Full title:

Higher Education Institutions, economic growth and GDP per capita in the European countries

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ABSTRACT

This paper presents an estimation of the contribution of Higher Education Institutions (HEIs) to economic growth and the Gross Domestic Product per capita of the European countries over the period 2000-2015. For this purpose, we analyse the universities' effects on the supply side of their national economies, especially the contribution of the R&D of HEIs to technological capital of the European countries. We proposed a methodology of counterfactual scenarios, which assume a hypothetical situation in which HEIs do not exist, to estimating the effects of HEIs, applying techniques of growth accounting. The results obtained indicate that these effects are a significant source of growth in European countries, contributing to mitigating the adverse effects of the periods of crisis. The estimates show that GDP per capita would currently be more than 11% higher than that corresponding to a scenario without HEIs. The results obtained also show significate differences in GDP per capita between European countries associated with the activity of HEIs.

KEYWORDS Higher Education Institutions; long-term economic impacts; economic growth; GDP per capita.

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1. Introduction

Globalization and the recent economic crisis have made it clear that there is a need not only to increase levels of company competitiveness, but also to the reorientation of the productive specialization of economies towards activities that generate more value added. Knowledge is a crucial factor nowadays in the development of innovation, the management of new technologies and the complex financial and commercial relations. Therefore, higher education plays a relevant role since all knowledge-intensive production activities require highly qualified workers.

In this new stage of socioeconomic development in which the knowledge-based societies are immersed, the role of Higher Education Institutions (HEIs) is very important because the results of their teaching, research and transfer activities are essential in this global process. The awareness of the contributions made by HEIs has led to studies where their impacts to economic and social development are measured. Nevertheless, most of these studies focus on quantifying the impacts in the short term by the demand side of HEIs activities in employment and the demand in local companies through their own spending as well as the spending of other agents related to HEIs activities. These studies do not take into account the HEIs contributions by the supply side and in the long term, which are produced by their teaching, research and transfer activities.

The central idea of Sudmant's (2009) study is that the economic impacts of HEIs are different from those attributable to other organizations because, as well as the 'static impact' on the economy, universities also have a 'dynamic impact' that increases the productive capacity of the economy. Thus, the argument is that HEIs' educational activities increase the human capital available in the economy, which has a positive impact in employment and income, as university graduates have higher activity and employment rates, and have higher productivity and earn higher salaries than people with lower educational levels. Further, HEIs' research and transfer activities generate scientific and technological knowledge, which increase the technological capital. All of these impacts are more important than impacts on the demand side because their effects last much longer. Additionally, the increase of both human and technological capital generates positive impacts on the growth of the economy and their Gross Domestic Product.

In sum, human capital, research, and knowledge in general (the areas of HEIs' specialization) are crucial for the long-term development of societies today, characterized by a knowledge-intensive use in all daily activities (Eriksson & Forslund, 2014). Therefore, we can consider HEIs as an instrument for social and economic development at country level. Our study focuses on the contribution of HEIs activities to the supply of resources in the European economies and their spillover effects on the economic growth and the Gross Domestic Product per capita (GDPPC) of the European countries, taking a broader time perspective (over the period 2000-2015). To carry out the analysis and quantification of the long-term impacts of HEIs in 28 European countries, we estimate counterfactual scenarios that assume that HEIs do not exist for each European country following the methodology developed by Pastor, Serrano and Soler (2016), and applying techniques of growth accounting.

The paper is organized as follows. The second section briefly outlines the long-term effects of HEIs' activities. The third section presents the impacts of HEIs on human capital. The fourth section shows the contribution of HEIs to the creation of technological capital. The fifth section describes the models used to estimate the contribution of HEIs to economic growth and presents estimates of its impacts on economic growth and on per capita income. Finally, the sixth section concludes.

2. The literature on the long-term effects of Higher Education Institutions

It is recognised that the expansion of higher education has had a positive effect on economic growth around the world and yet there is little research on the economic impact of universities. In a recent study, Valero and Van Reenen (2016) analyse data on almost 15,000 universities in about 1,500 regions in 78 countries for the period 1950-2010 and find that there is a strong positive impact of university expansion on regional economic growth. They estimate fixed effects models and show that the effect of universities on growth of GDP is not simply driven by the direct expenditures related with the universities, the part quantitative more important of this effect is due to the fact that universities are producers of human capital and innovation, and universities are institutions that promote the growth (increasing democratic attitudes).

The studies of Gennaioli et al. (2012, 2013) show the importance of human capital in accounting for regional differences in economic development, and also that regional growth is shaped by similar factors as national growth, such as geography and human capital. Belenzon and Schankerman (2013) study how geography affects university knowledge spillovers and find that is strongly localised. Toivanen and Väänänen (2016) find in Finland a positive effect of engineering education on the propensity to patent and their counterfactual calculation show that establishing new technical universities resulted in a high increase in the number of patents. Acemoglu et al. (2016) provide evidence that democracy has a significant positive effect on GDP. Their results suggest that democracy increases future GDP by encouraging investment, increasing schooling, and inducing economic reforms, improving public good provision, and increasing the social capital.

Most of the studies on the short-term economic impacts of HEIs activities that focus on the demand side through the HEIs' spending or the expenditure they induce in other agents do not address the major contributions of HEIs on the supply side of the economy. These studies do not take account the direct long-term contributions of HEIs activities to the supply of human and technological capital and the spillover effects (e.g. no market benefits and transformation of productive structures). These contributions have other crucial impacts on the national economies, such as the generating of economic growth and their positive impact on income. Thus, all studies of the impacts of HEIs on regional development find evidence that employment growth rates are higher in regions with many and good HEIs (Lendel, 2010; Pugh, Hamilton, Jack & Gibbons, 2016).

In the studies on the long-term contributions of HEIs, we can distinguish between two types of analyses. First, there are studies on the direct impact of HEIs by the supply side (Drucker & Goldstein, 2007), where HEIs are considered as instruments of socioeconomic development in their respective regions. These studies analyse the role of HEIs as incubators of technological innovation and quantify their contribution to the creation of human and technological capital through their teaching and research activities and their subsequent economic effects. Their contribution is established in terms of the increase in the level of studies, technological capital, wage returns, increases in activity and occupation rates or their contribution to economic growth and national income. Second, there are studies on the economic and social spillover effects of HEIs (McMahon, 2009; Pastor, Peraita & Soler, 2016), which review the non-quantifiable private and social benefits directly associated with HEIs activities (quality of life, health, respect for the environment, social capital, gender equality, etc.).

Many studies provide data on the activities developed by HEIs and show the relationship between these HEIs activities and various socioeconomic variables at local and regional level. It is certainly difficult to determine a causal link between university activities and the economic outcomes in their environment (Drucker & Goldstein, 2007). However, the regularity observed confirms that universities have a role to play in local and regional development (Comunian, Taylor & Smith, 2014). Undoubtedly, the variables that are most used in studies to highlight the contribution of HEIs to their environment are human capital and research.

Goldstein and Renault (2004) analyse the research and technology activities for the top fifty universities in the United States, suggesting that with the reorientation towards a knowledge-based economy, university activities have become increasingly important and, consequently, have more important dissemination impacts which can be internalized and generate economic growth in the regional environment. Similarly, Anselin et al. (1997) analysed the degree of "spatial diffusion" between university research and high technology innovations for the case of the United States. They used Griliches-Jaffe knowledge production function (Griliches, 1979; Jaffe, 1989) both at state and metropolitan levels, to estimate the effects of spatial diffusion between different US states. Other important contributions refer to the role of universities as entrepreneurial and knowledge transfer universities.[1] Bramwell and Wolfe (2008) analyse the impacts of the University of Waterloo in Ontario including an excellent summary of the literature on the mechanisms of knowledge transmission from universities to the economy. Sudmant (2009) studies the economic impact of the University of British Columbia (UBC) in Vancouver incorporating concepts adapted from the literature on the economics of education, innovation and economic growth.

