Rewards to university investment in research

Abstract

This paper investigates whether universities benefit from the resources invested in academic research. Specifically, we examine whether the ability of universities to attract the best performing students is related to the strength of their research activity. Using the population of bachelor's degrees offered by Spanish public universities for the period 2007-2017, we document a positive relationship between admission grades and research, which suggest that the best ability students prefer to enrol at a research intensive university. When we split the sample by field of knowledge, we find that the association between research and admission grades holds for the areas with intermediate levels of demand for their degrees (i.e. engineering, sciences, and social sciences), which altogether account for 84 per cent of the observations in our sample. In the areas with the highest and lowest level of demand for their degrees (i.e. health and humanities, respectively), we find that admission grades are unrelated to research. The evidence suggests that, whenever universities compete among them for students, academic research helps in attracting (the best performing) students.

Keywords: university research, admission grades, university reputation, competition

1. Introduction

A significant amount of time, effort, and financial funds of universities is being devoted to research activities and there are voices questioning whether the current emphasis on research is detracting resources from teaching (e.g. Laband and Tollison, 2003). Critics of the research orientation of universities argue that faculty's time and effort and financial resources invested in research activities cannot be dedicated to teaching and, therefore, an excessive emphasis on research might end up hampering teaching quality (e.g. Besancenot et al., 2009). Prior research, however, does not provide clear evidence of researchers being less effective in their teaching activities than non-researchers; at most, there is no significant difference between research-oriented and teaching-oriented faculty (e.g. Hattie and Marsh, 1996). Furthermore, when examining students' perceptions, the evidence suggests that, although students perceive disadvantages in staff involvement in research (e.g. lack of availability), they also perceive clear benefits from staff research, being up-to-date knowledge and enthusiasm the two main tangible benefits (e.g. Jenkins *et al.*, 1998, Lindsay *et al.*, 2002).

The present study seeks to contribute to this line of research by examining the relationship between teaching and research from a different angle. Prior literature generally focuses on teaching and research performance at the individual (teacher) level, whereas in this study we examine whether students' choices, when selecting the university in which to study a given degree, are related to the overall university research performance in the specific field of knowledge to which the degree pertains.

In the same way as research and development (R&D) carried out by firms, academic research is expected to provide universities with future benefits. Whenever funding is related to research achievements, research quality directly affects the amount of financial funds gathered by the university. The benefits linked to research, however, are not likely to be limited to financial resources. In this paper, we argue that research intensive universities benefit from their ability to attract the best performing students. Given the importance of university prestige for students' future labor outcomes (e.g. Black and Smith, 2006, Mitra and Golder, 2008, Broecke, 2012, Ashley et al., 2015), and the prominent role played by university research in rankings and league tables (e.g. Dill and Soo, 2005), we expect that the best ability students opt for research intensive universities.

To test our hypothesis we select a country, Spain, where the funding received by public universities mainly comes from the regional government and it is not strongly linked to research performance. In such an institutional setting, the incentives to promote research activities at universities are likely to

arise from factors other than funding; specifically, competition for (the best performing) students might incentivize a research orientation in universities.

Using data on the cut-off grades to be enrolled in any of the bachelor's degrees offered by Spanish public universities in the period 2007-2017, we find that admission grades are positively and significantly related to university research activity (i.e. number of publications in first quartile journals, number of citations in the Web of Science, and total number of publications). When splitting the sample into the main fields of knowledge (i.e. engineering, sciences, humanities, health, and social sciences), the positive association between scientific research and admission grades documented for the full sample is observed in the fields of engineering, sciences, and social sciences, which altogether account for more than 84 per cent of the observations in our sample. In the fields of health and humanities, however, we do not find a significant association between research and admission grades. Humanities (health) is, precisely, the area with the lowest (highest) ratio of applications to number of places offered and we conjecture that the abnormally low (high) demand for the degrees in the field of humanities (health), joined to the relatively low (high) level of research intensity in all universities in the humanities (health) area, substantially reduce competition for students among universities and, therefore, the role played by research in attracting the best performing students is attenuated or eliminated.

The study contributes to prior literature in two main different respects. First, our findings suggest that universities benefit from investments in research, as research quality allows them to enrol the best performing students. Second, we provide evidence, although indirect, relating to the research-teaching nexus. Our findings are consistent with the view that there are mutual synergies between research and teaching (e.g. Bell *et al.*, 1993, Beaver, 2015, Rodriguez and Rubio, 2016, Artés *et al.*, 2017, Cadez *et al.*, 2017), as students' choices suggest that they prefer to enrol at universities actively involved in research. Whether teaching quality is higher in research intensive universities than in the rest we cannot say, but our findings suggest that students with high academic performance prefer to enrol at universities excelling in research. Apart from the potential synergies between research and teaching, enrolling students with strong academic performance is likely to boost the teaching quality of the university. These students are highly motivated and they are likely to be willing to devote their time and effort to learn and develop different skills, which will undoubtedly trigger the interest and enthusiasm of the academic staff. Therefore, even if we assumed that research and teaching are competing activities and that the effort devoted to research could hinder the quality of teaching (e.g.

