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Cities and Innovation

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ABSTRACT: Human capital is one of the most important channels via which universities positively affect regional development. This paper analyzes the relationship between university characteristics and graduation rates, and the role of regional characteristics in this process. We assemble a dataset for the entire public university system in Spain over the last decade. Observing the same university over several years helps us address the problem of unobserved heterogeneity. The main findings that can be drawn from our results are that university features, such as expenditure, student-teacher ratio and financial-aid to students are important in accounting for graduation rates. Likewise, regional characteristics such as labour market conditions appear to matter when generating graduate students.

JEL Codes: C31, I23, O18, R11

Keywords: Universities, graduation, human capital, regional economy

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1. Introduction

Since the pioneering studies of Schultz (1961) and Becker (1964), human capital (hereinafter, HC) has become a significant factor in the economics literature, and it is afforded a key role in neo-classical endogenous growth models. The influential studies of Lucas (1988), Romer (1990), and Barro (1991) identify the accumulation of HC as the main source of productivity growth, while a related research line reports that a large stock of HC makes it easier for a country to absorb new products and ideas discovered elsewhere (Nelson & Phelps 1966). These perspectives assume education to be a direct input into production, and consider growth rates to be related to increasing endowments of various inputs. Thus, changes in the HC stock are a decisive explanatory factor of growth (Hanushek & Kimko 2000; Mankiw et al. 1992). Here, as Becker (1964) suggested, education is an investment of time and foregone earnings in exchange for higher rates of return at a later date. Two main mechanisms account for the accumulation of HC, namely, schooling (Lucas 1988) and learning-by-doing (Arrow 1962).

Seen from another perspective, the skill-biased technological change hypothesis affirms that there is considerable complementarity between new technologies and skilled labour. Hence, the recent increase in demand for highly skilled workers in developed countries is mainly driven by technological change (Acemoglu 1998; Piva et al. 2005). There is, therefore, a constant upskilling of the workforce across developed countries.

In this setting, HC is not just a key element for economic growth but at the same time it is experiencing a rise in demand. While we are aware of several studies that discuss the effects of HC accumulation on, for example, wage premiums in a microeconomic context (Mincer, 1974; Moretti 2004; Ciccone & Peri 2006), regional income disparities (Coulombe & Tremblay 2007), regional development (Florida et al. 2008), regional productivity (Ramos et al. 2010), regional employment (Mollick & Mora 2010) and the level of economic activity (Abel & Gabe 2010)[1], relatively little is known about the factors that determine the production of human capital.

Because the creation of HC is one of the most important channels via which universities positively affect regional development (Audretsch et al., 2005; Acosta et al., 2009), it is interesting to analyse the factors that determine its production, and the strategic role played by universities in this process.

[1] Table A3 in the appendix provides a review of recent studies on the relationship between regional development and human capital.

The literature on Higher Education Institutions (hereinafter, HEIs) has been mainly concerned with distributional questions related to access and cost faced by different groups. Nevertheless, there have been attempts to model universities from other perspectives. Just and Huffman (2009) adopt a theoretical approach to model universities as behavioural institutions making decisions as regards tuition rates, research and teaching incentives, that follow from utility maximization subject to production technology and resource/budget constraints.

From an empirical perspective, the estimation of university efficiency has been a highly fertile field. For instance, Archibald and Feldman (2008) and Johnes (2006) use non-parametric techniques, while other papers employ parametric methodologies to analyse the presence of economies of scale and scope in the universities of various countries, e.g. the US (Groot et al. 1991; Dundar & Lewis 1995), the UK (Glass et al. 1995; Izadi et al. 2002; G. Johnes & J. Johnes 2009), Japan (Hashimoto & Cohn 1997), China (Longlong et al. 2009)**,** and Spain (Duch et al. 2010).

As one of the most valued outcomes of the universities is degree completion, i.e. their contribution of high-skill workers to the labour force, much of the research has been concerned with estimating the impact of expenditure on student persistence and graduation rates (Ryan 2004; Webber & Ehrenberg 2010), student engagement (Pike et al. 2006), and calculating the time-to-degree using duration models (Lassibille and Navarro 2011). Others, such as Berger and Kostal (2002), Perna and Titus (2004), Sá et al (2004), and Bedard and Herman (2008) analyse the determinants of enrolment in HEIs.

We seek to contribute to this body of literature in a number of ways. First, while previous studies have tended to use cross section estimations, in this paper we adopt a panel model in order to better control for unobserved university characteristics[2]. By observing the same university over time, we can control the factors that make a university permanently more productive, e.g. in terms of graduate numbers. Second, the previous literature on graduation rates has mostly sought explanations at the individual (student) level; nonetheless, student achievements are equally attributable to the institutional or regional context. The possible impact of these factors is, therefore, considered in our analysis.

Finally, we analyze a new case study, namely, the entire public university system in Spain. At least two traits of the Spanish case make it an interesting object of study. First, since the 1980s Spain has undergone fundamental economic and social changes. One of the most

[2] Besides controlling more effectively for unobserved heterogeneity, panel estimations are clearly more efficient than pooled ones, providing smaller standard errors and narrower confidence intervals.

significant has been the substantial increase in the educational achievement of its labour force. Over the last four decades, the share of the economically active population attaining tertiary education rose from 1 to 9.4% (IVIE, 2010). Second, the Spanish university system is characterised by a number of specific features that make its analysis of particular interest. While in most OECD countries, public expenditure per student on HEIs declined between 1995 and 2004, in Spain, it increased appreciably by 71%. In parallel, Spain was the only OECD country in which the absolute number of tertiary students fell (by 7%) between 2000 and 2005 (OECD 2008).

Two main research questions have guided this study: (1) What factors determine the creation of human capital in universities? (2) How do regional characteristics affect university performance in terms of human-capital creation?

The rest of this paper is organized as follows. The next section describes the Spanish university framework. Section 3 provides details of the data and describes the empirical strategy. Section 4 reports our results. A robustness check using unconditional quantile regression is conducted in Section 5. Section 6 concludes.

2. Spanish university framework

Over the last three decades, the Spanish university system has increased three-fold in terms of the number of students enrolled[3]. The number of HEIs has evolved in parallel, with the establishment of universities in all the state's cities and major towns. Along with this expansion process, a major transformation has taken place in the university system. Two reform measures introduced changes resulting in its political and administrative decentralisation. The first of these was the University Reform Act (LRU), which came into force in 1983, and was concerned with the organization of the universities and the modernization of their scientific work. The second was the Universities Act (LOU) introduced in 2001, which sought to implement quality assurance policies and prepare the Spanish university system for entry into the European Higher Education Area (EHEA). In 2007, the modification of the LOU made changes to the rectoral election procedures, faculty accreditation and selection, and the coordinating bodies of university policy.

[3] Since 2000, the Spanish university system has been one of the largest in Europe in terms of number of enrolled students, surpassed only by Germany, the UK, France and Poland.

The governance structure of the Spanish university system is based on a decentralised model that comprises three levels: the state, the autonomous regions, and the educational institutions[4]. The central government is responsible for its overall co-ordination, its international representation under a unique voice, and the control of scholarships and grants. Likewise, through the Ministry of Education, it establishes the regulatory framework for obtaining, issuing and validating academic degrees.

The regional government is responsible for administering the HEIs within its territory. It establishes directives regarding staff (teaching and administrative) qualifications, quality measurement, salaries and the recruitment system[5]. The building of new educational facilities and the renewal of existing ones also fall under the control of the autonomous regions. Mechanisms of university funding are one of the main issues at this level of government.[6] Although over recent years there has been a convergence in the regional funding mechanisms, differences persist[7]. However, two common types of funding can be identified across regions: 1) basic funding, which considers variables related to both demand and costs of production factors and 2) non-recurrent funding, which supports program-contracts tied to output-performance, e.g. in terms of research outputs or graduation rates (Consejo de Coordinación Universitaria 2007). In order to illustrate the main regional features of budget allocation we describe two examples - Madrid and Catalonia, which represent about 34.6% of Spanish university expenditure and account for 31% of its university students. The Autonomous Community of Madrid allocates resources to universities according to the following model: 59.5% to teaching[8], 25.5% to research, 10% to enhance aspects such as teaching performance, undergraduate job placement, quality of services, and finally, 5% to accomplish other objectives. In turn, Catalonia's funding model comprises five elements: 1) *Fixed* - lump-sum payment for each university, 2) *Basic* - linked to scale of university activity, 3) *Derivative* - policy promoting academic personnel, 4) *Strategic* – linked to objectives, and 5) *Competition* - through official announcements.