Sudmant (2009) considers that the economic impact of HEIs is different from those of other institutions because, along with the "static impact" on the economy, there is also a "dynamic impact" (long-term). This dynamic or long-term impact refers to the role of HEIs in the creation and transmission of knowledge, an impact on the supply side insofar as it increases the productive capacity of the regional economy. Four economic impacts are estimated in this study: direct expenditure, those induced by expenditures that are not specific to the university but would not take place if they did not exist, the impact on the level of education of the labour force and the impact of the new knowledge created or transmitted by universities. This study stresses the importance of this dynamic impact on the supply of resources and calculates the impact of the research activities of the UBC on the economy, the so-called dynamic multiplier effect, using total factor productivity (TFP).

The consultancy BiGGAR Economics (2015) carried out a study to analyse the role of universities belonging to the League of European Research Universities (LERU) to assess the contribution of the 21 member universities of LERU in Europe. The study is very broad and analyses both short and long-term economic impacts derived from the core activities of the member universities of LERU across Europe. As noted in the study itself, "an important limitation of traditional approaches to economic assessment of value is that they do not take into account the long-term effects on the economy". This is because much of the activity undertaken by HEIs focuses on the long-term results that often take some time to manifest themselves.

Similarly, the study of Pastor, Peraita and Pérez (2016) quantifies the contributions by the supply side of the Spanish University System with a new methodology to estimate HEIs' long-term economic impacts. We propose the same methodology, a counterfactual scenario where the question is: if the European HEIs had not existed, then what would have been their contribution on the European countries' economies. Therefore, this study identifies the channels through which universities contribute to the long-term growth of GDP of the EU countries and presents a methodological proposal where the HEIs' supply-side economic impacts are estimated using a counterfactual scenario and growth accounting (Solow, 1957). We evaluate the impacts of universities on human capital, salaries and occupation, on generation of technological capital and, finally, on the GDP per capita of the EU countries in the period 2000-2015. The contribution of HEIs in the EU countries are estimated by comparing the current situation and a hypothetical one in which human and technological capital generated by universities are not present in productive activities.

3. The contributions of Higher Education Institutions through the generation of human capital

HEIs train part of the population and its educational activities increase their human capital endowments. Similarly, the HEIs' research and transfer activities generate scientific and technological knowledge, which increase the technological capital in the economy. In this section, we present the contributions of HEIs to the human capital available in the economy. The increase of human capital endowments of the population results in a higher participation in the labour market and an increase in employment rates, with a greater proportion of working-age people employed (labour quantity effect). In addition, part of the employed population has higher levels of human capital thanks to higher education (labour quality effect).

Therefore, HEIs have contributed directly to the increase in available human capital of the population in the European countries, and have contributed indirectly to the increase in the human capital effectively available in the European countries through the willingness of their graduates to participate in the labour market. We follow the calculations of the study developed by Pastor, Serrano and Soler (2016), where they take into account the direct and indirect impacts of higher education on the human capital of European economies. To carry out the study, counterfactual scenarios that assume that HEIs do not exist are estimated for each European country. In order to do that, using EU-LFS microdata we estimate a probit model of the probability of employment for each European country including as explanatory variables educational attainment and other personal characteristics. We are able to obtain the direct impact of HEIs through their educational activities on the human capital of individuals, as well as the indirect impact on employment rates given the greater labour participation and employability of people with higher education.

Unfortunately, social scientists cannot conduct true experiments and they have no choice but to rely on counterfactual assertions in one way or another. Fearon (1996), in an excellent paper about counterfactuals and hypothesis testing in political and social science, essential reading for any counterfactual study, says that propositions, like the one in this paper, “If there were no Higher Education Institutions in European countries”, play a necessary and fundamental role in the efforts of political scientists to assess their hypotheses about the causes of the phenomena they study. In this paper we follow the strategy proposed by Fearon based on counterfactual scenarios that is an extensively technique used in the social sciences to analyse diverse topics and are applied in a wide range of fields where real experiments cannot be performed. Thus, we measure some long-term economic impacts of the HEIs by comparing the real situation with another hypothetical situation in which the HEIs do not exist, and maintaining everything else constant.

The combination of the two contributions mentioned has a significant effect on the human capital used in Europe (see Table 1). The total years of study of the employed population in the European countries would have been, on average for period 2000-15, 11.2% higher than in the counterfactual scenario without HEIs. In addition, the magnitude of the difference attributable to HEIs increased from 9.5% in 2000 to 13.2% in 2015.

[Table 1 near here]

Table 1 show that the two contributions of HEIs to the relative increase of total years of study of employed population are logically positive in all European countries, although there is considerable heterogeneity in their magnitude. The average values for the period 2000-2015 range from 5.7% in Czech Republic to 16.6% in Ireland. Thus, the impact is especially relevant in Ireland, Cyprus, Lithuania, Spain, Belgium, Estonia, the United Kingdom, Finland, Greece, France, Netherlands and Luxembourg. In all these countries, the difference with respect to the scenario without higher education exceeds 13%. However, in Czech Republic, Slovakia, Romania, Italy and Austria the average difference does not reach 8%. There are also significant disparities between countries in the evolution of this impact over the period, although in most of them it is increasing. In 2015 the estimates indicate that the total impact of HEIs' contribution would have increase the years of study of the employed population, ranging from around 8%, as in Slovakia and the Czech Republic, to levels close to 20%, as in Ireland, Cyprus, Lithuania and Spain.

Part of the effect of higher education to additional human capital, as mentioned earlier, is due to changes in employment rates associated with better education levels. For the European Union-28, this effect would mean that the total years of study of the employed population would be, for the 2000-15 period, 3.1% higher over the period analysed than in the counterfactual scenario. This pattern is generally repeated in almost all European countries, with a positive and increasing effect, albeit with different intensity. In all countries, the impact has increased except in Lithuania, although the relative increase is more intense in countries such as Malta, Poland, Portugal, Austria, Slovakia and Romania and weaker in Germany, Sweden and Estonia.

The effect of the increase in the number of years of education per worker associated with the existence of higher education is even more intense. In the case of the European Union-28 as a whole, it would represent a difference of 8.1% on average over the period with respect to the counterfactual scenario. The magnitude of the effect increased from 7% in 2000 to 9.4% in 2015. Again, there is a marked inequality between countries. While this impact has exceeded 10% on average during the period in certain countries (Spain, Belgium, Ireland, Cyprus, Finland and the United Kingdom), in others it is between 4% and 6% (Romania, the Czech Republic, Slovakia and Italy). With the exception of Lithuania, the intensity of this impact increased in all countries, albeit at a different pace.

In general, the direct impact for most of the European countries is larger than the indirect impact associated with the improvement of employment rates. For the European Union-28 and for the average 2000-2015, 72.3% of the total impact would correspond to the direct impact and 27.7% to the impact via the labour market. In addition, this distribution is very stable throughout the period analysed. The individual behaviour of European countries is also characterised by high stability throughout the period, but within a heterogeneous pattern in terms of the importance of each factor in the total impact. Finally, we can see that in some countries, the direct impact is of particular relative importance compared to the employment rate impact.

4. The contribution of Higher Education Institutions to the creation of technological capital

Research and development (R&D) activities and those of transfer are two important missions of HEIs in advanced societies. And although they may not be as visible as teaching activities, the fact is that through R&D and transfer activities, HEIs contribute to the socioeconomic development of their respective environments, generating, developing and transferring knowledge to companies and institutions in their national economies. The universities devote funds to research which provide the basis for technologies that are subsequently used by firms (BiGGAR Economics, 2015). The development of such technologies and the transfer of knowledge between HEIs and industry are fundamental for the long-term competitiveness of their economies. In some cases, HEIs have led to the development of large-scale innovation centres that are important drivers of regional economic growth.

Figure 1 presents the total intramural R&D expenditure (GERD) undertaken by the three sectors for which Eurostat provides disaggregated data (European Union Labour Force Survey): Government, higher education sector, and business enterprise and private non-profit sector. As can be observed, the participation of HEIs in total intramural R&D expenditure is very significant in European countries as a whole and increases over time representing 20.9% in 2000 and 23.2% in 2015. In most countries, HEIs are the second most important agent of expenditure on R&D, and in some cases the first, as in Greece, Slovakia, Latvia, Cyprus and Lithuania.

