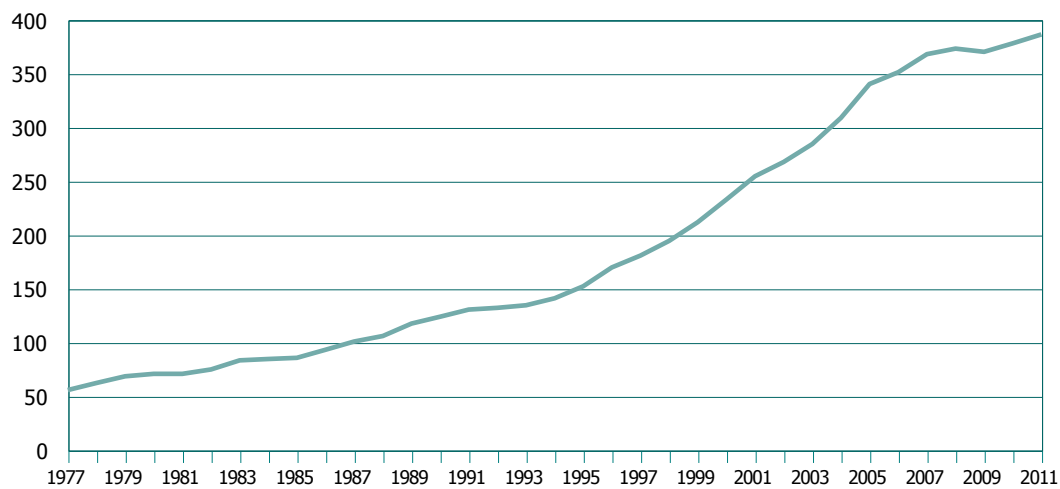
Source: INE and own preparation.

Additionally, using the results of the estimations presented in Model (2) of Table 1, our calculations indicate that the unemployment rate in 2011 is 21.5% and without the contribution of the SUS would have been 22.2% (0.7 percentage points higher).

The contribution of the SUS to the increase in occupation can be expressed in absolute terms. Figure 7 shows the results of this exercise, indicating a very positive and growing contribution which only slightly decreases its rate of growth with the start of the economic crisis. In 2011 Spain's occupied population consisted of 18,156,000 people. Without the SUS's contribution the occupied population in 2011 would have been 17,770,000 (2.1% of total employment in Spain).

Figure 7. Contribution of SUS to increase in occupied population

Difference between real and counterfactual occupied population. Spain. 1977-2011* (thousands of people)



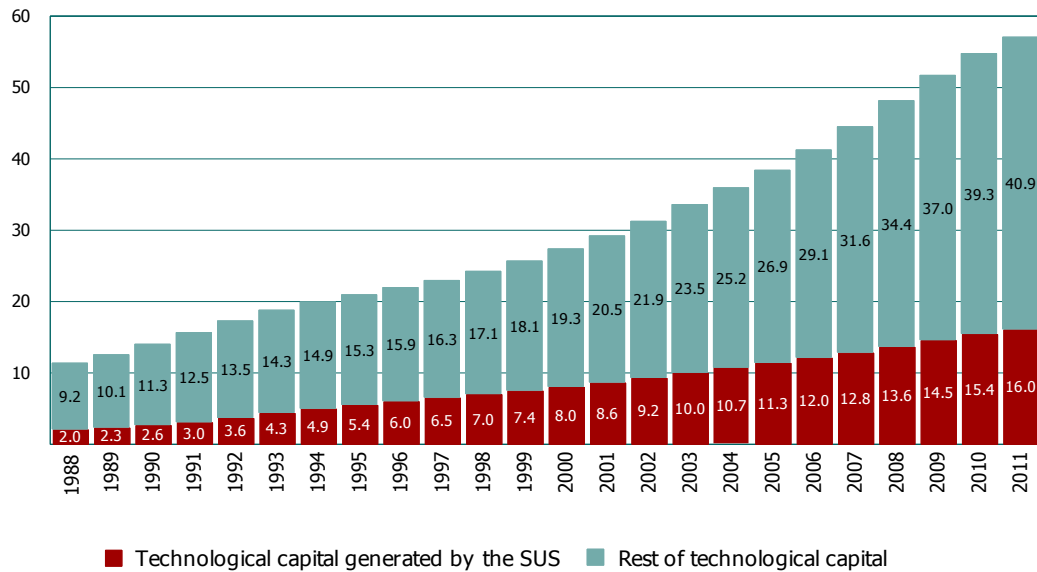
Source: INE and own preparation.