Bellas and Toutkoushian, 1999, Berbegal-Mirabent *et al.*, 2016), given the students' motivation and demands, the commitment of faculty to high quality teaching seems inevitable.

The paper proceeds as follows. The next section reviews the literature and develops the hypothesis. Section three describes the research design, Section four presents the results, and Section five discusses the main findings and provides the conclusions.

2. Review of the literature and hypothesis development

The selection of the university in which to study a bachelor's degree is a key decision to be made by prospective students. Extant research suggests that students coming from reputable institutions enjoy higher job opportunities (e.g. Ashley *et al.*, 2015, Drydakis, 2016), earn higher wages (e.g. Behrman *et al.*, 1996, Brewer *et al.*, 1999, Black and Smith, 2004, Black and Smith, 2006, Broecke, 2012), and their promotion is quicker (e.g. Araki *et al.*, 2016). As an example, Ashley et al. (2015) find that elite law, accountancy, and financial service firms tend to recruit a large proportion of new entrants from a reduced group of prestigious universities, which translates into applicants from these universities enjoying a higher probability of getting a job in the aforementioned elite firms. Along the same line, Drydakis (2016) finds that graduates who studied in more reputable universities gain higher chances of receiving invitations to interviews to access vacancies and of being shortlisted for higher earnings jobs. Similarly, Chevalier (2014) finds a significant non-linear wage premium to university quality, being the premium significantly higher for the most prestigious institutions.

The impact of university reputation on students' labour opportunities is explained by university prestige being a key input for employers when first forming an opinion on workers' ability (e.g. Araki *et al.*, 2016, Bordón and Braga, 2017). As employers cannot directly observe the performance of prospective employees, they are likely to take the reputation of the university in which the prospective employee graduated as signal of her/his ability and productivity (e.g. Drydakis, 2016). Because of their selective admission system, only the best-ability students have access to the most prestigious universities. Furthermore, high performing students are likely to select the most reputable university from their set of options (e.g. Dale and Krueger, 2002). Additionally, it is the best performing students who are likely to find it easier to cope with the strong requirements and demands of reputable universities. This is why attending a prestigious university signals students' strong ability and productivity.

When making their choices, students are likely to use university rankings and league tables as a means

of assessing the quality of universities (e.g. Griffith and Rask, 2007). Two leading determinants of university rankings are the quality of the incoming students and the quality of staff and research (e.g. Dill and Soo, 2005). The most prestigious universities attract high ability students and this, in turn, enhances the reputation of the university. As for research, university administrators are investing significant resources in research hoping that these investments strengthen the reputation of their institutions (Siemens *et al.*, 2005). In the end, they are competing for the best able students who are likely to select the most prestigious universities from the options open to them. Hence, research performance is deemed essential to maintain or enhance the prestige of the university and this explains why the most reputable universities are generally research intensive institutions (e.g. Armstrong and Sperry, 1994, Borokhovich *et al.*, 1995, Kim *et al.*, 2009).

Given the role played by research in building the reputation of the university and taking into account the importance of university prestige for students' labour outcomes, we expect that research intensive universities attract the best performing students. This is the hypothesis to be tested in this study.

3. Research design

3.1. Sample

The sample comprises all bachelor's degrees offered by Spanish public universities with face-to-face teaching for the period 2007-2017[1]. Data on the number of students enrolled, admission grades, and places offered per degree and university were downloaded from the website of the Ministerio de Educación, Cultura y Deporte (Spanish Ministry of Education, Culture, and Sports). Whenever a university offers the same degree in two or more different campuses, detailed data per campus is provided. In spite of this, we decided to aggregate all data referring to the same degree and university because our main explanatory variables are measured at the university-field of knowledge level. As for the admission grades, we computed a weighted average across all campuses using the number of students enrolled as weights.

Data on research activity (e.g. number of first quartile publications, number of citations, or total number of publications) for Spanish public universities was gathered from the website of the IUNE Observatory (www.iune.es). Research data is disaggregated by field of knowledge and it is available for the period 2005-2016. As we need up to two lags of research variables, our analysis is restricted to the period 2007-2017.

[1] We exclude from our analyses the degrees offered by centres which are not directly run by a public university.

3.2. Dependent variable

Admission grade is the cut-off grade to be admitted in a given bachelor's degree-university-year. Admission grades largely vary across degrees and universities. The ratio of total demand to total number of places offered (in the whole country) is well above one in a number of degrees (e.g., medicine), whereas in others it is far below one. Specifically, the number of places offered approximates the demand in the fields of engineering and humanities, whereas in the field of health the demand multiplies by almost four the number of places offered. As a result, cut-off grades in engineering and humanities are, on average, close to five, the minimum grade required to be admitted in a Spanish public university, whereas in the field of health the average admission grade is above eight.