[Figure 1 near here]

However, the fact that the contribution through the R&D of HEIs to the economy is produced in the long term makes it complicated to capture by the traditional methods of economic impact analysis. The results of R&D activities of HEIs, unlike teaching, are more difficult for society to visualize and their achievements tend to be undervalued. This section therefore offers a quantitative assessment of the contribution that HEIs make to generating technological capital in the economies of European countries via the important weight of HEIs' R&D expenditure[2] in the total. Technological capital is defined as the knowledge asset resulting from the accumulation of staff payment flows, inputs and investments in equipment, as well as the facilities, which are necessary for R&D activities.

To estimate the series of technological capital stock generated by HEIs we use the standard inventory method according to the expression:

$$KT_{i,t} = (1-\delta)KT_{i,t-1} + I_{i,t-\theta} \qquad (1)$$

where $KT_{i,t}$ is the capital stock of period t, δ is the rate of depreciation and I is the amount 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 (θ=1). The capital stock is estimated as described below:

$$KT_{i,t} = \frac{I_{i,t-\theta}}{g+\delta} \quad , \tag{2}$$

g being the rate of growth of investment in R&D. Following the work of Hall and Mairesse (1995) and Pastor, Peraita and Pérez (2016), we use a depreciation rate of 15%.

[Table 2 near here]

Table 2 presents the percentage of technological capital generated by HEIs and other sectors in 2000 and 2015. At the end of the analysed period, the total technological capital in the European Union-28 countries was 1.64 trillion euros, of which HEIs would have contributed 378 billion, or 23.1% of the total. The importance of HEIs in total technological capital is not homogeneous, however, with significant differences between countries. Those countries where the technological capital generated by HEIs is more significant are Lithuania (53.1%), Cyprus (49.6%), Latvia (44.3%) and Greece (40.8%). It is important to note that the effects of the economic crisis and the budget cuts in R&D are reflected in the accumulation of technological capital that reduces its growth from 2008 in all countries without exception. These effects of the crisis are even more visible in the technological capital generated by HEIs. Thus, in countries such as Greece, the annual growth rate until 2007 was 8 times the post-crisis rate. Similarly, in countries such as Italy, Hungary, Romania, Lithuania, Cyprus and the United Kingdom, pre-crisis growth rates are 2 to 5 times higher than those following the crisis.

5. Contribution of Higher Education Institutions to economic growth

To compute the contribution made by HEIs to economic growth in European countries, we shall use a growth accounting methodology (Solow, 1957), that allows us to breakdown the economic growth of economies into the contributions corresponding to each of the factors of production, as well as to technical progress or total factor productivity (TFP). The basic idea is that assuming the existence of perfect competition and constant returns to scale, the contribution of each factor to production can be estimated through its own real growth rate multiplied by the share of that factor's income in the total income.[3]

To briefly illustrate the methodology, we consider a production function in which output (Y) in each period (t) depends on the capital used (K), the quantity of different types of labour used, aggregating them by means of weights based on the years of study of the employed population (EYS), and the technological capital accumulated (KT):

$$Y_t = F_t\,(K_t,\ EYS_t,\ KT_t). \tag{3}$$

Note that, instead of considering the number of people employed, we consider the total years of study of the employed population, $EYS=AYS \cdot L$, which is the product of the average years of study (AYS) and the number of people employed (L). This procedure allows us to collect both the contribution in terms of average years of study and the contribution in the number of people employed. The HEIs contribute to economic growth with the following three effects:

- *Quantity effect:* The impact of HEIs on the total number of people employed. To estimate this contribution, we breakdown labour (*EYS*) in terms of quantity (*L*) and quality (*AYS*). Furthermore, we separate the quantity of labour into those jobs associated with the existence of HEIs (L^{HEI}) and those that would have existed without their existence (L^{CF}, counterfactual employed population).
- *Quality effect:* The impact of HEIs on the generation of human capital. To estimate this contribution, we breakdown the increase in the quality of the employment of European countries (average years of study, *AYS*) in the share of the growth attributable to HEIs (AYS^{HEI}), and the improvement in the average years of study of the employed population that would have occurred in the case of HEIs not existing (average counterfactual years of schooling, AYS^{CF}).
- *Technological capital effect:* The impact on the generation of technological capital. To estimate this contribution, we breakdown the growth of total technological capital (*KT*) in the part attributable to the existence of HEIs (KT^{HEI}) and the one that would have been accumulated without the contribution of HEIs (KT^{CF}, counterfactual technological capital).

Thus, according with growth accounting, the growth of the years of study of the employed population (*EYS*) in each country can be expressed as the weighted average of the total labour growth associated with the existence of HEIs (EYS^{HEI}) and the counterfactual scenario which would be observed if they did not exist (EYS^{CF}) following the expression:

$$E\hat{YS}_t = \left(\theta E\hat{YS}_t^{HEI} + \left(1-\theta\right) E\hat{YS}_t^{CF}\right) , \tag{4}$$

where the circumflex symbol above the variables denotes rates of variation, θ is the weight of the years of study generated by HEIs in the total, and (1-θ) is the weight of the remaining years of study in the total. Specifically,

$$\theta = EYS_{t-1}^{HEI} \big/ EYS_{t-1} ; \quad (1-\theta) = EYS_{t-1}^{CF} \big/ EYS_{t-1} \ . \tag{5}$$

Given that *EYS* is the product of the average years of study and of the number of people employed, equation (4) can be broken down, in turn, as:

$$E\hat{YS}_t = \left(\theta\left(A\hat{YS}_t^{HEI} + \hat{L}_t^{HEI}\right) + (1-\theta)\left(A\hat{YS}_t^{CF} + \hat{L}_t^{CF}\right)\right). \tag{6}$$

The above expression can be expressed by approximating the rate of variation by logarithmic differences:

$$deys_t = \left(\theta\left(days_t^{HEI} + dl_t^{HEI}\right) + (1-\theta)\left(days_t^{CF} + dl_t^{CF}\right)\right). \tag{7}$$

In the same way, technological capital can be broken down as follows:

$$dkt_t = \left(\psi dkt_t^{HEI} + (1-\psi) dkt_t^{CF}\right), \tag{8}$$

where dkt_t^{HEI} is the growth of technological capital associated with investments made by HEIs in R&D, dkt_t^{CF} is the growth of the counterfactual technological capital without HEIs, ψ is the weight of technological capital generated by HEIs in the total and $(1-\psi)$ is the weight of the remaining technological capital. Specifically, if KT_{t-1}^{HEI}, KT_{t-1}^{CF}, and KT_{t-1} are, respectively, the technological capital of HEIs, the rest of the technological capital, and the total of technological capital in the initial year, we have that

$$\psi = KT_{t-1}^{HEI} / KT_{t-1}\,;\ (1-\psi) = KT_{t-1}^{CF} / KT_{t-1}\,. \tag{9}$$

With the above expressions, the breakdown of growth can be expressed as

$$\begin{aligned} dy_t = da_t + \alpha dk_t + \beta\left[\left(\theta\left(days_t^{HEI} + dl_t^{HEI}\right) + (1-\theta)\left(days_t^{CF} + dl_t^{CF}\right)\right)\right] + \\ + \lambda\left(\psi dkt_t^{HEI} + (1-\psi) dkt_t^{CF}\right) \end{aligned} \tag{10}$$

This last expression is the one that allows us to breakdown Gross Domestic Product (GDP) growth (dy_t) into the contribution of capital (αdk_t), the quality of labour ($\beta days_t$), the quantity of labour (βdl_t), technological capital (λdkt_t), and total factor productivity (da_t), and in turn, which part of these sources of growth is associated with HEIs. Specifically, ($\beta\theta days_t^{HEI}$) measures the share of growth related to improvements in the quality of the labour factor associated with HEIs via the human capital generated, ($\beta\theta dl_t^{HEI}$) measures the share of growth related to the increase in the number of people employed associated with HEIs through increases in the rate of activity and employment, and ($\lambda\psi dk_t^{HEI}$) measures the share of growth related to the technological capital generated by HEIs.

[Table 3 near here]

Table 3 presents the growth accounting results of European Union-28 countries for the period 2000-2015 and breaks it down into the contribution of productive factors, showing the contributions of HEIs to the economic growth of each country. Additionally, Table 3 offer also the growth accounting of European countries as a whole for the periods 2000-2007 and 2007-2015, distinguishing between the period before and after 2007 to analyse possible changes associated with the past economic crisis.[4] When assessing the contributions of HEIs, it should be noted that the intensity of this impact depends on its effect on the growth rate of the quantity, and quality, of employment and technological capital. Thus, this effect will tend to be more significant in countries where education, although less developed, has increased more strongly during the period analysed in relative terms.