4.3. Technological Capital

Following the equation (5), the technological capital stock of the Spanish economy is estimated applying a rate of depreciation⁵ of 15%. Following the methodology described and using the R&D expenditure series we estimated the stock of technological capital generated both by the Spanish universities and by the rest of the sectors since the year 1988. The results are presented in Figure 8. The stock of technological capital generated by all sectors in 2011 was 56.9 thousand million euros, while that generated by the Spanish University System was 16.0 thousand million euros. That is to say that the SUS generated 28.1% of Spain's technological capital.

⁵ There is no unanimity as to the rate to be used. Pakes and Shankerman (1984) and Hall (1988) use a maximum rate of 25%. Other studies apply lower rates similar to those used for physical capital stock. In our opinion, the obsolescence of technological capital is greater than all other capital, so higher rates should be used. We use an intermediate rate of 15%, used by Hall and Mairesse (1992) and by Puente and Pérez (2004).

Figure 8. Contribution of the SUS to the generation of technological capital
Spain, 1988-2011 (thousand million euros)



Source: INE, BBVA Foundation-Ivie, and own preparation.

4.4. Economic Growth

In earlier subsections we have estimated the contribution of the SUS to the human capital of the Spanish economy by means of the production of university graduates. In addition, the SUS has had a very positive impact on the human capital effectively used, due to its contribution to the increase of the activity rate and the increase in employment in Spain (386.000 workers). In consequence, we give the name *quantity effect* to the SUS's contribution to the economic growth of Spain associated with the impact of the SUS on the employed population. It has also been estimated that 11% of the human capital of the Spanish economy can be attributed directly to the SUS. Similarly, we give the name *quality effect* to the SUS's contribution to the economic growth of Spain associated with the impact of the SUS on human capital.

Another of the sources of economic growth is technological progress. Human capital and investment in R&D are the two most important factors of investment in knowledge, and currently have a high potential to favor productivity gains and economic growth. In the previous subsection we estimated the technological capital generated by the SUS through its R&D activities (14,092 million euros, 28.1% of Spain's technological capital). We therefore give the name *technological capital effect* to the contribution of the SUS to the economic growth of Spain associated with the impact of the SUS on technological capital.

Table 3 summarizes the origin of the statistical information used to calculate the decomposition of the growth of the Spanish economy. Table 4 shows the sources of economic growth of Spain's economy for the period 1989-2010.

Table 3. Sources of data for Economic Growth in Spain

Variable	Definition	Source
Y: Level of income	GDP in real terms	INE. Contabilidad regional de España (various years)
K: Physical capital	Capital stock (private, non-dwellings) in real terms.	Fundación BBVA-Ivie.
AET: Years de education	Years of education of the occupied population	Fundación Bancaja-Ivie.
L: Occupied	Occupied population	Fundación Bancaja-Ivie.
KT: Technological capital	See equations (8)-(13)	INE. Estadística sobre actividades de R&D.
AS: Average years of education	Average years of education of the occupied population	Fundación Bancaja-Ivie.
Contribution to generation of income		
β : Labor	Ratio of remuneration of earners to GDP	INE. Contabilidad regional de España (various years)
λ : Technological capital	$\lambda=0.08$	López and Sanau (2001)
α : Physical Capital	Calculated as difference $\alpha=1-\beta-\lambda$. Constant returns to scale assumed.	

