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Document de treball de l'IEB 2011/6

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UNIVERSITIES AND REGIONAL ECONOMIC GROWTH IN SPANISH REGIONS*

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ABSTRACT: This paper examines the main contributions of universities to the economic growth of Spanish regions. It calculates the separate effects of the different university functions on the regional economy, namely the creation of human capital, research and technology transfer. It includes a panel data set with the key variables of university activities and their effects on the economy at provincial level. The econometric estimations are based on information for all 47 public universities and include 34 Spanish provinces. The empirical results suggest that the growth of regional GVA is positively correlated to both the human capital created by universities and the stock of university patents.

JEL Codes: R15, I23, O18

Keywords: regional economic development, universities, higher education, human capital, research, technology development

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* Comments are welcome. The opinions expressed in this paper do not necessarily reflect the IEB's opinions. We would like to thank Pere Arqué and Jordi Jofre for their helpful comments. Javier García-Estévez acknowledges support from the Alßan scholarship programme.

1. Introduction

Nowadays higher education plays a crucial role in a country's economic welfare and development. Indeed, higher education is perceived as being an important precondition enabling countries to compete in a globalized economy and enhance leadership in knowledge sectors. The challenges posed by globalization have led to a rapid increase in the demand for higher education and, at the same time, many countries are earmarking more and more resources to improve their population's skill levels and knowledge. In OECD countries, around 1.4% of GDP is invested every year in higher education (OECD, 2009).

The Lisbon objectives aim to make the European Union the most dynamic and competitive knowledge-based economy in the world, through education and R&D. This has had two main effects. On the one hand, the university has acquired a strategic role given that it is the natural creator of knowledge and human capital, while on the other, the regional dimension of analysis and policy for enhanced economic development has taken on a new relevance. It would therefore be interesting to analyse the relationship between university presence and regional economic development. Indeed, the university has a substantial impact on the region surrounding it in several areas: demography, politics, economy, infrastructure, generation and attraction of talent, culture and social effects (Lazzaretti, 2005).

In recent decades many countries have increased the incentives for (and pressure on) universities to become more involved in their regions. In response, the universities have developed what is known as the “Third Mission” whereby they collaborate with their milieu in a more direct way. A symbiotic relationship has emerged. Firstly, the region achieves better outcomes in terms of social and economic development, and secondly, universities, through their regional activities, can access funding which would otherwise be unavailable (e.g. from European and national budgets), enabling them to contribute to the region’s economic regeneration and competitiveness (Hudson, 2006).

The relationship between higher education and economic growth has been the subject of numerous theoretical and empirical studies over the years. According to Boucher

(2003), the existing literature emphasizes that the role of universities in regional economic development is basically to promote a learning environment, to develop skills and build resources for competitiveness and social cohesion. Goldstein and Renault (2004) identify and describe the range of outputs from modern research universities: knowledge creation, human capital creation, transfer of existing know-how, technological innovation, and provision of leadership and regional milieu.

The aim of this paper is to contribute to the empirical literature that analyses the university's contribution to regional growth. More precisely, our interest is to identify the university functions that have the most decisive effects in regional growth terms. To this end we estimate separately the effects of different university functions on the regional economy, namely the creation of human capital, R&D and technology transfer. In order to perform our analysis we have built a panel data set with the key variables of university activities and their effects on regional economies. The unit of analysis is the Spanish province. The paper is organized as follows: Section 2 presents a review of the literature, Section 3 is devoted to a description of the data, variables and econometric specifications, while Section 4 reports and discusses the results. Section 5 concludes.

2. Literature review

Recent economic growth theory has underlined the endogenous character of growth sources. Accordingly, geographic disparities in economic growth can be explained by differences in technological level, institutional features and public and human capital endowments, by the mechanisms of creation and diffusion of knowledge, and consequently by the quality of the universities and their different activities.