Table 3 shows that HEIs would have boosted European growth, with a contribution of 0.63 percentage points to the average growth rate of the European Union-28 (0.57 percentage points for the quantity and quality of human capital, and 0.06 percentage points for their contribution to the increase of technological capital). The contribution is positive in all countries, albeit the differences are notable. In Germany it is only 0.24 percentage points while in Portugal it is 1.69 percentage points, and in Spain, Ireland and Greece it stands at around 1 percentage point. With the exception of a few cases, the growth impulse from HEIs occurs more through the contribution of human capital than through R&D capital. Furthermore, most of the increase in human capital associated with higher education corresponds to the direct impact of improving labour quality. The share related to the improvements in the employment rate associated with having higher education is markedly more moderate in all countries. The contribution of HEIs via technological (R&D) capital is especially significant in the Baltic republics. The improvement of the human capital per capita of the employed population associated with HEIs has had an impact which also shows a high heterogeneity. These are contributions of greater importance than those linked to the increase in the rate of employment induced by higher education.

Another question refers to the lags between the university output and GDP growth. It is possible that the impact of research activity on economic growth has a longer time lag than the impact of human capital. Our fifteen-year observation period (2000-2015) may be too short to full account for favourable longer term impacts of the research activity on GDP. However, the method used in this paper to estimate the effects on GDP through innovation capitalises these R&D investments in a stock of technological capital under the assumption that the results of the R&D activities are not immediate. The effects of investment in R&D are assumed to be incorporated into the technological stock with a delay of one year. This method allows, to some extent, to take into account the possible time lag between research activity and GDP growth.

In the European Union-28 countries as a whole, there is an increase in contributions linked to the increase in the human capital per capita of the employed population and the employment rate. On the contrary, the contribution through R&D capital remains stable. Consequently, one aspect to be highlighted is the different behaviour of the contribution of higher education to growth. The crisis generally affected all sources of growth. The contribution of physical capital went from 0.53% prior to the crisis to 0.29%. The contribution of the labour factor estimated for the counterfactual scenario without higher education would have fallen from 1.20% to 0.28%, mainly due to the quantity impact that would have gone from 0.87% to -0.08%. The TFP would also have performed worse than in the pre-crisis period. However, the estimates obtained for the impact associated with higher education far from being reduced would have been maintained (R&D capital) or even increased (quality and quantity labour effects). In total, while but the GVA's growth rate suffered a great fall, from 2.27% to 0.40%; the contribution of education would have remained at a stable rate of 0.35% per year between 2000 and 2015.

The robustness of the economic impact generated by Higher Education Institutions in their national economies is reinforced by the universal nature of the positive economic contributions observed. The estimated total effect is positive for the EU as a whole and each of the 28 European countries included in the analysis. In addition, the estimated effect is positive for each of the three considered channels (labour quality, labour quantity and R&D capital) among which the economic impact on GDP can be disaggregated. That is, the results of this study include an individualized analysis of each of the 28 EU countries from their own statistical data with specific econometric estimates for each of the European countries. For example, using the EU-LFS microdata, we have estimated a probit model of the probability of employment for each European country, which includes the educational achievement and other personal characteristics corresponding to each country as explanatory variables.

These results indicate that higher education would have contributed to partially alleviating the negative impact of the crisis on the overall economic growth in Europe. However, the overall contribution of education, while remaining positive, would have worsened after the crisis in certain countries (see Table A1 and Table A2 in Appendix). In short, the contribution of higher education to growth is very relevant in all European countries. It is undoubtedly one of the main sources of economic growth and contributes to a more stable growth, with better performance during the crises than other growth engines.

Our results show that the impact of human capital is higher than the impact from R&D. Nevertheless, given that institutions of higher education are multiproduct firms, education and research are to some extent interconnected and the quality of education is dependent on the quality of research. As a result, part of the human capital effect is indeed linked to the research activity at HEIs.

5.1. Contribution of Higher Education Institutions to the increase in per capita income

The impact of HEIs on technological capital and the human capital endowments used do indeed affect growth, as we have seen, and therefore influence the relative levels of GDP per capita of the different countries at a given moment in time. By applying growth accounting methods, the contributions of each input can be estimated through the differences in the levels of output or output per capita between two periods. These comparisons can be made between two different scenarios for the same economy. Let these two observations be A and B (real and counterfactual scenarios), the approximation would be:

$$log\left(\frac{Y_A}{Y_B}\right) = log\left(\frac{TFP_A}{TFP_B}\right) + \frac{\alpha_A+\alpha_B}{2} log\left(\frac{K_A}{K_B}\right) + \frac{\lambda_A+\lambda_B}{2} log\left(\frac{KT_A}{KT_B}\right) + \frac{\beta_A+\beta_B}{2} log\left(\frac{EYS_A}{EYS_B}\right), \quad (11)$$

were *TFP* is Total Factor Productivity, *K* is physical capital, *KT* is technological capital, *EYS* is human capital (total years of education of employed population), α_i the share of physical capital income in the total income of i, λ_i that of technological capital income and β_i that of human capital (labour income). The contribution of each input is given by the relative variation in the use of the input multiplied by its share in total income.

Higher education has an influence through its effect on technological capital and human capital endowments. Human capital is modified because human capital per capita varies and because the number of people employed changes. Thus,

$$\frac{\beta_A+\beta_B}{2} log\left(\frac{EYS_A}{EYS_B}\right) = \frac{\beta_A+\beta_B}{2} log\left(\frac{AYS_A}{AYS_B}\right) + \frac{\beta_A+\beta_B}{2} log\left(\frac{L_A}{L_B}\right), \quad (12)$$

where AYS_i is the years of study per capita of the employed population (labour quality effect) and L_i the quantity of labour (labour quantity effect). In the later analysis, the hours worked were used as a variable representing the quantity of labour input.

This approach can be used to estimate the contribution of higher education to GDP per capita in each European country by comparing actual results (*A*) with those corresponding to the counterfactual scenario without higher education (*B*). For each country, it is assumed that the weight of income of each factor in the total income in the counterfactual scenario (*B*) is the same as that observed (*A*).

[Figure2 near here]

[Table 4 near here]

Figure 2 shows the estimated impact of higher education provided by HEIs in 2015 on the GPD per capita for the 28 European countries. The total contribution is considerable, standing at 10.7% for the whole of the European Union-28, indicating that GDP per capita is one-tenth higher than it would have been in the absence of higher education. The contribution via human capital endowments (8.6%) would be somewhat higher than that produced via technological capital (2.1%), but both are relevant. The impact of human capital would occur mainly through the improvement in the average years of labour per capita (labour quality effect) with a contribution of 6.1%. Although to a lesser degree, there would also be a significant labour quantity effect due to the increase in the employment rates associated with higher education levels (with a contribution of 2.5%). As can be seen, significant positive effects are estimated for all countries, although their magnitude varies from one case to another. The channels through which these impacts materialize also differ from country to country.

In Cyprus, Lithuania, Belgium, Greece, Spain, the Netherlands, Estonia, Latvia, the UK, France, Finland, Denmark, Ireland and Portugal, the relative impact of higher education would be above the European average, with total contributions ranging from 10.7% to 16.7%. The impact through technological capital is especially intense in Cyprus, Lithuania, Latvia, Portugal and Greece with values between 4% and 6%. The improvement in human capital per capita represents 7-8% more GDP per capita in Belgium, Spain, Finland, France, the UK, Cyprus and the Netherlands. Table 4 shows that the increase in employment rates plays a smaller role in all countries in quantitative terms. Finally, the different magnitude between countries in terms of higher education contributions means that the relative situation of European countries is different from that which would have existed in the counterfactual scenario without HEIs.