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[4] In specific instances, the central government and the autonomous regions have delegated powers to city councils. This includes a wide range of responsibilities from providing information on the city's educational institutions to the management of non-university institutions.

[5] The central government also has a voice in the definition of categories and personnel salaries.

[6] In 2005, for instance, 91.8% of public spending on tertiary education was allocated as direct subsidies to institutions, with only 8.2% going to student financial-aid (OECD 2010).

[7] The existence of several models of funding across regions implies differences in the mechanisms of university expenditure allocation, which we take into account in the econometric analysis.

[8] The amount of resources allocated to teaching corresponds to demand. Hence, degrees with low demand and high dispersion are penalized.

Higher education regulations have granted autonomy to universities. This autonomy embraces the following powers: 1) drawing-up their statues and electing their institutional governing and representative bodies, 2) definition of their own structure, 3) organisation of educational programmes, 4) preparation and management of their own budgets, and 5) administration of assets.

Given its importance for this study, mention should also be made of the way in which Spanish universities structure their degree courses. Prior to the Bologna reform, the degree structure included both short (first) and long (first and second) cycle courses. Short, first cycle programmes were more vocationally oriented with a duration of two to three years and led to a Diploma degree. About 35% of students were enrolled on short-cycle programmes in 2007[9] (INE, 2009). Second cycle courses, lasting a further two years, commenced on completion of short programmes, and led to the awarding of a Bachelor's degree. These long-cycle programmes were more academic, preparing students for entry into the professions (law, engineering, medicine, etc.). Third cycle courses are equivalent to the current PhD programmes.

3. Data description and empirical strategy

The empirical analysis is carried out at the university level for the period 1998-2008. We use data on the Spanish public university system, collected biannually by the Rector's Conference of Spanish Universities (RCSE)[10]. This database contains detailed information on university performance such as enrolment, graduation, expenditure, investment, and faculty, among others. Private universities are excluded from our analysis for two reasons. First, the information available is more recent and, then, scarcer, which could give lead to degrees of freedom problems. Second, as Just and Huffman (2009) noted, there are major differences between public and private universities in terms of their funding, management structure, resource/budget constraints, social issues, and so forth. Therefore, in trying to avoid these problems and to reduce those associated with heterogeneity, our sample is restricted to the state's public university system, i.e. 47 universities. In 2008, 86% of students were enrolled in

[9] This percentage has changed very little over the years.
[10] Although this represents an attempt to build a systematic database for the Spanish university system, and one that has improved over time, there are many missing values in the first years of data collection, which does not allow us to obtain more degrees of freedom.

public universities. A major advantage of the data is that they offer a wide perspective of the Spanish University system, especially with regard to post-graduate students.

3.1. Dependent variable

The dependent variable is the overall weighted graduation rate[11], which is calculated using the following expression

$$WGR_{it} = \sum_{j=1}^{3} \frac{G_{ijt}}{E_{ijt-m}} \,.S_{jit}$$

where WGR_{it} = overall weighted graduation rate[12] of university *i* in year *t*, G_{ijt} = number of graduates of university *i*, cycle *j* and year *t*. E_{ijt} = number of students enrolled in first year of university *i* cycle *j* and year *t-m*[13]. S_{ijt} = share of graduates of university *i*, cycle *j* and year *t*[14]. *i* = university, *j*= cycles (undergraduate – long and short cycle - and PhD), *t* = year.

The mean graduation rate during the period analysed was 66.2%. The minimum and maximum values were 32.2% and 98.4%, respectively. This measure showed huge variation both across universities and regions. Indeed, although there was a trend towards convergence across universities, the ratio between the highest graduation rate and the lowest during the whole period was three. In the case of the regions, two (Catalonia and Madrid) consistently performed better than the others, while the Balearic Islands and the Canary Islands were placed at the other end of the distribution. Despite the general convergence noted - with very few variations, there was considerable persistence in the ranking occupied by each university over the period in terms of their graduation rates.

3.2. Explanatory variables

The explanatory variables can be classified into four groups: 1) expenditure variables, 2) university characteristics related to scale and technical orientation, 3) measures of input quality,

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[11] The cohort-graduation rate is the usual measure of degree completion in the literature. For instance, Webber & Ehrenberg (2010) use the six-year graduation rate for students who entered the institution as full-time first-year students six years earlier. Other alternatives of widespread use are net or gross graduation rates, and Graduation/Successful completion. Calculation details can be seen in the OECD publication “Education at a Glance”.

[12] Henceforth, graduation rate.

[13] When j= short cycle, m=3; if j= long cycle, m=5; when j= MSc, m=2; finally, if j=PhD, m=3.

[14] $S_{ijt} = \frac{G_{jit}}{G_{it}}$, G_{jit} = number of graduates in cycle *j*, at university *i* in year t; G_{it} = number of graduates at university *i* in year *t*. This term seeks to weight the duration of the different cycles.

and 4) proxies of other university activities besides teaching[15]. In the first group we consider both the effect of total expenditures and their three main components on the graduation rate. These expenditure categories constitute the core of educational and general expenditures within the Spanish public universities[16]. The first category is made up of personnel expenditures, including total salary outlays and the fringe benefits of faculty and administrative staff. The average personnel expenditure per student enrolled in the sample was 3,053 € each year. This category grew steadily during the period of analysis, and represents 55.85% of total expenditures.

The second category is made up of financial aid to students, including scholarships and fellowships awarded to students such as grants-in-aid, trainee stipends, tuition and required fee waivers, and other monetary subsidies given to students. As discussed earlier, Spain's Ministry of Education promotes and manages these grants, which are paid to the university or directly to the student. These expenditures averaged an annual 327.9 € per student enrolled. The third category comprises research and development (R&D) expenditures, including charges for activities specifically organized to produce research outcomes. The mean level of these expenditures was 918.2 €, representing 12% of total university expenditures. Finally, total expenditures are the sum of these three categories plus investment, capital transfers and financial operations. The mean level was 5,659.4 € per student enrolled each year. This variable presented a sustained increase during the period analysed (See Figure 1)[17].

In the case of the second group of variables, previous studies often include the number and the square of the number of undergraduate ($Undergra\_stu_{it}$) and graduate students ($Grad\_stu_{it}$) enrolled at the university (Groot et al. 1991; Longlong et al. 2009; Webber & Ehrenberg 2010). These variables are introduced separately to control for differences in costs of undergraduate and graduate education, and their squared terms to allow for economies of scale[18]. In addition, as a measure of family effort, the tuition fees ($fees_{it}$) paid by students are included. These fees are fixed by the regional governments and are the same for all universities in that region, but vary across academic fields. We introduce a simple average of the public price of the teaching credit by university. Similarly, we include a further two variables to

[15] Table A1 depicts the details used to build the explanatory variables.
[16] All financial data used in the study are expressed in per enrolled-student terms and have been adjusted to 2001 values.
[17] In turn, Figure 2 shows the relationship between graduation rate and total expenditure per student enrolled in 2004 and 2008.
[18] Alternatively, some specifications include the total number of student (tot_stu_{it}) which is the sum of $Undergra\_stu_{it}$ and $Grad\_stu_{it}$.

control for university characteristics: the share of students receiving financial support from the Ministry of Education (*Supp_stu*$_{it}$) and the share of students enrolled on science and engineering courses (*Sci_stu*$_{it}$). The former is included to control for differences in the number of fellowship recipients across universities, which are assigned according to family income and other socioeconomic characteristics; and, the latter in order to take into account the fact that each academic field has different associated costs.