Apart from the differences between degrees, cut-off grades for a given degree vary across universities, particularly in the case of degrees with intermediate levels of the ratio demand to number of places offered. Because of the variability of cut-off grades across degrees and universities, we decided to compute a measure of the abnormal admission grade for a given degree, university, and year:

$$Abn\_Admission\ grade_{ijt} = \frac{Admission\ grade_{ijt} - Mean\ admission\ grade_{it}}{Standard\ deviation\ admission\ grade_{it}}$$

Where the subscript *ijt* stands for the degree *i* in university *j* and period *t*. *Admission grade* is the cut-off grade to be admitted in a given degree and university in a particular year. We standardize this variable by subtracting from the admission grade its mean, computed across all Spanish public universities with face-to-face teaching, and dividing the resulting amount by the standard deviation (also across all universities). Positive (negative) values of the standardized variable (i.e. *Abn_ Admission grade*) indicate that the cut-off grade for a given degree-university-year is higher (lower) than the mean for the same degree-year in the whole country. Put differently, the higher the value of the *Abn_Admission grade* variable, the stronger is the position of the university as regards that degree. This is the dependent variable used in our regression analyses.

3.3. Treatment variables

The research activity developed by universities is likely to crystallize in the publication of papers in highly reputed scientific journals. We use the total number of papers published with the affiliation of the university in the first quartile of the respective *Journal of Citation Reports* as a proxy for

university-area scientific activity[2]. To account for the size of the university, we scale the scientific research variable by the total number of tenured staff. The scientific activity largely varies across areas and because of this, we standardize the research variable by subtracting its country mean and dividing all by its country standard deviation. Specifically, we compute the abnormal scientific research variable as follows:

$$Abn\_First\ quartile_{jkt} = \frac{First\ quartile_{jkt} - Mean\ First\ quartile_{kt}}{SD\ First\ quartile_{kt}}$$

The subscript *j*, *k*, and *t* stands for university, area, and year, respectively. The abnormal scientific research variable (i.e. *Abn_First quartile*) reflects the research strength of university *j,* in the field of knowledge *k,* as compared to the same area in the rest of the Spanish public universities.

3.4. Control variables

Admission grades are likely to be influenced by factors other than the research activity of the university. Therefore, we include the following variables as controls:

Tuition fees – When making their choice between different universities offering the same degree, students are likely to consider the amount of tuition fees (e.g., Soo and Elliott, 2010, Walsh *et al.*, 2015). To control for this potential factor, we add the *Abn Fee* variable, measured as the first year enrolment tuition fee per European Credit Transfer and Accumulation System (ECTS) (in euros) for a given degree minus its country-year mean and all divided by its country-year standard deviation. In the computation of the *Abn fee* variable we require that the degree is offered by a minimum of three universities. Tuition fees are set at the region level[3] and they are updated every year. By computing the *Abn fee* variable, we obtain a measure that is not affected by changes in prices.

Second enrolment premium – Second enrolment fees are usually higher than first enrolment ones (i.e., there is a second enrolment premium). High premiums might deter (attract) low (high) performing

[2] The information is disaggregated by field of knowledge and this is the reason to define the variable at the university-field of knowledge level. Although the number of first quartile publications is the variable used in our main analysis, we also estimate all our models employing the total number of citations in the Web of Science, and the total number of papers published in journals included in the Web of Science, as proxies for the research activity of the university.

[3] Regions usually set tuition fees that vary across degrees depending on their level of experimentalism (e.g. tuition fees for a medicine degree are usually higher than tuition fees for an economics degree), but the classification of degrees according to their level of experimentalism varies across regions.

students. We use the ratio of the second to the first enrolment fee as a measure of the premium required in a second enrolment.

Number of places offered – Admission grades will increase as the number of places offered decrease, *ceteris paribus*. This is why we add the number of places offered for a given degree-university as an additional control variable.

Percentage of tenured staff – Students' decisions might also be affected by the proportion of tenured staff. In our regression models, we include the ratio of tenured staff to total staff (*Tenured staff (%)*) as an additional control variable.

Student-to-staff ratio – This ratio is often regarded as an objective measure of teaching quality (Horstschräer, 2012). Although a low ratio does not guarantee better teaching, it is likely that students receive more attention from academics when the number of staff is high. We use the ratio of first-year students in a given university-year scaled by the total number of academic staff in that university as a proxy for the staffing level of the institution.

University size – Large universities might attract more students (e.g. Cattaneo *et al.*, 2017). We use the number of first-year students enrolled in a given university as a proxy for university size. As the variable *University enrolment* is highly skewed, we employ its natural logarithm transformation in the regression analyses.

University age – The attractiveness of universities for students might vary depending on the age of the university. Some students might appreciate being enrolled at a university with a long history, whereas others will prefer young universities specialised in certain fields of knowledge. Therefore, we include the age of the university as an additional control in our regression analyses.

Population – Students prefer to enrol at universities located in major cities where they have access to a wide array of cultural and social life options (e.g. Soo and Elliott, 2010). We add the population of the city in which the university is headquartered (*Populatio*n) as a proxy for the cultural and social life attractiveness of the university environment. In the same way as with the *University enrolment* variable, we use its natural logarithm transformation in our regression analyses because of the skewness of the original variable.