Finally, we are aware of the debate on the economic contributions of the HEIs compared to their costs. A comparison between our estimates for the long-term impact of HEIs on GDP with the expenditure on tertiary education institutions (including R & D activities) as a percentage of GDP may be useful. In 2014, the last year for which data are available for all the EU countries (OECD, 2017); the total expenditure of EU countries on HEIs (from public and private sources of funds) represents 1.3% of their GDP. A rough calculation between the previous percentage and the 10.7% contribution of tertiary education to GDP per capita (see Table 4) shows that the quantitative impact of HEIs would be on average eight times higher compared to their annual cost in terms of GDP of the EU countries. This calculation is highly simplified, but the results obtained by Valero and Van Reenen (2016) when they consider the expansion of universities in the United Kingdom are similar. In their approximation, the benefits of university expansion are five times as large as the costs. We note that their effect is a "marginal impact" of university expansion on a consolidated university system, whereas our calculation is an "average impact" for all the already existing university systems of the countries of the EU. The relative costs and benefits of HEIs would vary by country. For example, Germany's expenditure on tertiary education is 1.2% of GDP, in France 1.5% and in the United Kingdom 1.8%. Following the corresponding data of Table 4, the impacts of HEIs on their GDP per capita would be, respectively, seven, eight and seven times as large as their costs.

6. Conclusions

Higher Education Institutions make a significant contribution to the economies of European countries. Our study has reviewed and quantified some of the most relevant economic contributions by the supply side of HEIs. With this objective, exercises have been designed to quantify these contributions as accurately as possible. The direct contribution to the generation of human capital and technological capital has been quantified, as well as the indirect contributions to increasing activity and employment rates, to economic growth and to increasing Gross Domestic Product per capita.

The teaching activities of HEIs increase the human capital endowments and productive capacities of population. The increase of human capital endowments of the population results in a higher participation in the labour market and an increase in employment rates, with a greater proportion of working-age people employed (labour quantity effect). In addition, part of the employed population has higher levels of human capital thanks to higher education (labour quality effect). We have presented the estimations of the contribution of HEIs to the human capital available in the European economies.

The HEIs carry out a considerable part of research and development activities in European countries. The HEIs' research and transfer activities generate scientific and technological knowledge, which increase the technological capital in the economy. Therefore, much of the accumulation of technological capital corresponds precisely to Higher Education Institutions (R&D capital effect), which also leads to greater economic development in European economies.

In short, because of the existence of HEIs, technological capital increases, as well as the labour input used and its quality. This study has attempted to estimate the positive effects of higher education on the levels of production and income per capita for the European Union-28 countries, covering the period 2000-2015. For this objective, a counterfactual scenario was estimated in which HEIs did not exist. In this alternative scenario without higher education graduates and R&D of HEIs, the impact of higher education is obtained by comparing it with the counterfactual scenario in terms of differences in human capital used and technological capital, as well as differences in GDP per capita and economic growth rates. To compute the contribution made by HEIs to economic growth in European countries, we used a growth accounting methodology that allows us to breakdown the economic growth of economies into the contributions corresponding to each of the factors of production, as well as to technical progress or total factor productivity.

The estimates obtained highlight the relevance of the contributions of HEIS. At present it would mean a 13% increase in the human capital used in the European countries and 23% in technological capital. The results of the growth accounting exercise indicate that HEIs would have boosted European growth, with a contribution of 0.63 percentage points to the average growth rate of the European Union-28 (0.57 percentage points for the quantity and quality of human capital, and 0.06 percentage points for their contribution to the increase of technological capital). In fact, estimates indicate that the contribution of higher education to the European Union's overall growth would have increased after the crisis, unlike that of other sources of growth.

The estimated impact of higher education provided by HEIs on the GPD per capita for the 28 European countries in 2015 is considerable, standing around 11% for the whole of the European Union-28. The contribution via human capital endowments would be somewhat higher than that produced via technological capital, but both are relevant. In sum, the results obtained indicate that the activities of HEIs are a significant source of growth in European economies, contributing to mitigating the adverse effects of the periods of crisis.

Notes

1. The study of Mian (1996) on university technology parks concludes that business incubators have a very positive impact on the creation and development of new technology-based companies. O'Shea et al. (2005) analyse the success of universities in generating technological spin-off companies based on a set of determinants.
2. We use the definition of R&D expenditure established in 2002 by the OECD's Frascati Manual (OECD, 2015), which states that all R&D expenditures are understood to be creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of that stock to devise new applications. This manual is the basic reference in the development of R&D statistics.
3. This implies assuming that each factor is remunerated in accordance with its productivity marginal. The share of production growth that is not explained by the contribution of each factor; i.e. the residue of Solow, also called growth of total factor productivity, is attributed to technical progress.
4. Tables A1 and A2 in Appendix offer the complete growth accounting results of each one of the 28 European countries analysed for the periods 2000-2007 and 2007-2015, respectively. The tables show that there are common features regarding the contribution of higher education in both periods. Both the effect through R&D capital, as well as the quality and quantity labour effects of higher education are positive with a few exceptions. Furthermore, the relative importance of the labour quality impact is constant, and is more significant than the R&D capital impact or the labour quantity impact in both periods.

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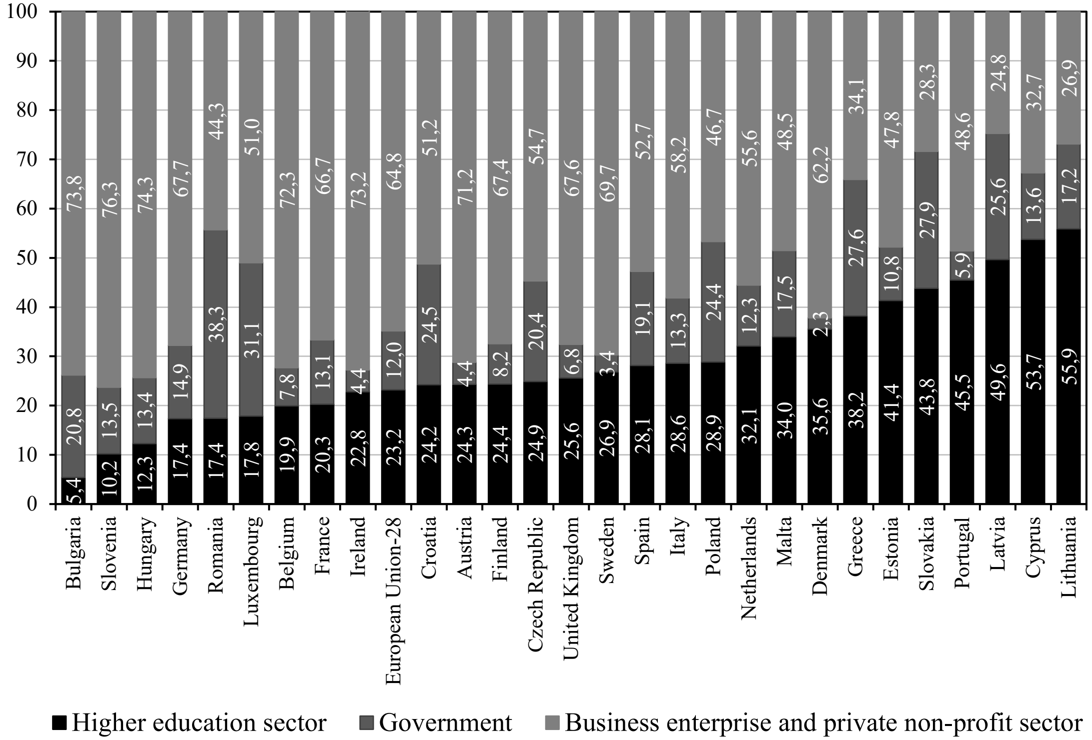

Figure 1. Total intramural R&D expenditure (GERD) by sectors of performance. International comparison. 2015 (Percentage)
Source: Eurostat and authors' elaboration.