According to Dolan and Schmidt (1994), a model of higher education should reflect the broader perspective that the quality of output can influence the quality of inputs, and that certain institutional resources may themselves enhance the quality of the inputs. Hence, the third group of variables includes measures of student ability and faculty quality. The *student ability*$_{it}$ is introduced through the minimum score required to gain admission to the university[19]. As a control for faculty quality, we use the ratio of the number of scientific articles published in JCR journals to full-time faculty (*publi*$_{it}$)[20].

The last group of explanatory variables refers to university activities. These are generally classified into three main categories; teaching, research, and technology transfer (TT). Depending on its specific profile, each university assigns a different weight to each, which correlates with the amount of resources allocated. We introduce different indicators for each of these activities: the number of patent applications (*Pat*$_{it}$) for TT, and the above variable *publi*$_{it}$ for research. Table A2 presents descriptive statistics for the variables used.

3.3. Empirical strategy

In order to estimate the relationship between university characteristics and graduation rate, we specify a panel structure to reduce unobserved heterogeneity. A problem that can be addressed in this way is, for instance, the fact that the estimated effects of financial resources may be confounded by unobserved institutional characteristics. The function to be estimated can be written as:

$$WGR_{it} = \alpha_i + \tau_t + \lambda_j + \beta_1\, Expenditures_{it} + \beta_2\, Undergra\_stu_{it} + \beta_3\, Undergra\_stu^2_{it} + \beta_4\, Grad\_stu_{it} + \beta_5\, Grad\_stu^2_{it} + fees_{it} + \gamma_2\, Sci\_stu_{it} + \gamma_3\, Supp\_stu_{it} + \gamma_1\, ability_{it} + \gamma_4\, publi_{it} + Pat_{it} + \mu_{it}$$

i=1,2,..., N universities, and t=1998, 2000, ..., 2008.

[19] An average of the 75th percentile of scores or those entering a first-year class was calculated. Data come from the Ministry of Education. Figure 3 provides scatter-plots of graduation rate and student ability in 2000 and 2002.
[20] These data come from the information provided by the institute of documentary studies on science and technology.

Expenditures$_{it}$ refer to the three expenditure categories mentioned above, which are expressed in terms of enrolled students. The inclusion of university fixed effects (α_i) minimizes the influence of any unobserved variables that may be correlated with both the dependent variable and the disturbance term. Finally, τ_t and λ_j are time and regional dummies, N= 47 is the cross section and T= 6 the time-series sample size.

Considerations of multicollinearity among different categories of expenditure preclude any attempt at including them within the same specification; hence, we run separate regressions for each. Panel estimations with both fixed (FEs) and random effects (REs) were carried out. A Robust-Hausman test was performed, indicating that differences between the coefficients of fixed and random effects are not systematic. Therefore, both procedures are appropriate. Since university policy varies across regions (i.e. the budget is allocated by the regional government), we prefer REs because they are more efficient and allow us to include a set of regional dummies[21].

Other empirical issues should be mentioned. First, the graduation rate is measured at three- and five-year intervals, but the resources required to achieve this outcome span multiple periods. In order to control for this and to capture the dynamic nature of the graduation rates, we consider resources expended over multiple years, as well as graduation rates from multiple cohorts. Second, all specifications include both year and university fixed effects. Hence, any university permanent characteristics, e.g. infrastructure quality, are controlled for by a set of university dummies. Third, data on personnel expenditure do not enable us to separate items out between teachers and administrative staff. In order to obtain reliable results, the student-teacher ratio is adopted, which is a cleaner measure of university effort in terms of teaching personnel. Finally, information on R&D expenditures contains many errors and missing values. Conversely, the information on research outcomes - by which R&D activity can be assessed - is accurate. Therefore, the effects of university R&D on graduation rate are analyzed through research outcomes such as patents and publications.

[21] For sake of brevity some FE estimations are not reported here. They are, however, available from the authors upon request.

4. Results

4.1. University characteristics

Two specifications are included. Regressors from two groups of explanatory variables are included in the first specification, i.e. expenditures and university characteristics. The other groups are introduced in the second specification (i.e. measures of input quality and proxies of other university activities). In addition, the number of students enrolled is divided between undergraduates and graduates and their square terms are also included.

We present results separately for total expenditure (Table 1), student-teacher ratio (Table 2) and financial-aid to students (Table 3). The first general finding is that all regressors in the group of expenditure variables have a statistically significant effect on the graduation rate. Aside from the financial-aid results, the magnitude of the aforementioned coefficients is held relatively stable across specifications. Likewise, the student-teacher ratio coefficient is negative and always statistically significant at least at the one-percent level (see Table 2). Second, the total number of students (*tot_stu)* consistently shows a positive and statistically significant effect on the graduation rate. Third, the share of students on science and engineering courses (*Sci_stu)* and the measures of input quality (*student ability and public*) do not have any effect on the dependent variable. This last result might indicate that student ability is randomly distributed and plays no role in the determination of graduation rates. This being the case, graduation rates should be explained by university characteristics.

Since the column 7 specification in Tables 1, 2 and 3 includes all the groups of regressors and a set of regional dummies[22], the following remarks and the calculations on the magnitude of impact are based on that specification. In the case of the relationship between total expenditure and the graduation rate, the estimated coefficient is positive and statistically significant across specifications (see Table 1). Hence, a one standard deviation increase in total expenditures leads to a rise in the graduation rate of about 4.8 percentage points. *Supp_stu* has a positive and significant effect on the dependent variable. Regressors from the other groups of variables do not have any effect on graduation rates. Although this might seem somewhat unusual, it is, in fact, in line with previously reported findings (Weber, 2010).

[22] As mentioned, these dummies seek to control for differences in university policy across regions.

When the student-teacher ratio is included, a negative and statistically significant coefficient is obtained (see Table 2)[23]. An increase by one standard deviation reduces the graduation rate by about 9.5 percentage points. *Undergad_stu*^{2} and *pat* show a positive and statistically significant effect on the graduation rate.

Finally, expenditure on student financial-aid presents the following features[24]. First, the estimated coefficient suggests that a one standard deviation increase in this item leads to a rise in the graduation rate of about 4.9 percentage points. Second, the number of undergraduate students *(Undergrad_stu)* and its squared value *(Undergrad_stu*^{2}*)* are statistically significant, and their signs (negative and positive, respectively) present a U-shape (See column 7, Table 3). It would seem, therefore, that there are two ranks of university size at which the graduation rate presents higher levels. Moreover, in the case of small universities, increasing the number of undergraduate students leads to a reduction in the graduation rate. By contrast, at larger universities, increasing the number of students can lead to a rise in the graduation rate. Third, in line with the results in Table 2, *pat* is again positive and statistically significant at least at the 10 percent level. This result can be interpreted as showing the complementarity effect among university tasks.

4.2 Regional characteristics

The expansion of the Spanish university system and its geographical distribution has sought to introduce regional balance. As discussed, universities can make a significant contribution to the regional economies by generating human capital, since better regional economic performance is expected as a result of graduates joining the labour force. At the same time, features of the regional economy can affect university performance. This section analyses the impact of regional context on graduation rates. The key point is that, since the university framework remains unchanged across the period of analysis, regional socio-economic characteristics, together with university characteristics, might explain differences between university outcomes. We assume that the graduation rate (*GR*) of university *i* in year *t* is modelled as a function of university characteristics *U* and regional characteristics *R*.

$$GR_{it} = f\,(U_{it}\ , R_{it})$$

The difficulty lies in the fact that it is not easy to find regional variables that are not correlated with university characteristics. We perform this analysis focusing solely on regional

[23] The variable *fee* was dropped from the regressions in Table 2 due to problems of collinearity.
[24] *fees* and *supp_stu* were excluded because of collinearity.

characteristics. Furthermore, total university expenditure, the number of students enrolled and university fixed-effects are included.

We add associated variables to two groups of regional features: demographic structure and labour market[25]. In the case of the latter, we introduce regional employment since it influences enrolment and persistence (Bedard & Herman, 2008; Mollick & Mora, 2010). Although it is likely that students (and families) consider the unemployment rate when making decisions over education plans, it is no less likely that the level of employment is a good indicator of labour market performance and, therefore, it is taken into account by families. The assumption here is that once students have started higher education, the probability of persistence, and then graduation, correlate highly with the level of employment in the economy. To capture this effect, we use the employment in province *i* in year *t*, for 16- to 24-year-olds[26].