4. Results

4.1. Descriptive statistics

Table 1 presents the descriptive statistics for the variables used in our analyses. As it can be seen, there are large differences in the admission grades between the observations included in our sample. Cut-off grades are measured at the degree-university-year level. The minimum is five (5), which is the entry requirement to be admitted in any degree in a public university in Spain, disregarding whether the degree program has a restricted number of places or not. By examining Table 1, it can be observed that the admission grade is five (5) for almost half of the observations in our sample. Cut-off grades close to five are observed whenever places are not restricted or the number of available places exceeds the demand.

[Insert Table 1 about here]

Admission grades, as well as research activity, tend to be rather stable over time, whereas we observe important differences between universities. Table 1 shows that, in both cases (admission grades and research variables), the *between* standard deviation is much larger than the *within* deviation, thereby indicating that cross-sectional differences are far more important than time-series variation.

As for the control variables, Table 1 shows large differences across the observations in our sample in the first enrolment fee and the second enrolment premium. Tuition fees are set at the region level and there are large differences across regions. Important divergences are also observed in the number of places offered by each university for a given degree, as well as in the proportion of tenured staff. Dissimilarities are likewise observed in the size and age of universities, as well as in the population of the city where the university is headquartered.

Table 2 presents the correlation matrix. As it can be seen, admission grades are positively and significantly related to research activity as measured by the number of first quartile publications. Similar correlation coefficients, untabulated, are observed for the number of citations and the total number of publications variables. Admission grades are also significantly related to abnormal tuition fees, student-to-staff ratio, university size and age, and population. Finally, Table 2 also shows significant correlations between first quartile publications and control variables.

[Insert Table 2 about here]

4.2. Regression analyses

To test whether admission grades are related to the research activity conducted at the university, we regress admission grades on the research proxy. Specifically, we estimate the following equation:

$$Abn\_Admission\ grade_{ijt} = \alpha + \beta_1\ Research_{kjt-1} + \beta_2\ Abn\_Tuition\ fee_{ijt} + \beta_3\ 2^{nd}\ enrolment\ premium_{ijt} + \beta_4\ Student\text{-}to\text{-}staff\ ratio_{jt-1} + \beta_5\ Ln\ No\ places\ offered_{ijt} + \beta_6\ Tenured\ staff_{jt} + \beta_7\ Ln\ University\ enrolment_{jt} + \beta_8\ Ln\ University\ age_{jt} + \beta_9\ Ln\ Population_{jt} + Time\ effects + \varepsilon_{ijt} \quad (1)$$

Where *Research* refers to the research activity proxy (e.g. *Abn_First quartile*) and all variables are as defined in Section 3. The subscripts *i*, *j*, *k*, and *t* stand for degree, university, field of knowledge, and time, respectively. The research variable, the student-to-staff ratio, and the percentage of tenured staff are lagged one year.

As the research variable is not strictly exogenous, we estimate a two-stage regression model. In the first stage, we regress the research variable on the instruments and the controls used in the second stage regression. We use the number of state research grants (*State grants*) and European Union research grants (*EU grants*) received by the university, and the number of research internships (*Research internship*) and university internships (*University internship*) as instruments for the research activity variable. Research grants and internships are correlated with the research proxies, but they are not expected to affect admission grades, except for the influence exerted via their impact on research. We estimate the model using the random effects technique and Table 3 presents the results of this estimation[4].

[Insert Table 3 about here]

Table 3 shows that the coefficients of the instruments included in the first stage are significantly different from zero in all four cases and the Sargan-Hansen test indicates that the null of exogenous instruments is not rejected (p=0.147), thereby suggesting that research grants and internships are valid instruments for the research activity conducted at universities.

By examining the results of the second stage regression, it can be observed that prior year first quartile publications are positively and significantly related to current admission grades (p=0.000) [5]. Results indicate that cut-off grades are significantly higher in research intensive universities, which suggests that they are attracting the best ability students. As for control variables, we find that admission grades are positively related to the second enrolment premium, the proportion of tenured staff, university

[4] Table 3 reports the results obtained when the research activity is proxied by the number of first quartile publications, but the tenor of the results remains qualitatively unchanged when we use the total number of citations or the total number of publications in the Web of Science, as proxies for the research activity. These results are not tabulated, but they are available from the authors.

[5] To account for differences in size across universities, when computing the abnormal measure of research, we scale the research variable (e.g. first quartile publications) by the total number of tenured staff in the university. We obtain similar results if the research variable is unscaled.

size, as measured by first-year students' enrolment, and population of the city where the university is headquartered, and negatively related to the tuition fees, the number of places offered, the student-to-staff ratio, and university age. Consistent with prior evidence, results suggest that students prefer large universities, conveniently staffed, and located in areas with easy access to a wide array of social activities (e.g., Sá *et al.*, 2012). Results also show a preference for young universities, perhaps due to their specialization. As for the second enrolment premium, which is set by the regional government, it does not seem to discourage students; on the contrary, the positive association between this variable and abnormal admission grades suggests that the best performing students, which are the first to choose, prefer to enrol at a university located in a highly demanding region.