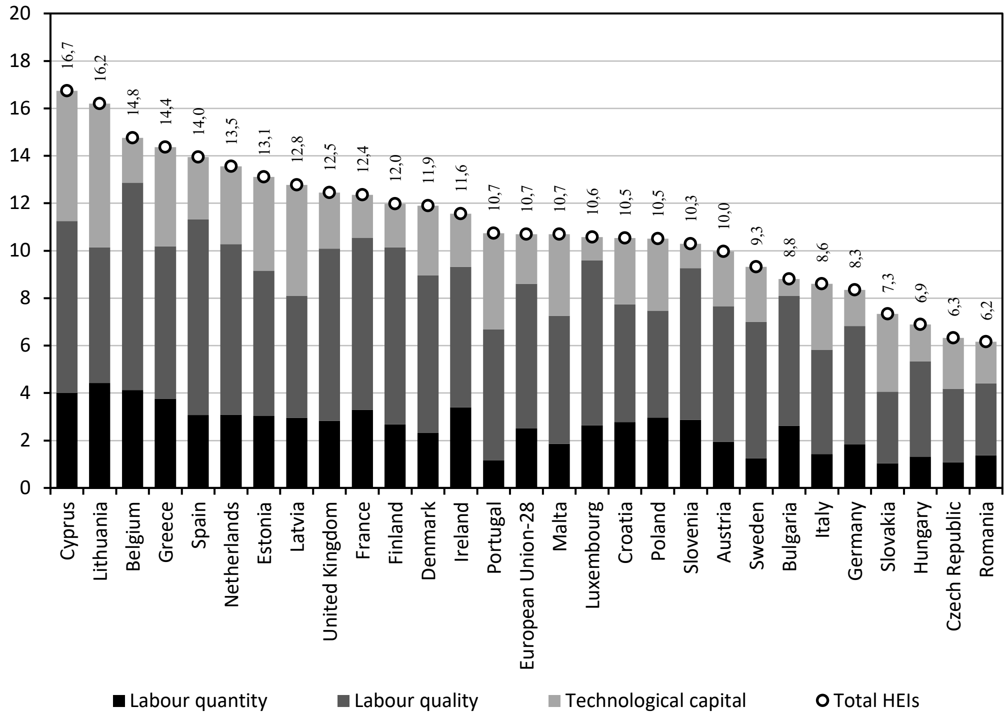

Figure 2. Higher education contribution to GDP per capita. 2015 (Real vs. counterfactual scenario without tertiary education)
Source: Eurostat and authors' elaboration.

Table 1. Higher education contribution to additional human capital. Relative increase of total years of schooling of employed population. International comparison. 2000 y 2015 (Percentage)

	2000			2015			Difference* 2015-2000			Average 2000-2015		
	Employment rate	Years of schooling per worker effect	Total	Employment rate	Years of schooling per worker effect	Total	Employment rate	Years of schooling per worker effect	Total	Employment rate	Years of schooling per worker effect	Total
European Union-28	**2.5**	**7.0**	**9.5**	**3.8**	**9.4**	**13.2**	**1.3**	**2.3**	**3.7**	**3.1**	**8.1**	**11.2**
Belgium	4.1	10.5	14.6	5.6	11.8	17.4	1.5	1.3	2.8	4.9	11.1	16.0
Bulgaria	3.1	6.9	10.0	4.1	8.5	12.6	0.9	1.6	2.6	3.5	7.5	11.0
Czech Republic	1.0	3.3	4.3	2.0	5.8	7.9	1.0	2.5	3.5	1.4	4.3	5.7
Denmark	2.3	7.2	9.5	3.5	9.9	13.4	1.1	2.7	3.9	3.0	9.0	12.0
Germany	2.7	7.2	9.8	2.8	7.5	10.3	0.1	0.4	0.5	2.7	7.3	10.0
Estonia	4.1	8.4	12.6	5.0	10.0	15.0	0.8	1.6	2.4	4.6	9.2	13.9
Ireland	3.5	8.4	11.9	7.3	12.8	20.1	3.8	4.4	8.3	5.6	11.0	16.6
Greece	3.0	7.5	10.5	6.2	10.6	16.8	3.2	3.1	6.3	4.3	9.0	13.3
Spain	3.3	11.0	14.3	5.0	13.3	18.3	1.7	2.3	4.0	4.0	12.1	16.2
France	3.2	8.1	11.3	4.8	10.6	15.4	1.6	2.5	4.1	3.9	9.3	13.2
Croatia	2.7	5.0	7.7	4.1	7.4	11.6	1.5	2.4	3.9	3.1	6.0	9.1
Italy	1.2	4.5	5.7	2.2	6.8	9.0	1.0	2.3	3.3	1.7	5.6	7.3
Cyprus	4.0	9.5	13.4	6.9	12.5	19.4	2.9	3.0	6.0	5.3	11.0	16.2
Latvia	3.2	5.8	9.1	5.2	9.1	14.3	2.0	3.3	5.3	4.1	7.3	11.4
Lithuania	10.0	12.3	22.3	8.4	10.9	19.3	-1.6	-1.4	-3.0	7.0	9.2	16.2
Luxembourg	2.3	7.0	9.3	4.7	12.4	17.1	2.4	5.4	7.8	3.5	9.6	13.1
Hungary	1.5	4.8	6.3	2.3	7.1	9.5	0.9	2.3	3.2	2.0	6.0	8.0
Malta	1.0	4.1	5.1	3.1	9.1	12.3	2.2	5.0	7.2	2.4	7.7	10.1
Netherlands	3.0	7.9	10.9	4.4	10.4	14.8	1.4	2.5	3.9	3.8	9.3	13.1
Austria	1.3	4.5	5.9	3.0	8.7	11.7	1.6	4.2	5.8	1.8	5.7	7.4
Poland	2.3	4.0	6.4	5.6	8.5	14.1	3.2	4.5	7.7	4.1	6.4	10.5
Portugal	0.7	5.0	5.7	1.9	9.3	11.3	1.3	4.3	5.6	1.2	7.0	8.2
Romania	1.3	3.2	4.6	2.8	6.2	9.0	1.5	3.0	4.5	2.1	4.6	6.7
Slovenia	2.0	5.1	7.1	4.0	8.8	12.8	2.0	3.7	5.7	2.8	6.7	9.4
Slovakia	1.0	3.2	4.2	2.0	5.8	7.8	1.0	2.6	3.6	1.5	4.5	5.9
Finland	3.0	9.6	12.6	3.9	10.9	14.8	0.9	1.3	2.2	3.3	10.0	13.3
Sweden	1.8	8.4	10.2	2.2	10.1	12.3	0.4	1.7	2.1	1.8	8.5	10.3
United Kingdom	2.9	9.1	12.1	4.5	11.4	15.9	1.5	2.3	3.8	3.6	9.9	13.5

* In percentage points.

Source: Eurostat and authors' elaboration.

Table 2. Technological capital. Higher education and other sectors. International comparison. 2000 and 2015 (Percentage)

	2000		2015		HE. Difference* in weight. 2015-2000	Growth rate. Technological capital
	Higher education (HE)	Other sectors (OS)	Higher education (HE)	Other sectors (OS)		
European Union-28	**20.0**	**80.0**	**23.1**	**76.9**	**3.0**	**44.6**
Belgium	20.4	79.6	21.1	78.9	0.7	59.7
Bulgaria	12.0	88.0	8.6	91.4	-3.4	227.4
Czech Republic	12.0	88.0	23.5	76.5	11.4	223.7
Denmark	16.2	83.8	30.7	69.3	14.6	84.0
Germany	15.6	84.4	17.3	82.7	1.7	56.1
Estonia	56.1	43.9	39.0	61.0	-17.1	745.3
Ireland	19.5	80.5	24.4	75.6	4.9	153.2
Greece	55.2	44.8	40.8	59.2	-14.4	100.7
Spain	30.2	69.8	28.1	71.9	-2.1	117.4
France	18.2	81.8	20.2	79.8	2.1	23.9
Croatia	45.4	54.6	29.5	70.5	-16.0	36.5
Italy	32.1	67.9	29.4	70.6	-2.7	40.1
Cyprus	19.7	80.3	49.6	50.4	30.0	237.0
Latvia	34.6	65.4	44.3	55.7	9.8	266.8
Lithuania	32.4	67.6	53.1	46.9	20.7	361.2
Luxembourg	0.1	99.9	11.6	88.4	11.5	53.0
Hungary	30.8	69.2	17.7	82.3	-13.1	192.7
Malta	56.6	43.4	34.9	65.1	-21.7	429.4
Netherlands	31.9	68.1	33.6	66.4	1.7	36.9
Austria	30.9	69.1	25.1	74.9	-5.8	118.7
Poland	32.4	67.6	31.5	68.5	-0.9	218.2
Portugal	35.1	64.9	39.7	60.3	4.6	152.2
Romania	10.4	89.6	19.6	80.4	9.2	170.7
Slovenia	19.9	80.1	12.1	87.9	-7.8	165.6
Slovakia	6.4	93.6	33.6	66.4	27.2	221.0
Finland	15.7	84.3	20.6	79.4	4.9	17.2
Sweden	18.4	81.6	25.2	74.8	6.8	23.7
United Kingdom	18.9	81.1	25.6	74.4	6.7	33.9

* In percentage points.