The graduation rate could be affected by the regional demographic structure through the following mechanism. Moretti (2004) indicates that the US labour force is characterized by a long-run trend of increasing education, with younger cohorts being better educated than their older counterparts[27]. In addition, Ciccone and Peri (2006) argue that cities with a larger share of older workers in a certain decade will experience a greater increase in average schooling in subsequent years. In line with these arguments, we use the share of population with tertiary education[28] (*40Greater*) and the share of old workers in the previous decade (*OLD*). Here the expected effect is that provinces in which these shares are higher will obtain a higher graduation rate. Finally, as in the preceding analysis, a set of regional dummies is included.

To deal with collinearity between *Employment* and *40Greater* two specifications were introduced. The main findings can be summarized as follows. After controlling for regional characteristics in the model, the total university expenditure maintains a positive and statistically significant relationship with the graduation rate. In keeping with this, the total number of enrolled students once again positively affects the dependent variable (see Table 4).

In the case of the influence of regional characteristics on the graduation rate, three results are worth stressing. First, the coefficient of *40Greater* is negative and statistically significant (See columns 1 to 3 in Table 4). Second, *Employment* has a negative and

[25] A third variable related to the standard of living was also considered, namely, per capita GDP. Nonetheless, it was excluded for problems of collinearity.
[26] These data are taken from the Economically Active Population Survey conducted by the INE.
[27] OECD data (*Education at a Glance, 2010*) show that in Spain, the proportion of people aged 25 to 34 that have attained tertiary education qualifications more than doubles the number in the 55- to 64-year-old cohort (39% and 16% in Spain compared to the OECD average of 35% and 20% respectively).
[28] Specifically, we include the share of population with higher education and aged over 40.

statistically significant effect on the dependent variable. This suggests that once students enrol at university, the probability of persistence, and subsequently of graduation, will be lower if regional employment presents a good performance. Finally, *OLD* seems to have no effect on the graduation rate, being significant only in the case of the random-effect model without regional dummies (see column 5) [29].

5. Empirical Extensions

OLS estimates provide the average effect of an explanatory variable over the entire distribution of an outcome variable. Nonetheless, in some contexts, this summary statistic may not be representative of the relationship in any one part of the outcome distribution. To look beyond the underlying questions of economic and policy interest concerning graduation rates, we use a quantile framework to characterize their entire distribution. Quantile regressions are often used to show differential impacts of the variables of interest throughout the outcome distribution.

We apply a new unconditional quantile estimation technique for panel data based on Powell (2011) and Firpo et al. (2009)[30]. The method consists of running a regression of a transformation - the Recentered Influence Function (RIF) - of the outcome variable on the explanatory variables. The basic difference between conditional quantile treatment effects (QTEs) and unconditional QTEs is that the former are defined conditionally on the value of the regressors, whereas unconditional effects summarize the causal effect of a treatment for the entire population (Frölich & Melly 2010).

Two categories of university expenditure were analysed through unconditional QTEs: total and financial-aid to students. We introduce a fixed-effect model to control for time-invariant unobserved university heterogeneity.

The results show that the relationship between total university expenditures and the graduation rate is only statistically significant at the low quantiles i.e. q=0.20, 0.40 (see Table 5). In turn, estimates of the coefficient of financial-aid to students lead us to conclude that, aside from the lowest quantile i.e. q=0.20, there is a strong relationship with the graduation rate, across the distribution (see Table 5). Likewise, the magnitude of coefficients presents an

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[29] In a second step, to reduce any suspicions of endogeneity problems, we re-estimated this last specification introducing the share from the previous decade. Our results were very similar and are not reported here for reasons of space.

[30] We adopt the second estimator (RIF-Logit regression), its main advantage being that it allows heterogeneous marginal effects.

inverted-U shape when we move to the right-hand side of the distribution. A further pattern that emerges from this exercise is that the standard errors are smaller for lower quantiles than they are for the upper ones, reflecting greater precision in that part of the distribution.

These findings can be attributed to following circumstances. First, the results seem to show that that there is a point up to which the graduation rate can be increased via university expenditure. From that point, expenditure has a reduced capacity to bring about better outcomes. Here, any possible advances are determined by the students themselves and may be triggered by financial support to the students. Therefore, a well-designed fellowship program seems to play an important role in degree completion.

Second, from a regional perspective, we identify a weak level of persistence among universities occupying the lowest ranks (in terms of graduation rates). It would seem feasible for them to escape from these positions by adopting a policy that combines elements of university expenditure and student fellowship programs. This would seem to constitute a more effective strategy for reduce disparities between regions in terms of their university performance.

Like the current national fellowship program run by Spain's ministry of education, financial support to students should be tied to educational achievements as well as regional socio-economic characteristics.

6. Concluding remarks

Graduation rates remain one of the most frequently applied measures of institutional performance and continue to draw the attention of both academics and policymakers. This paper has sought, in the first place, to analyse university characteristics that affect the graduation rate, and secondly, to determine whether regional characteristics influence university performance in terms of graduation. To the best of our knowledge, this is the first economic study conducted in Spain to consider institutional characteristics and regional features.

The answers to the research questions formulated here help further our understanding of the ways in which institutional and regional features can affect university outcomes. Our results are largely consistent with findings in recent studies in related fields. University expenditure has been a key determinant of the graduation rate in Spain over the last decade. Moreover, results obtained here through quantile regression analysis show that a policy of increasing university expenditure only makes sense for universities with low graduation rates. Universities whose graduation rate does not belong to the 20th percentile can though improve their ranking by raising financial-aid to students. Yet, these questions require more careful attention since any expenditure increase needs to be tied to improvements in quality and efficiency.

The analysis also shows that it is not only the amount of university expenditure that is important, but also university research performance. Indeed, there would seem to be a complementarity effect between their teaching and research activities.

Future research might take the following directions. First, although high graduation rates have been viewed as a good indicator of institutional excellence, it should also be recognized that they reflect admission standards, the academic strength of the enrolled students, and the resources that institutions can devote to instruction, remediation, and retention. The influence of these factors should, therefore, be taken into account. Second, measuring the quality of both inputs and outputs is important when analysing higher education; thus, quality measures need to be incorporated. Third, when the data sources so allow it, information at the institutional level could be expanded to include a student-level component, which would serve to unite the two types of study currently in vogue.

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References

Abel, J.R. & Gabe, T.M., 2010. Human capital and economic activity in urban America. *Regional Studies*, pp.1-12.

Acemoglu, D., 1998. Why Do New Technologies Complement Skills? Directed Technical Change and Wage Inequality. *Quarterly Journal of Economics*, 113(4), pp.1055-1089.

Acosta, M., Coronado, D. & Flores, E., 2009. University spillovers and new business location in high-technology sectors: Spanish evidence. *Small Business Economics*, 36(3), pp.365-376.

Archibald, R. & Feldman, D., 2008. Graduation Rates and Accountability: Regressions Versus