Spanish economy grew at an average annual rate of 2.57% during the period analyzed. The main source of economic growth is the labor factor with 2.14 percentage points, of which 1.45 points can be attributed to the increase in the number of persons employed and the remaining 0.69 points to the increase in quality. Table 4 also shows that, of the 1.45% of growth associated with the number of people, 0.42 percentage points are due to the indirect contribution of the SUS. Additionally, of the 0.67% of growth associated with improvements in quality, 0.02 percentage points are due to the increase in human capital generated by the SUS. Therefore, via improvements in the quantity and quality of labor, the contribution of the SUS to the growth of Spain reached 0.44 percentage points.

Table 4. Sources of economic growth in Spain.

Contribution of the SUS to economic growth. 1989-2010

	1989-2010	1989-1994	1995-2000	2001-2010
GDP	2.57	2.20	3.81	2.04
Physical Capital	1.42	1.32	1.53	1.42
Labor	2.14	1.29	3.69	1.72
- <i>Spanish University System</i>	<i>0.44</i>	<i>0.30</i>	<i>0.63</i>	<i>0.40</i>
* Quantity	0.42	0.28	0.60	0.39
* Quality	0.02	0.02	0.02	0.01
- Counterfactual	1.70	0.99	3.06	1.32
* Quantity	1.03	-0.05	2.27	0.94
* Quality	0.67	1.04	0.79	0.38
Technological capital	0.56	0.78	0.42	0.52
- <i>Spanish University System</i>	<i>0.18</i>	<i>0.24</i>	<i>0.17</i>	<i>0.14</i>
- Counterfactual	0.39	0.53	0.25	0.38
TFP	-1.56	-1.18	-1.84	-1.62

Source: INE, Bancaja Foundation-Ivie, and own preparation.

The second source of Spain's economic growth is the increase in physical capital which had a contribution of 1.42 percentage points. Similarly, technological capital contributed to the growth of the Spanish economy by 0.56 percentage points. The result of the decomposition indicates that 0.18 percentage points can be attributed to the impact of the technological capital generated by the SUS.

Considering all the impacts of the SUS simultaneously (*quantity, quality and technological capital effects*) we observe that, for the total of the period analyzed, the Spanish universities contributed to the growth of Spain by 0.62 percentage points (0.44 via increases in quantity and quality of labor and 0.18 via increases in technological capital). Altogether, 24.1% of the total average growth of the Spanish economy in the period 1989-2010 can be attributed directly and indirectly to the Spanish University System.

5. Concluding Remarks

The estimations show that the impacts of the Spanish universities' activities on the economic development are very substantial. This study reviews some of the most important channels through which the SUS contributes to the socioeconomic development of Spain, attempting to quantify its medium and long term impacts on: (1) the generation of human capital, (2) the increase in activity and occupation, (3) the increase

of technological capital, and (4) the contribution to economic growth. The principal results are as follows:

The Spanish universities have increased by 11% the stock of human capital of the working age population of Spain, equivalent, according to the estimations performed, to an average increase of 1.07 years of education per person.

This human capital generated by the SUS increases by 1.3 percentage points Spain's rate of activity in 2011, reduces the rate of unemployment by 0.7 percentage points, and increases total employment by 2.1%. That is to say, in absolute terms the Spanish universities increase occupation by 386,000 workers.

The R&D spending of the SUS represents 27.1% of the national total and from 1989 generated technological capital to the value of 14,024 million euros in 2011. This figure represents 28.1% of the technological capital in Spain.

The universities' activities also have a positive impact on the economic growth of Spain. The estimations indicate that between 1989 and 2010, the SUS contributed to the annual growth of the Spanish economy by 0.62 percentage points for an average annual growth of 2.57%. Of these, 0.44 percentage points were via increases in quantity and quality of labor, and 0.18 points via increases in technological capital, i.e. 24.1% of the average total growth of the Spanish economy in the period 1989-2010 can be attributed directly and indirectly to the Spanish University System.

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