One of the usual approaches in endogenous growth models is to argue that human capital plays an important role. Papers by Lucas (1988), Romer (1990) and Barro (1991), for instance, underline the accumulation of human capital as the main source of productivity growth. Another approach emphasizes that a larger stock of human capital makes it easier for a country to absorb new products or ideas that have been discovered elsewhere (Nelson and Phelps, 1966). In order to obtain an empirical specification of economic growth and human capital several proxies have been adopted, e.g. spending on education (investment), number of students at undergraduate level or higher, stock of graduates, number of students enrolled in the designated grade levels relative to the total population of the corresponding age group.

The literature of endogenous growth is associated directly with higher education institutions (HEIs) because these are perhaps the main creators of both human capital and knowledge. In order to estimate these links, economists have built empirically testable knowledge production functions. Griliches-Jaffe's proposal describes a Cobb-Douglas knowledge production function, with patents as the measure of innovation constituting the dependent variable and industry and university R&D expenditures as two independent variables (Goldstein and Drucker, 2006).

Recent literature about the relationship between HEIs and regional economic development has focused on four topics. The first group of studies analyses the role of the HEI as an attractor, educator and retainer of students, shaping them into knowledge-based graduates for firms in the region (Boucher, 2003; Bramwell and Wolfe, 2008). This affects the local labour market and contributes to the stock of tacit knowledge to provide formal and informal technical support.

The second set of papers has studied the linkage between HEIs and firm formation. Woodward et al. (2006) point out a potential relationship between local university R&D expenditures (mainly science and engineering) and the total number of newly-created high-technology plants by US county. Kirchhoff et al. (2007) find that university R&D expenditure is positively related to firm formations, and consequently it stimulates employment growth.

There is a third important approach which has devoted considerable effort to understanding the generation of spillovers by university activity. Goldstein and Drucker (2006) assess the regional importance and geographic extent of spatial spillovers arising from university activities. They find that the university activities of research, teaching and technology development help to raise regional average earnings and that knowledge and other spillovers across regional boundaries are influential as well. However, the greatest impacts occur in small and medium-sized regions. Kantor and Whalley (2009) demonstrate that university spillovers occur through geographically localized mechanisms and are significantly larger for firms that are technologically closer to research universities.

Finally, there is a line of research which addresses the analysis of the effects of R&D activities on the rise of productivity and economic growth. Sterlacchini (2008) confirms the existence of a positive and significant relationship between the economic growth of European regions and their knowledge base and human capital endowments, captured by R&D expenditures and the share of adults with tertiary education respectively. However, the impact of R&D is significant only for those regions that are above a given threshold of per capita GDP. Andersson et al. (2009) investigate the economic effects of the Swedish decentralization policy of post-secondary education on the level of productivity and innovation and their spatial distribution in the national economy. Their model estimates the effects of university-based researchers on the productivity and innovation activity (award of patents) of local areas. They find a link between the number of university researchers in a community and output per worker in that community.

3. Empirical methodology and data

As noted in the previous section, the greatest impact of university presence is the production of knowledge, the so-called “knowledge impacts”. Some studies classify this production according to three types of output: human capital, research-based knowledge, and knowledge-related external services (Lazzeretti (2005), Goldstein and Drucker, (2006), and Sterlacchini (2008)).

The standard equation for measuring the effects of universities on regional growth in a cross-section analysis is given by Goldstein and Drucker (2006) and Sterlacchini (2008).

$$\Delta LnY_{t0-t1} = \alpha_0 + \alpha_1 \, Ln\,Y_{t0} + \beta_1 \, R\&D_{t0} + \beta_2 \, LnPAT_{t0} + \beta_3 \, HE_{t0} + \lambda_2 \, Z + \varepsilon$$

ΔLnY_{t0-t1} = Log difference between the initial and final year of real per capita GDP.

LnY_{t0} = Initial level of per capita GDP logarithm.

$R\&D_{t0}$ = Share of total (private & public) R&D expenditures in gross value added.

$LnPAT_{t0}$ = Number (in log) of total patent applications to the EPO (European Patent Office) per one hundred thousand inhabitants.

HE_{t0} = Share of adults with tertiary education

Z = Matrix of control variables, e.g. population density, share of total employment in industry or services.