Production Frontiers. *Research in Higher Education*, 49(1), pp.80-100.
Arrow, K.J., 1962. The economic implications of learning by doing. *The Review of Economic Studies*, 29(3), pp.155-173.
Audretsch, D.B., Lehmann, E.E. & Warning, S., 2005. University spillovers and new firm location. *Research Policy*, 34(7), pp.1113-1122.
Barro, R.J., 1991. Economic growth in a cross section of countries. *The Quarterly Journal of Economics*, 106(2), pp.407-443.
Becker, G., 1964. *Human capital: A theoretical and empirical analysis, with special reference to education*, New York: Columbia University Press.
Bedard, K. & Herman, D.A., 2008. Who goes to graduate/professional school? The importance of economic fluctuations, undergraduate field, and ability. *Economics of Education Review*, 27(2), pp.197-210.
Berger, M.C. & Kostal, T., 2002. Financial resources, regulation, and enrollment in US public higher education. *Economics of Education Review*, 21(2), pp.101-110.
Ciccone, A. & Peri, G., 2006. Identifying human-capital externalities: Theory with applications. *Review of Economic Studies*, 73(2), pp.381-412.
Consejo de Coordinación Universitaria, 2007. Financiación del Sistema Universitario Español. Ministerio de educación y ciencia.
Coulombe, S. & Tremblay, J.F., 2007. Skills, education, and Canadian provincial disparity. *Journal of Regional Science*, 47(5), pp.965-991.
Dolan, R.C. & Schmidt, R.M., 1994. Modeling institutional production of higher education. *Economics of Education Review*, 13(3), pp.197-213.
Duch, N., Parellada, M. & Polo, J., 2010. Economies of scale and scope of university research and technology transfer: a flexible multi-product approach. *Working paper nº 51 IEB Institut d'Economia de Barcelona, Spain.*
Dundar, H. & Lewis, D.R., 1995. Departmental productivity in American universities: Economies of scale and scope. *Economics of Education Review*, 14(2), pp.119-144.
Firpo, S., Fortin, N.M. & Lemieux, T., 2009. Unconditional Quantile Regressions. *Econometrica*, 77(3), pp.953-973.
Florida, R., Charlotta, M. & Stolarick, K., 2008. Inside the black box of regional development—human capital, the creative class and tolerance. *Journal of Economic Geography*, 8(5), pp.615-649.
Frölich, M. & Melly, B., 2010. Estimation of quantile treatment effects with Stata. *The Stata Journal*, 10(3), pp.423–457.
Glass, J.C., McKillop, D.G. & Hyndman, N., 1995. Efficiency in the provision of university teaching and research: An empirical analysis of UK universities. *Journal of Applied Econometrics*, 10(1), pp.61-72.
Groot, H. de, McMahon, W.W. & Volkwein, J.F., 1991. The Cost Structure of American Research Universities. *The Review of Economics and Statistics*, 73(3), pp.424-431.
Hanushek, E.A. & Kimko, D.D., 2000. Schooling, labor-force quality, and the growth of nations. *The American Economic Review*, 90(5), pp.1184-1208.
Hashimoto, K. & Cohn, E., 1997. Economies of Scale and Scope in Japanese Private Universities. *Education Economics*, 5(2), pp.107-115.
Izadi, H. et al., 2002. Stochastic frontier estimation of a CES cost function: the case of higher education in Britain. *Economics of Education Review*, 21(1), pp.63-71.
Johnes, G. & Johnes, J., 2009. Higher education institutions' costs and efficiency: Taking the decomposition a further step. *Economics of Education Review*, 28(1), pp.107-113.
Johnes, J., 2006. Data envelopment analysis and its application to the measurement of

efficiency in higher education. *Economics of Education Review*, 25(3), pp.273-288.
Just, R.E. & Huffman, W.E., 2009. The economics of universities in a new age of funding options. *Research Policy*, 38(7), pp.1102-1116.
Lassibille, G. & Navarro, M., 2011. How Long Does it Take to Earn a Higher Education Degree in Spain? *Research in Higher Education*, 52(1), pp.63-80-80.
Longlong, H., Fengliang, L. & Weifang, M., 2009. Multi-product total cost functions for higher education: The case of Chinese research universities. *Economics of Education Review*, 28(4), pp.505-511.
Lucas, R., 1988. On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), pp.3-42.
Mankiw, N.G., Romer, D. & Weil, D.N., 1992. A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107(2), pp.407-437.
Mincer, J, 1974. *Schooling, experience, and earnings*, New York: Columbia University Press.
Mollick, A. & Mora, M., 2010. The impact of higher education on Texas population and employment growth. *The Annals of Regional Science*, pp.1-15.
Moretti, E., 2004. Estimating the social return to higher education: evidence from longitudinal and repeated cross-sectional data. *Journal of Econometrics*, 121(1-2), pp.175-212.
Nelson, R.R. & Phelps, E.S., 1966. Investment in Humans, Technological Diffusion, and Economic Growth. *The American Economic Review*, 56(1/2), pp.69-75.
OECD, 2010. *Higher education in regional and city development. The autonomous region of Catalonia, Spain*,
OECD, 2008. *Tertiary Education for the Knowledge Society OECD* Thematic review of tertiary education: Synthesis report.,
Perna, L. & Titus, M., 2004. Understanding Differences in the Choice of College Attended: The Role of State Public Policies. *The Review of Higher Education*, 27(4), pp.501-525.
Pike, G. et al., 2006. Educational expenditures and student engagement: When does money matter? *Research in Higher Education*, 47(7), pp.847-872-872.
Piva, M., Santarelli, E. & Vivarelli, M., 2005. The skill bias effect of technological and organisational change: Evidence and policy implications. *Research Policy*, 34(2), pp.141-157.
Powell, D., 2011. Unconditional Quantile Regression for Panel Data with Exogenous or Endogenous Regressors. *RAND corporation*. Available at: http://www.rand.org/pubs/working_papers/WR710-1.html [Accessed November 9, 2011].
Ramos, R., Suriñach, J. & Artís, M., 2010. Human capital spillovers, productivity and regional convergence in Spain. *Papers in Regional Science*, 89(2), pp.435-447.
Romer, P.M., 1990. Endogenous Technological Change. *The Journal of Political Economy*, 98(5), p.S71-S102.
Ryan, J.F., 2004. The Relationship Between Institutional Expenditures and Degree Attainment at Baccalaureate Colleges. *Research in Higher Education*, 45(2), pp.97-114-114.
Schultz, T.W., 1961. Investment in Human Capital. *The American Economic Review*, 51(1), pp.1-17.
Sá, C., Florax, R.J.G.M. & Rietveld, P., 2004. Determinants of the Regional Demand for Higher Education in The Netherlands: A Gravity Model Approach. *Regional Studies*, 38(4), pp.375-392.
Webber, D.A. & Ehrenberg, R.G., 2010. Do expenditures other than instructional expenditures affect graduation and persistence rates in American higher education? *Economics of Education Review*, 29(6), pp.947-958.

Figure 1
Evolution University total expenditure per enrolled student[31]