Source: Eurostat and authors' elaboration.

Table 3. Economic growth sources. Universities economic growth contribution. 2000-2015 (Percentage)

	GVA	Physical capital	Labour							R&D Capital			TFP
			Total	Universities			Counterfactual			Total	Univer-sities	Counter-factual	
				Total	Quantity	Quality	Total	Quantity	Quality				
EU-28 (2000-2015)	**1.27**	**0.40**	**1.00**	**0.29**	**0.16**	**0.13**	**0.71**	**0.36**	**0.35**	**0.20**	**0.06**	**0.14**	**-0.33**
EU-28 (2000-2007)	**2.27**	**0.53**	**1.49**	**0.29**	**0.18**	**0.10**	**1.20**	**0.87**	**0.34**	**0.20**	**0.06**	**0.14**	**0.05**
EU-28 (2007-2015)	**0.40**	**0.29**	**0.58**	**0.30**	**0.14**	**0.15**	**0.28**	**-0.08**	**0.36**	**0.19**	**0.06**	**0.14**	**-0.67**
Belgium	1.41	0.26	1.09	0.29	0.17	0.12	0.80	0.36	0.44	0.25	0.06	0.19	-0.19
Bulgaria	3.36	1.81	0.59	0.19	0.10	0.09	0.40	0.13	0.27	0.63	0.05	0.58	0.33
Czech Republic	2.61	0.76	0.53	0.20	0.11	0.10	0.33	0.20	0.13	0.63	0.17	0.46	0.69
Denmark	0.58	0.28	0.29	0.24	0.12	0.12	0.05	-0.04	0.09	0.33	0.15	0.17	-0.31
Germany	1.18	0.19	0.75	0.10	0.07	0.03	0.66	0.53	0.13	0.24	0.05	0.19	0.00
Estonia	3.31	2.09	0.41	0.16	0.09	0.07	0.25	0.18	0.07	1.14	0.43	0.71	-0.33
Ireland	2.86	1.33	1.30	0.47	0.25	0.22	0.84	0.35	0.48	0.50	0.14	0.35	-0.26
Greece	-0.09	0.33	0.24	0.27	0.11	0.16	-0.03	-0.55	0.52	0.37	0.10	0.27	-1.04
Spain	1.48	0.81	1.54	0.41	0.23	0.18	1.13	0.52	0.61	0.41	0.11	0.30	-1.28
France	1.16	0.45	1.21	0.35	0.20	0.16	0.86	0.44	0.42	0.11	0.03	0.08	-0.61
Croatia	1.45	0.84	0.84	0.28	0.15	0.13	0.56	0.25	0.31	0.17	-0.02	0.19	-0.39
Italy	0.01	0.31	0.97	0.24	0.13	0.11	0.72	0.28	0.44	0.18	0.04	0.14	-1.45
Cyprus	1.38	0.99	1.65	0.42	0.25	0.17	1.23	0.78	0.45	0.65	0.37	0.28	-1.91
Latvia	3.76	1.02	0.08	0.23	0.11	0.13	-0.15	-0.28	0.13	0.69	0.32	0.37	1.97
Lithuania	4.01	1.68	-0.18	-0.07	-0.05	-0.02	-0.11	-0.22	0.11	0.82	0.48	0.34	1.69
Luxembourg	2.64	1.25	2.02	0.59	0.35	0.24	1.44	1.07	0.36	0.23	0.07	0.16	-0.86
Hungary	1.95	0.85	0.70	0.22	0.12	0.10	0.48	0.32	0.17	0.57	0.08	0.50	-0.18
Malta	2.94	0.82	2.53	0.57	0.32	0.25	1.95	0.91	1.04	0.89	0.26	0.63	-1.30
Netherlands	1.18	0.35	0.70	0.29	0.15	0.14	0.41	0.13	0.28	0.17	0.07	0.10	-0.04
Austria	1.39	0.42	1.10	0.41	0.22	0.19	0.69	0.44	0.25	0.42	0.08	0.33	-0.54
Poland	3.53	1.39	0.94	0.39	0.21	0.18	0.55	0.31	0.24	0.62	0.20	0.42	0.59
Portugal	0.33	0.31	1.27	0.48	0.23	0.25	0.79	-0.37	1.16	0.49	0.20	0.30	-1.74
Romania	3.59	1.45	-0.20	0.22	0.09	0.12	-0.42	-0.74	0.32	0.53	0.13	0.40	1.82
Slovenia	2.10	0.45	0.82	0.40	0.20	0.20	0.42	0.10	0.33	0.52	0.04	0.48	0.31
Slovakia	3.98	0.91	0.70	0.19	0.11	0.09	0.51	0.43	0.08	0.62	0.27	0.35	1.75
Finland	0.97	0.40	0.54	0.20	0.10	0.10	0.34	0.01	0.33	0.08	0.04	0.04	-0.06
Sweden	2.05	0.66	0.85	0.20	0.12	0.08	0.64	0.47	0.18	0.11	0.06	0.05	0.43
United Kingdom	1.71	0.36	1.53	0.37	0.22	0.15	1.17	0.74	0.42	0.16	0.07	0.08	-0.34

Source: Eurostat and authors' elaboration.

Table 4. Higher education contribution to GDP per capita 2015. Real vs. counterfactual scenario without tertiary education. (Percentage)

	Labour quantity	Labour quality	Technological capital	Total Universities
European Union-28	**2.50**	**6.09**	**2.10**	**10.70**
Belgium	4.13	8.74	1.90	14.76
Bulgaria	2.61	5.48	0.72	8.81
Czech Republic	1.07	3.11	2.14	6.32
Denmark	2.31	6.64	2.94	11.89
Germany	1.84	4.99	1.52	8.35
Estonia	3.03	6.12	3.96	13.11
Ireland	3.40	5.93	2.24	11.56
Greece	3.76	6.42	4.19	14.37
Spain	3.07	8.24	2.64	13.95
France	3.29	7.26	1.81	12.36
Croatia	2.77	4.97	2.79	10.54
Italy	1.43	4.40	2.78	8.61
Cyprus	4.01	7.24	5.49	16.74
Latvia	2.95	5.15	4.68	12.78
Lithuania	4.42	5.72	6.06	16.20
Luxembourg	2.64	6.95	0.98	10.57
Hungary	1.32	4.02	1.55	6.89
Malta	1.86	5.40	3.43	10.69
Netherlands	3.08	7.20	3.27	13.55
Austria	1.94	5.71	2.31	9.96
Poland	2.96	4.51	3.03	10.50
Portugal	1.16	5.53	4.04	10.74
Romania	1.37	3.04	1.74	6.16
Slovenia	2.88	6.38	1.03	10.29
Slovakia	1.04	3.02	3.28	7.33
Finland	2.68	7.46	1.84	11.98
Sweden	1.25	5.74	2.32	9.31
United Kingdom	2.83	7.26	2.37	12.45

Source: Eurostat and authors' elaboration.

Appendix

Table A1. Economic growth sources. HEIs economic growth contribution. 2000-2007 (Percentage).