Results presented in Table 3 refer to the full sample comprising all bachelor's degrees offered by Spanish public universities. Research intensity and the number of students' applications received vary, however, across fields of knowledge and because of these dissimilarities, the association between research and admission grades might be different in each of the main areas.

Panel A in Table 4 presents the ratio of demand to number of places offered for each area. As it can be observed, in the fields of engineering and humanities, the ratio is below one for more than half of the observations in our sample. This low demand contrast with the high values observed in the health area, where the same ratio is over one for almost 90 per cent of the observations.

As for admission grades, Panel B in Table 4 disaggregates the descriptive statistics of this variable by areas. In the field of health, the high ratio of demand to number of places offered observed in Panel A translates into cut-off grades well above the minimum grade to be admitted in a public university. In the case of humanities, however, the admission grade is five for almost 75 per cent of the observations in our sample.

[Insert Table 4 about here]

Regarding the research activity, Panel C in Table 4 also shows large dissimilarities between the main fields of knowledge. The median number of first quartile publications per academic staff is over 0.1 in the fields of sciences, health, and engineering, below 0.03 in social sciences, and even lower (<0.01) in the arts and humanities field. As it can be appreciated, the highest level of scientific research intensity corresponds to the field of sciences, intermediate positions are occupied by health and engineering, and the lowest levels correspond to social sciences and humanities.

In light of the differences observed between areas, we decided to re-estimate Equation (1) for each of the main fields of knowledge. Table 5 reports the results of these re-estimations under the headings of Engineering, Sciences, Humanities, Health, and Social Sc., respectively.

[Insert Table 5 about here]

The evidence reported in Table 5 is consistent with that obtained for the full sample, except for the fields of humanities and health, in which the coefficient of the research variable is indistinguishable from zero. In the rest of the fields, however, the coefficient of *Abn_First quartile* is positive and statistically significant, thereby indicating that cut-off grades are significantly higher in research intensive universities. The magnitude of the coefficient and the level of significance are higher in the fields of social sciences and engineering. Results for these two areas, which altogether account for 60 per cent of the observations in our sample, suggest that the best ability students prefer to enrol at research oriented universities. The evidence is less strong in the case of sciences, the area with the highest level of first quartile publications. In this field, most universities reach a high level of first quartile publications and there is less variation across universities than in other areas; this might explain why the association between research and admission grades is weaker in the science field than in the areas of engineering or social sciences.

In the humanities and health areas, the fields with the lowest and highest ratio of demand to number of places offered, respectively, we do not find a significant association between research and admission grades. As explained before, the cut-off grade to be enrolled in a bachelor's degree in the humanities field is five (the entry requirement to be admitted in a Spanish university) for two thirds of the observations in our sample. The relatively low demand for most of the humanities degrees, joined to the low number of first quartile publications in this field (see Panel B in Table 4), might explain the insensitivity of the abnormal admission grades to the research activity in this field of knowledge.

Table 5 also shows differences between humanities and the rest of fields in the coefficients of some of the control variables. In the case of the abnormal tuition fee variable, the coefficient is indistinguishable from zero in all areas except for humanities. Hence, high fees do not seem to discourage students, except in the humanities area, where students show a preference for universities located in regions with lower prices per ECTS. Students' choices in the humanities area are unrelated to the rest of the control variables included in the model except for the population of the city where

the university is headquartered. Once again, the low demand for most of the degrees in the humanities field might explain these findings.

In the health field the situation is the inverse; the demand doubles the number of places offered in almost 60 per cent of the observations in our sample and we conjecture that the strong demand for the degrees offered in this area, joined to the high level of first quartile publications in this field in most universities, might underlie the absence of an association between research and admission grades. When the number of places offered in the whole country is far below the total number of applications received, as in the case of the health field, cut-off grades are inevitably high in all universities. The best performing students are attracted by these highly demanded degrees which generates a fierce competition to get a place in one of the universities offering the degree. In such a competitive environment, the characteristics of the university offering the degree might be of second order of importance.

Letting aside the fields of health and humanities, which represent less than 16 per cent of the observations in our sample, our findings suggest that research oriented universities benefit from enrolling the best ability students. Even in the case of health and humanities, we do not find evidence consistent with the best ability students being discouraged by universities actively involved in research.

5. Discussion and conclusions

This paper investigates whether research effort helps universities in attracting the best performing students. Using data on the cut-off grades to be admitted in any of the bachelor's degree offered by Spanish public universities, we document a positive association between university research and students' choices for all fields of knowledge except for health and humanities. From our results we infer that the best ability students prefer to enrol at a research intensive university (i.e. admission grades are significantly higher in these universities).

Our findings suggest that universities compete for the best performing students and research provides them with a significant competitive advantage. Students' preference for research intensive universities is justified by the widely documented superior labour outcomes associated with graduating in a prestigious university. In building the prestige of the university, research quality plays a key role. First, it is usually a key factor in university rankings and league tables, which are likely to inform prospective students and employers about the quality of the university. Second, high quality research enhances the visibility of the university because of the media coverage of its main advances.