Empirical implementation of the model described above requires data on knowledge production for each university in each region. The database built to carry out the estimations holds information for the whole Spanish public university system.

Public universities in Spain account for 91.7% of total university expenditure on R&D and employ 92.1% of all university researchers measured in full-time equivalent (INE, 2007). The units of analysis are those Spanish provinces with a university presence. There are 52 Spanish provinces and 35 of them have as least one university. We have information covering the period 1998-2006. Appendix A describes the variables and sources.

The dependent variable is the per capita gross value added at constant prices of 2001[4]. The data for this variable was taken from the Spanish regional accounts. As discussed above, universities can produce regional impacts via their three main tasks: education, research and technology transfer. Accordingly, in order to approximate the main university functions, the next explanatory variables are included in the regressions.

The creation of human capital is measured by the share of adults with tertiary education for each year. It is more difficult to approximate the measure of university research and technology transfer because their outputs are extremely diverse and generate spillovers whose effects are difficult to capture. Boucher (2003) argues that academics are trained and partly paid to create "knowledge innovations" that can be informally and formally "learned" by others through interactions, networking, teaching, presentations and

[4] Additionally, some empirical papers have used employment growth as a measure of economic growth on a sub-national level since it is a highly accurate measure and a primary focus of economic development efforts at regional level. See Kirchhoff (2007).

publications. Also, Bramwell and Wolfe (2008) point out that university provides both formal and informal support, as well as specialized expertise and facilities for ongoing, company-based R&D activities.

Nevertheless, there exist standard measures for estimating research and technology transfer activities. We have adopted three proxies, namely the share of R&D expenditures in the regional gross value added (GVA), the number of patents applications per university researcher measured in full-time equivalent, and finally the number of students attending internships organized by the university. Alternatively, we also use university R&D income as another measure of technology transfer. These incomes are the result of R&D activity and technical support regulated through a contract between university and technology buyer.

It is also necessary to include a measure of patents as a stock variable. Therefore, in order to obtain a stock variable by accumulating past patented ideas, the perpetual inventory method is adopted. Using the same method as Bottazzi and Peri (2003), we assume that the stock of knowledge is continually increased by the addition of new patents but is also continually decreased by constant depreciation (obsolescence) rate δ. Thus we can capture the fact that new ideas may displace or improve on old ideas and make them obsolete.

$$A_{it_0} = \sum_{i=0}^{-\infty} \frac{Pat_{it_0}}{(1+\bar{g}_i)^i}(1-\delta)^i = \frac{Pat_{i,t_0}}{(\bar{g}_i + \delta)}$$

where $\bar{g}_i$ is the growth rate of patenting in province i in the period registered by the Spanish Patents Office (OEPM) and δ is equal to 0.1[5]. This initial stock is at best a rough estimate of initial knowledge in province i. To compute $A_{i,t}$ for the following years we use the formula:

$$A_{i,t} = Pat_{i,t} + (1-\delta)A_{i,t-1}$$

[5] We do estimations for the case of δ=0.2 and find no significant variation in the results.

Finally, we complement our panel with two control variables. The first is the share of total employment in services in order to obtain the structural features of the regional economies. The population density is also included. This variable is a good proxy for agglomeration economies that can be exploited by the most urbanized regions.

The econometric analysis is approached in two ways. On the one hand, we estimate the effect of university functions on the level of per capita GVA, while on the other we analyse the effect of university functions on GVA growth rate. For this analysis we use the initial condition value of each explanatory variable.

$$LnY_{it} = \alpha_i + \tau_t + \beta\, HK_{it} + \psi\, R\&D_{it} + \gamma\, LnPat_{it} + \lambda_1\, Popden_{it} + \lambda_2 Emp\_serv_{it} + \varepsilon_{it} \qquad (1)$$

$$\Delta LnY = \alpha_0 + \alpha_1 LnY_{98} + \beta HK_{98} + \psi R\&D_{98} + \gamma\, LnPat_{98} + \lambda_1\, Popden_{98} + \lambda_2 Emp\_serv_{98} + \varepsilon \qquad (2)$$

where subscript i = 1,...34 denotes province and subscript t = 1998, 2000, ..,2006 denotes time. The variable Y is the per capita gross value added. The human capital created by the university is measured by the share of adults with tertiary education (HK in Equations 1 and 2). The variable R&D is the share of research and development expenditures in GVA. The variable Pat is the number of patents applications per university researcher measured in full-time equivalent. Our specification also includes province (α_i) and year (τ_t) fixed effects. Finally, the control variables are Popden (population density) and Emp_serv (the share of employment in services).