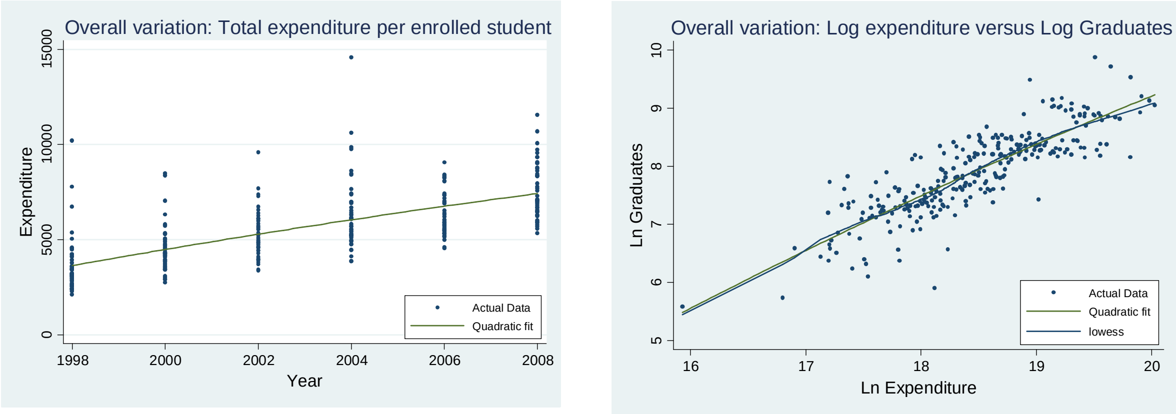


Figure 2 Graduation rate and per capita expenditure

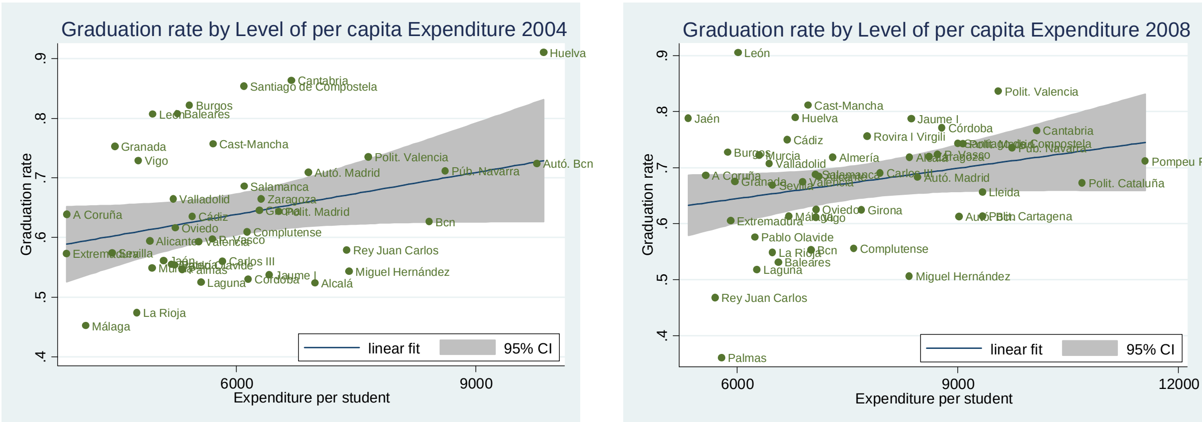
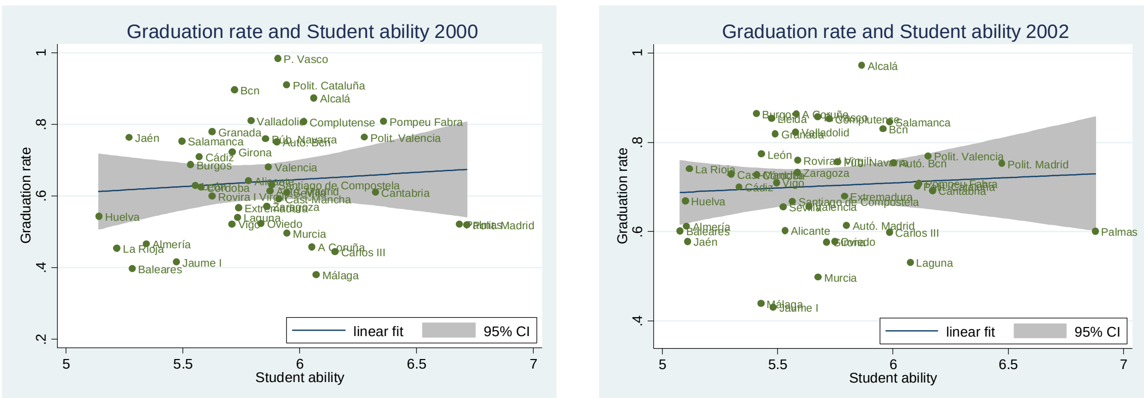


Figure 3 Graduation rate and student ability



[31] Each point in this figure represents an individual-year pair

Table 1 Econometric estimates: Total expenditure and graduation rate

	Pooled		Panel				
VARIABLES	(1)	(2)	(3) FE	(4) RE	(5) RE	(6) RE	(7) RE
Total expenditure $_{it}$	0.024***	0.023**	0.023*	0.024***	0.022**	0.027***	0.022**
	(0.009)	(0.009)	(0.013)	(0.009)	(0.010)	(0.009)	(0.010)
Sci_stu $_{it}$	0.036	0.056	-0.253	0.026	0.024	0.126	0.053
	(0.055)	(0.070)	(0.427)	(0.071)	(0.056)	(0.082)	(0.071)
Supp_stu $_{it}$	0.662*	0.813**	0.483	0.204	0.584	0.447	0.792**
	(0.355)	(0.323)	(0.522)	(0.258)	(0.356)	(0.278)	(0.331)
Fees $_{it}$	-0.049	-0.044	-0.069*	0.002	-0.056	0.014	-0.045
	(0.035)	(0.029)	(0.036)	(0.011)	(0.036)	(0.010)	(0.029)
Undergra_stu $_{it}$		-0.007				-0.005	-0.007
		(0.005)				(0.004)	(0.005)
Undergra_stu^2 $_{it}$		0.106				0.101	0.109
		(0.068)				(0.067)	(0.069)
Grad_stu $_{it}$		0.021				0.013	0.016
		(0.023)				(0.022)	(0.023)
Grad_stu^2 $_{it}$		-2.265				-2.752	-2.056
		(2.193)				(2.216)	(2.231)
Student Ability $_{it}$		-0.003				-0.011	0.001
		(0.021)				(0.022)	(0.022)
Publi $_{it}$		0.065				0.016	0.066
		(0.079)				(0.075)	(0.081)
Pat $_{it}$		0.002				-0.000	0.002
		(0.002)				(0.002)	(0.002)
Tot_stu $_{it}$	0.017***		0.113*	0.016**	0.018***		
	(0.006)		(0.059)	(0.007)	(0.006)		
Constant	0.702**	0.736**	1.022**	0.387**	0.849**	0.282	0.736**
	(0.297)	(0.291)	(0.484)	(0.164)	(0.347)	(0.196)	(0.297)
University fixed-effects	Not	Not	Yes	Not	Not	Not	Not
Regional dummies	Yes	Yes	Not	Not	Yes	Not	Yes
Adj. R-squared	0.39	0.41	0.16	0.13	0.39	0.21	0.41

Notes: the dependent variable is the graduation rate at university *i* in year *t*. *Total expenditure* $_{it}$ is the sum of expenditures of personnel, financial-aid to students and R&D, plus investment, capital transfers and financial operations. Sci_stu_{it} is the share of students in science and engineering. $Supp\_stu_{it}$ is the share of students with financial support from the Ministry of Education. $fees_{it}$ are tuition fees. $Undergra\_stu_{it}$ and $Undergra\_stu^2_{it}$ are the number and the square of undergraduate students. $Grad\_stu_{it}$ and $Grad\_stu^2_{it}$ are the number and the square of graduate students enrolled at the university. *student ability*$_{it}$ is the minimum score required to gain admission to the university. $publi_{it}$ is the ratio of the number of scientific articles published in JCR journals to full-time faculty. *Tot_stu* $_{it}$ is the sum of *Undergra_stu* $_{it}$ and *Grad_stu* $_{it}$. *Pat* $_{it}$ is the number of patent applications.
Robust standard errors clustered at university level are shown in parentheses. *,**,*** denote the significance at 90%, 95% and 99%, respectively. Number of observations: 217. Number of Universities: 46. Year effects are included in all models. The expenditure variables are expressed in 2001 Euros and per student enrolled.

Table 2 Econometric estimates: Personnel expenditure and graduation rate

	Pooled		Panel				
VARIABLES	(1)	(2)	(3) FE	(4) RE	(5) RE	(6) RE	(7) RE
Student-teacher ratio $_{it}$	-0.017***	-0.021***	-0.021***	-0.018***	-0.017***	-0.027***	-0.024***
	(0.006)	(0.006)	(0.006)	(0.004)	(0.005)	(0.006)	(0.007)
Sci_stu $_{it}$	0.019	0.045	-0.317	-0.007	0.006	0.070	0.040
	(0.043)	(0.069)	(0.235)	(0.057)	(0.040)	(0.077)	(0.068)
Supp_stu $_{it}$	0.326	0.553*	0.189	0.225	0.255	0.439**	0.460
	(0.346)	(0.310)	(0.423)	(0.179)	(0.313)	(0.207)	(0.357)
Undergra_stu $_{it}$		-0.007*				-0.005	-0.007
		(0.004)				(0.004)	(0.004)
Undergra_stu$^2_{it}$		0.116*				0.114*	0.123*
		(0.066)				(0.066)	(0.071)
Grad_stu $_{it}$		0.003				-0.018	-0.009
		(0.022)				(0.021)	(0.022)
Grad_stu$^2_{it}$		-1.590				-0.864	-1.008
		(2.082)				(2.186)	(2.153)
Student Ability $_{it}$		0.002				0.001	0.007
		(0.020)				(0.021)	(0.022)
Publi $_{it}$		0.105				0.099	0.114
		(0.070)				(0.068)	(0.075)
Pat $_{it}$		0.003*				0.002	0.003*
		(0.002)				(0.002)	(0.002)
Tot_stu $_{it}$	0.014***		0.100***	0.016**	0.016***		
	(0.005)		(0.034)	(0.007)	(0.005)		
Constant	0.875***	0.901***	0.853***	0.906***	0.876***	0.904***	0.829***
	(0.152)	(0.218)	(0.195)	(0.079)	(0.156)	(0.169)	(0.234)
University fixed-effects	Not	Not	Yes	Not	Not	Not	Not
Regional dummies	Yes	Yes	Not	Not	Yes	Not	Yes
Adj. R-squared	0.35	0.41	0.14	0.14	0.35	0.23	0.41