This is also likely to affect both students' and employers' perceptions. Furthermore, research quality helps in attracting the best ability students and this, in turn, enhances the reputation of the university (i.e. the quality of the income students is a key element in university rankings).

The evidence gathered in this paper also informs, although indirectly, the debate regarding whether teaching and research are mutually exclusive, complementary, or unrelated activities. The preferences shown by the best ability students are consistent with the existence of synergies between research and teaching. Our study focuses on bachelor's degree decisions; therefore, research in itself is not likely to be a key determinant of prospective students' decisions, as it would be in the case of doctoral studies; instead, we conjecture that research quality, either directly or via university rankings, is taken as a signal of teaching quality. Research oriented academic staff might impose higher demands on their students (e.g. Friedrich and Michalak, 1983, Demski and Zimmerman, 2000), but this, rather than discourage, seems to attract high ability students, willing to make the most of their bachelor's studies.

Overall, the evidence gathered in this paper suggests that investments in research allow universities to build important intangible assets from which they will benefit in the future. These assets might not be presented in the balance sheets of universities, but according to our findings they are taken into consideration by prospective students when making their choices.

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Table 1. Descriptive statistics

		Mean	Dev	Min	Max	P25	P50	P75
Dependent variable								
Admission grade	overall	6.621	2.070	5.000	13.667	5.000	5.533	7.820
	between		1.842					
	within		0.530					
Abn_Admission grade		0.042	0.959	-4.065	5.499	-0.565	-0.259	0.615
Treatment variable								
L1.First quartile	overall	0.102	0.114	0.000	1.072	0.022	0.062	0.144
	between		0.102					
	within		0.023					
L1.Abn_First quartile		0.085	0.974	-1.558	6.173	-0.435	-0.190	0.290
Control variables								
Tuition fees (€/ECTS)		17.652	7.066	7.900	39.530	12.620	14.750	22.930
Abn Tuition fee		0.038	0.965	-2.620	2.953	-0.766	-0.056	0.826
2nd enrolment premium		1.589	0.325	1.000	2.257	1.235	1.500	1.999
No places offered		125	107	10	950	60	85	150
Ln No places offered		4.561	0.720	2.303	6.856	4.094	4.443	5.011
L1.Tenured staff (%)		0.574	0.111	0.236	0.830	0.503	0.581	0.641
L1.Student-to-staff ratio		2.233	0.609	0.522	5.734	1.861	2.105	2.465
University enrolment		5337	2899	378	12684	3079	4502	7075
Ln University enrolment		8.429	0.570	5.935	9.448	8.032	8.412	8.864
University age		187	244	9	799	25	40	471
Ln University age		4.304	1.349	2.197	6.683	3.219	3.689	6.155
Population (thousands)		593	850	29	3265	138	230	666
Ln Population		5.663	1.157	3.375	8.091	4.928	5.439	6.501
Instrumental variables								
L2. State grants		0.043	0.021	0.002	0.214	0.031	0.040	0.051
L2. EU grants		0.006	0.008	0.000	0.109	0.002	0.004	0.007
L2.Research internship		0.011	0.008	0.000	0.078	0.007	0.010	0.014
L2.University internship		0.023	0.027	0.000	0.196	0.008	0.014	0.023

Table 1 (continued)

Data corresponds to the 47 Spanish public universities with face-to-face teaching and the sample comprises 11,979 university-degree-year observations for the period 2007-2017. *Admission grade* is the cut-off grade to be admitted in a given grade and university; *First quartile* is the total number of papers published with the affiliation of the university in the first quartile of the respective Journal of Citation Reports*; Tuition fee* is the tuition fee per ECTS (in euros); *2nd enrolment premium* is the ratio of second to first enrolment fees*; (LN) No places offered* is (the natural logarithm of) the number of places offered*; Tenured staff* (%) is the proportion of tenured staff; *Student-to-staff ratio* is the ratio of the total number of first-year students to the total academic staff of the university*; (Ln) University enrolment* is (the natural logarithm of) the total number of first-year students enrolled at the university; (*Ln*) *University age* is the natural logarithm of the age of the university; (*Ln*) *Population* is (the natural logarithm of) the population (data in thousands) of the city in which the university is headquartered; *State grants* is the number of research grants received from the central government; *EU grants* is the number of research grants received from the EU; *Research internship* is the number of research internship positions in the university; *University internship* is the number of university internships in the university. The prefix *Abn* means that the variable is standardized (i.e. we subtract its country-year mean and divide all by its country-year standard deviation). Student related variables are disaggregated at the university-degree level, whereas the research variable (i.e. *First quartile)* is measured at the university-field of knowledge level. The research variable and the instrumental variables are scaled by the university total number of tenured staff.