4. Empirical results

The main hypothesis we are testing is that university activities affect regional economic growth. Although there exists some consensus over the importance of universities, this paper adds more specific details by using better variables to measure the different university tasks. We follow a very parsimonious strategy (see Table 1), first introducing only one variable of interest (column 1) and then adding the others (in columns 2 and 5). Thus, in column 1 we only include the university objective of human capital creation, measured by the share of adults with tertiary education for each year. In column 2 we add the stock of university patents, and then the R&D expenditures are included in column 3. Finally, in order to estimate the effect of university technology transfer, we alternate with two measures, namely income stemming from R&D deals and the number of students attending internships organized by the university (see columns 4 and 5).

Interestingly, human capital and the stock of patents are always positive and significant. In contrast, university R&D expenditures, university R&D incomes and internships are never found to have a significant effect (see columns 3 to 5).

The positive coefficient of employment share of services activities is statistically significant (see columns 3, 4 and 5). This is in line with Goldstein and Drucker's (2006) findings, suggesting that provinces with a strong presence of tertiary activity have been able to grow fast. In contrast, population density is negatively associated with the level of per capita GVA. This estimate presumably reflects the fact that in recent years those regions with rapid growth have been based on the dynamism of the construction industry, which has a lower value added content.

Table 2 shows the results of the standard growth regressions. The negative coefficient of initial per capita GVA suggests that regions are converging, i.e. poorer regions are catching up. The coefficient of human capital is significantly positive and economically meaningful. For instance, in column (1) we can see that increasing the share of population with a tertiary degree by one standard deviation increases regional growth by about 0.5 percentage points. The specification in column (3) includes all university variables. The effects of university research and patenting activity on regional GVA growth are not significant.

VARIABLES	(1) reg1	(2) reg2	(3) reg3	(4) reg4	(5) reg5
lnHK	0.325***	0.222***	0.101***	0.095***	0.102***
	(0.03)	(0.05)	(0.03)	(0.03)	(0.03)
lnStock_Pat/PDI		0.069***	0.096***	0.095***	0.092***
		(0.02)	(0.02)	(0.02)	(0.02)
lnR&D_expend /GAV			-0.004	-0.013	-0.005
			(0.01)	(0.01)	(0.01)
lnInternship				0.014	
				(0.02)	
lnR&D_incomes /GAV					0.008
					(0.02)
lnPop_den	0.031	0.152	0.025	0.037	0.008
	(0.03)	(0.13)	(0.10)	(0.11)	(0.11)
Share of Empl serv	0.171	0.279	0.570***	0.459**	0.564***
	(0.20)	(0.23)	(0.18)	(0.20)	(0.18)
Constant	3.437***	2.753***	2.890***	2.720***	2.952***
	(0.21)	(0.65)	(0.52)	(0.58)	(0.55)
Observations	170	158	77	69	77
R-squared	0.76	0.77	0.76	0.79	0.77
Number of code	34	32	30	28	30
Adj. R-squared	0.75	0.76	0.75	0.77	0.75

Table 1. The effect of university activity on regional growth

Dependent variable: log of per capita gross value added. Panel data fixed effects

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10
Time dummies are included

Table 2. Growth equation
Dependent variable: growth rate of per capita gross value added.