Notes: the dependent variable is the graduation rate at university *i* in year *t*. *Student-teacher ratio* $_{it}$ is the ratio of full-time equivalent students and the number of full-time equivalent teachers. *Sci_stu*$_{it}$ is the share of students in science and engineering. *Supp_stu*$_{it}$ is the share of students with financial support from the Ministry of Education. *Undergra_stu*$_{it}$ and *Undergra_stu*$^2_{it}$ are the number and the square of undergraduate students. *Grad_stu*$_{it}$ and *Grad_stu*$^2_{it}$ are the number and the square of graduate students enrolled at the university. *student ability*$_{it}$ is the minimum score required to gain admission to the university. *publi*$_{it}$ is the ratio of the number of scientific articles published in JCR journals to full-time faculty. *Tot_stu* $_{it}$ is the sum of *Undergra_stu* $_{it}$ and *Grad_stu* $_{it}$. *Pat* $_{it}$ is the number of patent applications.

Robust standard errors clustered at university level are shown in parentheses. *,**,*** denote the significance at 90%, 95% and 99%, respectively. Number of observations: 217. Number of Universities: 46. Year effects are included in all models. The expenditure variables are expressed in 2001 Euros and per student enrolled.

Table 3 Econometric estimates: Financial-aid to student and graduation rate

	Pooled		Panel				
VARIABLES	(1)	(2)	(3) FE	(4) RE	(5) RE	(6) RE	(7) RE
Financial-aid $_{it}$	0.257*	0.470***	0.359**	0.116	0.294**	0.137	0.323***
	(0.131)	(0.171)	(0.147)	(0.097)	(0.125)	(0.104)	(0.116)
Sci_stu $_{it}$	0.052	0.044	-0.332	0.054	0.040	0.140	0.027
	(0.051)	(0.087)	(0.316)	(0.074)	(0.048)	(0.096)	(0.080)
Undergra_stu $_{it}$		-0.011**				-0.011**	-0.009*
		(0.005)				(0.005)	(0.005)
Undergra_stu$^2{}_{it}$		0.135*				0.156**	0.123*
		(0.069)				(0.078)	(0.071)
Grad_stu $_{it}$		0.044				0.028	0.028
		(0.031)				(0.027)	(0.028)
Grad_stu$^2{}_{it}$		-4.159				-3.716	-3.176
		(2.714)				(2.705)	(2.649)
Student Ability $_{it}$		-0.003				0.018	0.008
		(0.023)				(0.027)	(0.026)
Publi $_{it}$		-0.082				0.100	0.018
		(0.136)				(0.088)	(0.093)
Pat $_{it}$		0.002				0.001	0.003*
		(0.002)				(0.002)	(0.002)
Tot_stu $_{it}$	0.012*		0.051	0.013	0.014**		
	(0.006)		(0.039)	(0.008)	(0.006)		
Constant	0.477***	0.533***	0.551***	0.553***	0.461***	0.495**	0.462**
	(0.076)	(0.176)	(0.176)	(0.063)	(0.073)	(0.203)	(0.200)
University fixed-effects	Not	Not	Yes	Not	Not	Not	Not
Regional dummies	Yes	Yes	Not	Not	Yes	Not	Yes
Adj. R-squared	0.34	0.38	0.10	0.09	0.33	0.14	0.40

Notes: the dependent variable is the graduation rate at university *i* in year *t*. *Financial-aid* $_{it}$ refers scholarships and fellowships awarded to students such as grants-in-aid, trainee stipends, tuition and required fee waivers, and other monetary subsidies given to students. *Sci_stu*$_{it}$ is the share of students in science and engineering. *Undergra_stu*$_{it}$ and *Undergra_stu*$^2{}_{it}$ are the number and the square of undergraduate students. *Grad_stu*$_{it}$ and *Grad_stu*$^2{}_{it}$ are the number and the square of graduate students enrolled at the university. *student ability*$_{it}$ is the minimum score required to gain admission to the university. *publi*$_{it}$ is the ratio of the number of scientific articles published in JCR journals to full-time faculty. *Tot_stu* $_{it}$ is the sum of *Undergra_stu* $_{it}$ and *Grad_stu* $_{it}$. *Pat* $_{it}$ is the number of patent applications.

Robust standard errors clustered at university level are shown in parentheses. *,**,*** denote the significance at 90%, 95% and 99%, respectively. Number of observations: 217. Number of Universities: 46. Year effects are included in all models. The expenditure variables are expressed in 2001 Euros and per student enrolled.

Table 4 Panel estimations: Regional characteristics and graduation rate

VARIABLES	FE (1)	RE (2)	RE (3)	FE (4)	RE (5)	RE (6)
Total expenditure $_{it}$	0.019**	0.029***	0.028***	0.018*	0.026***	0.026***
	(0.009)	(0.007)	(0.008)	(0.009)	(0.007)	(0.008)
Tot_stu $_{it}$	0.084**	0.022***	0.022***	0.086**	0.022***	0.024***
	(0.037)	(0.007)	(0.005)	(0.042)	(0.006)	(0.005)
40greater $_{it}$	-0.662**	-0.237***	-0.512**			
	(0.307)	(0.081)	(0.215)			
OLD $_{it}$				0.582	1.259***	0.998
				(2.085)	(0.422)	(0.720)
Employment $_{it}$				-0.139**	-0.015	-0.043**
				(0.060)	(0.011)	(0.018)
Constant	0.401***	0.432***	0.443***	0.359	0.235***	0.296**
	(0.125)	(0.062)	(0.066)	(0.425)	(0.082)	(0.136)
Regional dummies	Not	Not	Yes	Not	Not	Yes
Adj. R-squared	0.12	0.20	0.33	0.11	0.21	0.34

Notes: the dependent variable is the graduation rate at university *i* in year *t*. *Total expenditure* $_{it}$ is the sum of expenditures of personnel, financial-aid to student and R&D, plus investment, capital transfers and financial operations. *Tot_stu* $_{it}$ is the sum of *Undergra_stu* $_{it}$ and *Grad_stu* $_{it}$. *40greater* $_{it}$ is the share of population with tertiary education and aged over to 40 at province i. *OLD* $_{it}$ the share of old workers in the previous decade. *Employment* $_{it}$ is the employment at province i.
Robust standard errors clustered at university level are shown in parentheses. *,**,*** denote the significance at 90%, 95% and 99%, respectively. Number of observations: 217. Number of Universities: 46. Year effects are included in all models. The expenditure variables are expressed in 2001 Euros and per student enrolled. Columns 1 and 4 show fixed-effect models, other columns show random-effect ones.

Table 5 Fixed-effects quantile regression results

	20th (1)	40th (2)	60th (3)	80th (4)
Total expenditure	0.011*	0.013*	0.002	0.024
Std. Error	(0.006)	(0.007)	(0.013)	(0.016)
Financial-aid to student	0.146	0.448**	0.573***	0.388**
Std. Error	(0.150)	(0.172)	(0.176)	(0.194)

Notes: the dependent variable is the graduation rate at university *i* in year *t*.
Robust standard errors clustered at university level are shown in parentheses. *,**,*** denote the significance at 90%, 95% and 99%, respectively. Number of observations: 217. Number of Universities: 46. Year effects are included in all models. The expenditure variables are expressed in 2001 Euros and per student enrolled.