Table 2. Correlation matrix (Spearman correlation coefficients)

	Abn_Adm. grade	*L1_Abn_ First q.*	*Abn_Tuition fee*	*2nd enrol premium*	*No places offered*	*Tenured staff*	*Student-to-staff*	*Enrolment*	*University age*
L1.Abn_First quartile	0.149								
	(0.000)								
Abn_Tuition fee	0.063	0.335							
	(0.000)	(0.000)							
2nd enrolment premium	-0.013	-0.122	-0.254						
	(0.177)	(0.000)	(0.000)						
Ln No places offered	0.038	0.091	0.029	0.047					
	(0.000)	(0.000)	(0.003)	(0.000)					
Tenured staff (%)	-0.002	-0.353	-0.354	0.198	0.043				
	(0.823)	(0.000)	(0.000)	(0.000)	(0.000)				
Student-to-staff ratio	-0.080	-0.280	-0.347	0.342	0.037	0.229			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
Ln University enrolment	0.227	-0.051	0.022	0.067	0.249	0.172	0.167		
	(0.000)	(0.000)	(0.025)	(0.000)	(0.000)	(0.000)	(0.000)		
Ln University age	0.105	-0.059	-0.004	0.103	0.119	0.271	-0.165	0.604	
	(0.000)	(0.000)	(0.662)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Ln Population	0.171	0.109	0.093	0.111	0.177	0.200	-0.080	0.335	0.354
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

The sample comprises 11,979 university-degree-year observations for the period 2007-2017. *Admission grade* is the cut-off grade to be admitted in a given grade and university; *First quartile* is the total number of papers published with the affiliation of the university in the first quartile of the respective Journal of Citation Reports*; 1st enrolment fee* is the tuition fee per ECTS (in euros); *2nd enrolment premium* is the ratio of second to first enrolment fees*; Ln No places offered* is the natural logarithm of the number of places offered*; Tenured staff* (%) is the proportion of tenured staff; *Student-to-staff ratio* is the ratio of the total number of first-year students to the total academic staff of the university*; Ln University enrolment* is the natural logarithm of the total number of first-year students enrolled at the university; *Ln University age* is the natural logarithm of the age of the university; *Ln Population* is the natural logarithm of the population (data in thousands) of the city in which the university is headquartered. The prefix *Abn* means that the variable is standardized (i.e. we subtract its country-year mean and divide all by its country-year standard deviation). Student related variables are disaggregated at the university-degree level, whereas research variables are measured at the university-field of knowledge level. Scientific research variables, as well as the student-to-staff ratio and the percentage of tenured staff are lagged one year. Significance levels are shown in parentheses.

Table 3. Regression of admission grades on research activity for the full sample

	First-stage regression	Random-effects IV regression
Dependent variable	*L1.Abn_First quartile*	*Abn_Admission grade*
L1.Abn_First quartile		0.349***
		(8.356)
Abn Tuition fee	0.101***	-0.048***
	(11.34)	(-3.123)
2nd enrolment premium	0.028	0.112***
	(1.26)	(3.133)
Ln No places offered	0.056***	-0.056***
	(4.64)	(-2.859)
L1.Tenured staff (%)	-1.351***	0.731***
	(-16.23)	(4.621)
L1.Student-to-staff ratio	-0.061***	-0.120***
	(-5.52)	(-6.772)
Ln University enrolment	-0.009	0.345***
	(-0.43)	(10.804)
Ln University age	-0.111***	-0.048***
	(-12.07)	(-3.287)
Ln Population	0.105***	0.034**
	(11.1)	(2.064)
L2. State grants	7.815***	
	(22.97)	
L2. EU grants	14.698***	
	(20.64)	
L2.Research internship	2.117***	
	(5.43)	
L2.University internship	4.332***	
	(14.74)	
Constant	-35.969***	-5.698
	(-9.05)	(-1.043)
Time effects	Yes	Yes
Observations	11,979	11,979
Wald Chi-Squared	3,861	282.9
P-value	0.000	0.000
R-Sq within		0.002
R-Sq between		0.089
R-Sq overall		0.079
Sargan-Hansen test		5.359
P-value		0.147

Table 3 (continued)

The sample comprises 11,979 university-degree-year observations for the period 2007-2017. *Admission grade* is the cut-off grade to be admitted in a given grade and university; *First quartile* is the total number of papers published with the affiliation of the university in the first quartile of the respective Journal of Citation Reports*; Tuition fee* is the tuition fee per ECTS (in euros); *2nd enrolment premium* is the ratio of second to first enrolment fees*; Ln No places offered* is the natural logarithm of the number of places offered*; Tenured staff* (%) is the proportion of tenured staff; *Student-to-staff ratio* is the ratio of the total number of first-year students to the total academic staff of the university*; Ln University enrolment* is the natural logarithm of the total number of first-year students enrolled at the university; *Ln University age* is the natural logarithm of the age of the university; *Ln Population* is the natural logarithm of the population (data in thousands) of the city in which the university is headquartered; *State grants* is the number of research grants received from the central government; *EU grants* is the number of research grants received from the EU; *Research internship* is the number of research internship positions in the university; *University internship* is the number of university internships in the university. The prefix *Abn* means that the variable is standardized (i.e. we subtract its country-year mean and divide all by its country-year standard deviation). Student related variables are disaggregated at the university-degree level, whereas the research variable is measured at the university-field of knowledge level. Research variable, as well as the student-to-staff ratio, and the percentage of tenured staff are lagged one year, and instrumental variables are lagged two years. Models are estimated using the random effects technique, year dummies are omitted from the table, and *t*-statistics are shown in parentheses. ***, **, * = statistically significant at the 1%, 5%, and 10% levels, respectively.