	GVA	Tangible capital	Labour							Technological Capital			TFP
			Total	HEIs			Counterfactual			Total	HEIs	Counter-factual	
				Total	Quantity	Quality	Total	Quantity	Quality				
European Union-28	**2.27**	**0.53**	**1.49**	**0.29**	**0.18**	**0.10**	**1.20**	**0.87**	**0.34**	**0.20**	**0.06**	**0.14**	**0.05**
Belgium	2.12	0.32	1.36	0.30	0.18	0.12	1.05	0.51	0.55	0.21	0.05	0.16	0.24
Bulgaria	5.89	1.96	1.38	0.17	0.11	0.05	1.21	0.86	0.35	0.58	0.05	0.53	1.98
Czech Republic	4.52	0.94	0.61	0.11	0.06	0.05	0.50	0.36	0.14	0.65	0.14	0.51	2.32
Denmark	1.32	0.45	0.06	0.22	0.11	0.10	-0.16	0.11	-0.26	0.34	0.14	0.20	0.46
Germany	1.62	0.22	0.89	0.04	0.04	-0.01	0.85	0.75	0.10	0.24	0.04	0.19	0.28
Estonia	7.07	3.12	0.91	0.15	0.11	0.04	0.76	0.73	0.03	1.39	0.56	0.83	1.65
Ireland	4.87	2.14	2.63	0.58	0.37	0.22	2.05	1.59	0.46	0.51	0.17	0.34	-0.41
Greece	3.73	0.84	1.67	0.35	0.21	0.14	1.32	0.83	0.49	0.46	0.17	0.29	0.77
Spain	3.47	1.28	3.63	0.56	0.40	0.16	3.07	2.36	0.72	0.52	0.14	0.38	-1.96
France	1.84	0.55	1.46	0.31	0.19	0.12	1.15	0.83	0.32	0.12	0.03	0.09	-0.30
Croatia	4.51	1.10	1.85	0.21	0.14	0.07	1.64	1.38	0.26	0.22	0.01	0.21	1.34
Italy	1.14	0.58	1.54	0.26	0.15	0.11	1.29	0.83	0.45	0.22	0.06	0.15	-1.20
Cyprus	3.90	1.32	3.18	0.55	0.37	0.17	2.63	2.08	0.56	0.87	0.42	0.45	-1.47
Latvia	8.47	2.33	0.78	0.15	0.10	0.06	0.63	0.68	-0.05	0.88	0.38	0.50	4.48
Lithuania	7.76	2.17	-0.20	-0.51	-0.25	-0.26	0.31	0.31	0.00	1.02	0.60	0.42	4.77
Luxembourg	3.94	1.38	1.68	0.46	0.27	0.19	1.22	1.00	0.22	0.30	0.02	0.28	0.58
Hungary	3.61	1.22	0.66	0.21	0.11	0.10	0.45	0.17	0.28	0.69	0.14	0.55	1.04
Malta	1.54	0.93	2.62	0.74	0.39	0.35	1.88	0.65	1.22	1.10	0.31	0.79	-3.12
Netherlands	1.99	0.46	1.28	0.38	0.21	0.17	0.90	0.54	0.36	0.16	0.07	0.09	0.09
Austria	2.33	0.50	0.77	0.14	0.09	0.06	0.63	0.50	0.12	0.48	0.09	0.40	0.58
Poland	4.04	0.94	1.05	0.42	0.22	0.19	0.63	0.33	0.30	0.44	0.14	0.30	1.62
Portugal	1.23	0.66	1.31	0.40	0.20	0.20	0.91	0.09	0.82	0.48	0.16	0.32	-1.21
Romania	6.02	1.12	-0.17	0.22	0.10	0.13	-0.39	-0.99	0.60	0.71	0.15	0.56	4.35
Slovenia	4.46	0.81	1.58	0.39	0.22	0.17	1.20	0.86	0.34	0.48	0.04	0.44	1.58
Slovakia	6.16	1.38	1.11	0.17	0.10	0.07	0.94	0.81	0.12	0.43	0.16	0.27	3.25
Finland	3.00	0.55	0.86	0.16	0.10	0.06	0.70	0.38	0.32	0.11	0.05	0.06	1.48
Sweden	2.98	0.69	0.86	0.07	0.06	0.01	0.79	0.69	0.10	0.14	0.05	0.08	1.29
United Kingdom	2.66	0.40	2.10	0.30	0.21	0.09	1.80	1.30	0.50	0.18	0.09	0.09	-0.02

Source: Eurostat and authors' elaboration

Table A2. Economic growth sources. HEIs economic growth contribution. 2007-2015 (Percentage).

	GVA	Tangible capital	Labour							Technological Capital			TFP
			Total	HEIs			Counterfactual			Total	HEIs	Counter-factual	
				Total	Quantity	Quality	Total	Quantity	Quality				
European Union-28	**0.40**	**0.29**	**0.58**	**0.30**	**0.14**	**0.15**	**0.28**	**-0.08**	**0.36**	**0.19**	**0.06**	**0.14**	**-0.67**
Belgium	0.78	0.21	0.86	0.27	0.15	0.12	0.59	0.23	0.35	0.29	0.06	0.22	-0.57
Bulgaria	1.14	1.67	-0.11	0.21	0.09	0.12	-0.32	-0.51	0.19	0.68	0.05	0.63	-1.11
Czech Republic	0.94	0.60	0.47	0.29	0.15	0.14	0.18	0.06	0.12	0.61	0.19	0.41	-0.74
Denmark	-0.06	0.12	0.49	0.26	0.12	0.14	0.22	-0.17	0.39	0.32	0.16	0.15	-0.98
Germany	0.79	0.16	0.64	0.15	0.09	0.06	0.49	0.33	0.16	0.24	0.05	0.19	-0.25
Estonia	0.03	1.19	-0.02	0.16	0.07	0.09	-0.19	-0.30	0.11	0.92	0.32	0.60	-2.06
Ireland	1.11	0.62	0.14	0.36	0.15	0.22	-0.23	-0.73	0.50	0.49	0.12	0.37	-0.13
Greece	-3.44	-0.11	-1.01	0.20	0.03	0.17	-1.22	-1.76	0.55	0.30	0.05	0.25	-2.62
Spain	-0.27	0.39	-0.29	0.27	0.08	0.19	-0.56	-1.09	0.53	0.32	0.08	0.24	-0.69
France	0.56	0.36	0.98	0.39	0.20	0.19	0.60	0.09	0.51	0.11	0.04	0.07	-0.88
Croatia	-1.22	0.61	-0.03	0.35	0.15	0.19	-0.38	-0.74	0.36	0.12	-0.05	0.17	-1.91
Italy	-0.98	0.08	0.46	0.23	0.11	0.12	0.23	-0.20	0.44	0.15	0.02	0.13	-1.67
Cyprus	-0.83	0.70	0.31	0.31	0.13	0.17	0.00	-0.35	0.35	0.46	0.33	0.13	-2.29
Latvia	-0.35	-0.12	-0.53	0.30	0.11	0.19	-0.83	-1.12	0.29	0.53	0.27	0.25	-0.23
Lithuania	0.74	1.25	-0.16	0.31	0.13	0.18	-0.47	-0.68	0.21	0.64	0.38	0.26	-0.99
Luxembourg	1.50	1.14	2.32	0.69	0.42	0.28	1.63	1.14	0.49	0.17	0.11	0.06	-2.13
Hungary	0.49	0.53	0.74	0.23	0.13	0.09	0.52	0.45	0.07	0.47	0.02	0.45	-1.25
Malta	4.16	0.72	2.45	0.43	0.26	0.17	2.02	1.14	0.89	0.70	0.22	0.48	0.29
Netherlands	0.48	0.26	0.20	0.21	0.09	0.11	-0.01	-0.23	0.22	0.17	0.06	0.11	-0.16
Austria	0.58	0.35	1.39	0.65	0.33	0.31	0.74	0.38	0.36	0.36	0.08	0.28	-1.51
Poland	3.09	1.79	0.85	0.36	0.19	0.17	0.48	0.30	0.18	0.77	0.25	0.52	-0.31
Portugal	-0.46	0.00	1.24	0.55	0.25	0.30	0.69	-0.77	1.45	0.51	0.24	0.27	-2.21
Romania	1.47	1.73	-0.23	0.21	0.09	0.12	-0.44	-0.51	0.07	0.38	0.11	0.27	-0.40
Slovenia	0.04	0.13	0.16	0.41	0.19	0.23	-0.26	-0.57	0.32	0.56	0.04	0.52	-0.81
Slovakia	2.07	0.50	0.35	0.21	0.11	0.10	0.13	0.09	0.04	0.79	0.37	0.42	0.43
Finland	-0.81	0.26	0.27	0.24	0.10	0.13	0.03	-0.30	0.33	0.06	0.04	0.03	-1.40
Sweden	1.24	0.64	0.84	0.32	0.18	0.15	0.52	0.27	0.25	0.09	0.07	0.03	-0.33
United Kingdom	0.88	0.33	1.04	0.43	0.23	0.20	0.61	0.25	0.36	0.13	0.06	0.08	-0.61

Source: Eurostat and authors' elaboration