Appendix

Table A1 List of variables

Variable	Description
Overall Weighted-Graduation rate $_{it}$	Overall Weighted-Graduation rate of university *i* at year *t*
Total expenditure $_{it}$	Sum of personnel, financial-aid to student and R&D, plus investment, capital transfers and financial operations
Personnel expenditure $_{it}$	Total salary outlays and fringe benefits of faculty and administrative staff
Financial-aid $_{it}$	Refers scholarships and fellowships awarded to students such as grants-in-aid, trainee stipends, tuition and required fee waivers, and other monetary subsidies given to students.
R&D expenditure $_{it}$	charges for activities specifically organized to produce research outcomes
Student-teacher ratio $_{it}$	is obtained by dividing the number of full-time equivalent students by the number of full-time equivalent teachers
Undergra_stu $_{it}$	Undergraduate students
Undergra_stu $^{2}_{it}$	Squared of undergraduate students
Grad_stu $_{it}$	Graduate students
Grad_stu $^{2}_{it}$	Squared of graduate students
Tot_stu $_{it}$	Sum of *Undergra_stu* $_{it}$ and *Grad_stu* $_{it}$
Fees $_{it}$	Weighted average of tuition fees by university
Supp_stu $_{it}$	Student percentage with financial support of ministry of education
Sci_stu $_{it}$	Share of students in science and engineering degrees
Student Ability $_{it}$	Minimum score to access to the university. Average of the 75th percentile of scores by university's entering first-year class
Publi $_{it}$	the ratio of the number of scientific articles published in JCR journals to full-time faculty
Pat $_{it}$	The number of patent applications

Table A2 Descriptive statistics

		Standard Deviation				
	Mean	**overall**	**between**	**within**	**Min**	**Max**
Overall Weighted-Graduation rate $_{it}$	0.6625	0.1525	0.0828	0.0955	0.3219	0.9846
Total expenditure $_{it}$	5.6594	2.1749	1.3422	1.7207	2.1239	21.9961
Personnel expenditure $_{it}$	3.0537	0.9510	0.5107	0.8051	0.7892	5.8690
Financial-aid to student $_{it}$	0.3279	0.1531	0.1463	0.0715	0.0248	0.9322
R&D expenditure $_{it}$	0.9182	0.6244	0.4898	0.3968	0.1426	3.4925
Student-teacher ratio $_{it}$	15.5202	3.9594	2.3347	3.2129	9.1824	51.5857
Undergra_stu $_{it}$	24.3505	16.0573	15.9428	2.8615	3.2230	82.5000
Undergra_stu $^{2}_{it}$	849.8688	1133.1630	1115.4510	248.9346	10.3877	6806.2500
Grad_stu $_{it}$	1.4041	1.5132	1.4828	0.3549	0	11.0620
Grad_stu $^{2}_{it}$	4.2531	13.2817	12.6018	4.4635	0	122.3679
Fees $_{it}$	10.3834	1.4475	1.0995	0.9512	0	15.1156
Supp_stu $_{it}$	0.1672	0.0537	0.0504	0.0195	0.0135	0.3459
Sci_stu $_{it}$	0.4478	0.1875	0.1873	0.0269	0.0097	1
Student Ability $_{it}$	6.5767	0.5576	0.4817	0.2867	5	7.9950
Publi $_{it}$	0.3305	0.1531	0.1346	0.0751	0.0601	0.8880
Pat $_{it}$	7.2128	7.5168	6.6258	3.6538	0	41

N = 271, n = 47, T=6. All financial data used in the study are expressed in terms of per enrolled student and have been adjusted to 2001 values.

Table A3 Recent studies on the relationship between regional development and human capital

Studies	***Dependent variables***	***Explanatory var.***	***Methodology***	***Unit of analysis***	***Period***
Artís et al. 2010	1. Δ Productivity 2. Δ GDP per capita	Stock of physical capital, Stock of human capital (primary, high school, Tertiary)	Spatial panel data. Weighted matrix (distances between province capitals)	Spanish provinces	1980 – 2007
Abel & Gabe 2010	GDP per capita (average 2000 – 2005)	Human Capital = The proportion of each metropolitan area's working-age population with a college degree, Physical capital investment.	Cross section, Instrumental Variables: Land-grant university.	US Metropolitan areas	2000 - 2005
Coulombe & Trembaly 2007	Provincial Per capita income	HK measured by: 1. University achievement 2. Indicator of skill based on literacy test scores. Year of Schooling	Mincerian estimates. Time series and cross section. GLS, FGLS. Instrumental variables.	Canadian provinces	
Ciccone & Peri 2006	Average-schooling externalities	Δ in average schooling Δ in av. experience	Theoretical model, Mincerian approach (identifying HK externalities)	US City	1970-1990
Florida et al. 2008	1. Productivity (measure by Wages) 2. Income	Human capital, creative class, technology variables, tolerance and related variable, universities (# of university faculty per capita), consumer services (amenities).	Cross section, Structural equation model. What are the factors that shape the distribution of human capital in the first place?	US metropolitan regions (331)	2000
Hanushek & Kimko 2000	Productivity and economic growth.	Labour force quality (based on student cognitive performance)	Equation system to explain: 1. Economic growth. 2. Resources devoted to schools & human capital production. 3. labor-force quality	Countries (drop out)	
Mollick et al. 2010	Δ population (or employment) County logarithmic population density growth between	Share of individuals in the county: Youth, Mid, Old. Argument: Cities with a larger share of older workers in 1970 experienced a greater increase in average	IV, Cross section.	Texas counties (254)	1980, 1990, 2000 census

	1980-1990 and between 1990-2000	schooling in subsequent years.			
Moretti 2004	Wages		Cross section and panel data. IV: 1. Lagged of age structure, 2. Land-grant university	US cities (201) NxT= 44891	1979 - 1994 census
Shapiro 2006	Growth in: Productivity, employment, wage, rental price, house value.	Share college educated. Dependent variables alternate as explanatory in other regressions. (a simple neoclassical growth model is calibrated)	IV: Land-grand colleges and Universities (1862), compulsory schooling laws.	US Cities	

2010

2010/1, De Borger, B., Pauwels, W.: "A Nash bargaining solution to models of tax and investment competition: tolls and investment in serial transport corridors"
2010/2, Chirinko, R.; Wilson, D.: "Can Lower Tax Rates Be Bought? Business Rent-Seeking And Tax Competition Among U.S. States"
2010/3, Esteller-Moré, A.; Rizzo, L.: "Politics or mobility? Evidence from us excise taxation"
2010/4, Roehrs, S.; Stadelmann, D.: "Mobility and local income redistribution"
2010/5, Fernández Llera, R.; García Valiñas, M.A.: "Efficiency and elusion: both sides of public enterprises in Spain"
2010/6, González Alegre, J.: "Fiscal decentralization and intergovernmental grants: the European regional policy and Spanish autonomous regions"
2010/7, Jametti, M.; Joanis, M.: "Determinants of fiscal decentralization: political economy aspects"
2010/8, Esteller-Moré, A.; Galmarini, U.; Rizzo, L.: "Should tax bases overlap in a federation with lobbying?"
2010/9, Cubel, M.: "Fiscal equalization and political conflict"
2010/10, Di Paolo, A.; Raymond, J.L.; Calero, J.: "Exploring educational mobility in Europe"
2010/11, Aidt, T.S.; Dutta, J.: "Fiscal federalism and electoral accountability"
2010/12, Arqué Castells, P.: "Venture capital and innovation at the firm level"
2010/13, García-Quevedo, J.; Mas-Verdú, F.; Polo-Otero, J.: "Which firms want PhDS? The effect of the university-industry relationship on the PhD labour market"
2010/14, Calabrese, S.; Epple, D.: "On the political economy of tax limits"
2010/15, Jofre-Monseny, J.: "Is agglomeration taxable?"
2010/16, Dragu, T.; Rodden, J.: "Representation and regional redistribution in federations"
2010/17, Borck, R; Wimbersky, M.: "Political economics of higher education finance"
2010/18, Dohse, D; Walter, S.G.: "The role of entrepreneurship education and regional context in forming entrepreneurial intentions"
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2010/20, Pelegrín, A.; Bolance, C.: "International industry migration and firm characteristics: some evidence from the analysis of firm data"
2010/21, Koh, H.; Riedel, N.: "Do governments tax agglomeration rents?"
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