Dependent variable: growth rate of per capita gross value added over the period 2002-2006. Variables	(1)	(2)	(3)
$LnPCGVA_{2002}$	-0.082***	-0.081***	-0.077***
	(0.02)	(0.02)	(0.03)
$LnHK_{2002}$	0.400*	0.396*	0.125
	(0.23)	(0.23)	(0.40)
$LnStock\_Pat_{2002}$		0.000	-0.000
		(0.00)	(0.00)
$LnR\&D_{2002}$			-0.001
			(0.01)
Pop_den_{2002}	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)
Emp_serv_{2002}	-0.020	-0.016	0.055
	(0.04)	(0.04)	(0.07)
Time Dummies	YES	YES	YES
Constant	0.260***	0.257***	0.233*
	(0.05)	(0.05)	(0.12)
Observations	68	68	50
R-squared	0.27	0.27	0.26
Adj. R-squared	0.21	0.20	0.14

Explanatory variables correspond to 2002.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

5. Concluding comments

This paper has explored the relationship between the presence of universities and recent economic growth across Spanish provinces. Previous econometric studies have analysed the effects of the presence of universities on regional economic growth across regions of different countries. However, more robust results are obtained when regions with a more homogeneous economic structure and institutional factors are compared.

Even though the period of analysis is short and the inference therefore more intuitive, most of the statistically significant coefficients indicate impacts that follow the directions suggested by theory and previous empirical studies. Thus human capital generated by universities is strongly associated with rises in regional value added. Goldstein and Drucker (2006), for example, found that the traditional outputs of knowledge and human capital are the primary means by which higher education institutions affect economic development outcomes. Hence our empirical results reinforce the idea that human capital is of fundamental importance for regional development, improving the region's competitiveness in the global economy.

The link between university research expenditures and economic growth is difficult to detect in the shorter term; therefore, the absence of statistical evidence here should be interpreted with caution. Additional data to build a larger time series is required, and we will study these problems further in our future work.

It has not been possible to detect the effects of university technology transfer on regional growth. This is firstly because technology transfer affects regional growth indirectly, and secondly, because the effect of these variables can be observed over a longer period of time than we can capture with the data available.

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Appendix A. Variables, definitions and data sources.

Variables	Description	Source
Dependent Variable		
PCGVA	Log of per capita gross value added.	INE
Explanatory variables		
University functions		
Human Capital		
HK	Share of adults with tertiary education	IVIE
Research and Technology transfer		
LnR&D exp/GVA	The share of university R&D expenditures in gross value added.	CRUE & INE
PATpdi	Stock of patent applications per university researcher measured in full-time equivalent.	OEPM
Internship	Number of students attending internships organized by the university	CRUE
LnR&D inc/GVA	The share of university income stemming from R&D deals in gross value added.	CRUE
Control Variables		
Pop_Den	Population density	INE
Share Empl_Serv	Share of total employment in services	INE

Note: INE = National Statistics Institute of Spain; CRUE = Spanish University Rectors Conference. OEPM = Spanish Office of Patents and Trade Marks, EPO = the European Patent Office. IVIE: Valencian Economic Research Institute

Table A1. Variable descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
LnPcGVA	170	2.644981	.2244597	2.103128	3.089248
LnHK	170	-3.211675	.3417683	-4.011181	-2.186578
lnPat_Stock / PDI	158	-4.316742	.6651798	-6.007612	-2.436793
LnR&D exp/GVA	83	-7.007135	.7183377	-8.561323	-5.447867
LnInternship	143	7.123257	1.062074	4.836282	9.41703
lnPop_density	170	4.572756	.9018173	3.179095	6.617942
Share Serv_empl	170	.6187619	.0666893	.4744785	.7787707
$\Delta LnPCGVA_{2002-2006}$	68	.0460841	.0293142	-.0593395	.0964899
$LnPCGVA_{2002}$	102	2.653671	.2146763	2.282146	3.0201
Hk_{2002}	102	.0422569	.0140829	.0262088	.0992716
$LnR\&D_{2002}$	75	16.11967	1.225765	13.77714	19.14485
$LnPat_{2002}$	75	1.737478	1.111832	0	4.204693
Emp_serv_{2002}	102	.6072442	.0687534	.4744785	.7490108
Pop_den_{2002}	102	148.7635	162.142	24.68148	688.4843

2009

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