Table 4. Descriptive statistics disaggregated by field of knowledge

Panel A: Ratio of demand to number of places offered disaggregated by field of knowledge

Area	Obs.	Mean	Dev	Min	Max	P10	P25	P50	P75	P90
Engineering and architecture	3,228	1.042	0.711	0.002	8.500	0.344	0.583	0.923	1.295	1.825
Sciences	1,461	1.398	1.205	0.033	12.680	0.467	0.773	1.120	1.585	2.446
Arts and humanities	1,719	1.026	0.628	0.020	4.711	0.360	0.600	0.933	1.289	1.694
Health sciences	1,552	3.379	3.238	0.002	27.717	0.933	1.473	2.386	4.179	6.833
Social sciences	4,019	1.473	0.961	0.001	16.100	0.629	0.945	1.269	1.709	2.457

Panel B: Admission grades disaggregated by field of knowledge

Area	Obs.	Mean	Dev	Min	Max	P10	P25	P50	P75	P90
Engineering and architecture	3,228	5.960	1.668	5	13.356	5	5	5	6.280	8.453
Sciences	1,461	7.018	2.393	5	13.667	5	5	5.850	8.598	11.070
Arts and humanities	1,719	5.605	1.264	5	12.300	5	5	5	5.480	7.296
Health sciences	1,552	8.968	2.125	5	13.110	6.170	7.343	8.777	10.698	11.999
Social sciences	4,019	6.536	1.747	5	12.942	5	5	5.892	7.600	9.190

Panel C: First quartile publications disaggregated by field of knowledge

Area	Obs.	Mean	Dev	Min	Max	P10	P25	P50	P75	P90
Engineering and architecture	3,228	0.149	0.086	0.023	0.440	0.061	0.086	0.130	0.192	0.277
Sciences	1,461	0.214	0.138	0.033	0.678	0.089	0.125	0.161	0.271	0.409
Arts and humanities	1,719	0.012	0.012	0.000	0.119	0.002	0.004	0.008	0.014	0.023
Health sciences	1,552	0.163	0.149	0.003	1.072	0.044	0.073	0.122	0.187	0.329
Social sciences	4,019	0.038	0.043	0.000	0.381	0.011	0.018	0.028	0.043	0.063

Data corresponds to the 47 Spanish public universities with face-to-face teaching for the period 2007-2017.

Table 5. Regression of admission grades on research activity for the main fields of knowledge

Panel A: First-stage regression

	Engineering	Sciences	Humanities	Health	Social Sc.
Abn Tuition fee	0.161***	0.083***	0.198***	0.138***	-0.017
	(7.9)	(3.9)	(7.03)	(7.14)	(-1.5)
2nd enrolment premium	0.254***	0.125***	-0.020	-0.023	-0.106***
	(4.14)	(2.57)	(-0.26)	(-0.56)	(-3.83)
Ln No places offered	0.115***	0.112***	0.102**	0.115***	0.010
	(4.51)	(3.03)	(2.47)	(3.68)	(0.61)
L1.Tenured staff (%)	-1.537***	-1.181***	-1.553***	-1.287***	-1.764***
	(-8.53)	(-5.85)	(-5.41)	(-6.96)	(-16.43)
L1.Student-to-staff ratio	-0.190***	0.012	-0.045	-0.062***	0.102***
	(-8.39)	(0.38)	(-1.01)	(-2.63)	(7.03)
Ln University enrolment	-0.140***	-0.009	0.320***	0.061	-0.101***
	(-3.44)	(-0.19)	(5.23)	(1.37)	(-3.69)
Ln University age	-0.220***	-0.081***	-0.084***	0.028	-0.055***
	(-10.95)	(-3.85)	(-3.23)	(1.37)	(-4.27)
Ln Population	0.200***	0.027	-0.149***	0.074***	0.123***
	(9.75)	(1.28)	(-5.54)	(3.36)	(9.5)
L2. State grants	4.301***	10.029***	12.081***	6.794***	9.064***
	(5.64)	(11.22)	(9.6)	(9.05)	(22.23)
L2. EU grants	11.017***	16.675***	13.435***	15.972***	16.659***
	(7.1)	(6.16)	(4.81)	(8.43)	(21.21)
L2.Research internship	3.097***	-2.810***	0.447	0.600	4.463***
	(3.14)	(-2.86)	(0.32)	(0.68)	(9.92)
L2.University internship	2.241***	6.453***	5.005***	2.861***	5.231***
	(2.85)	(10.46)	(6.26)	(4.35)	(13.83)
Constant	-29.701***	-49.099***	-25.582*	-33.794***	-42.412***
	(-3.18)	(-5.34)	(-1.79)	(-4.32)	(-8.33)
Time effects	Yes	Yes	Yes	Yes	Yes
Observations	3,228	1,461	1,719	1,552	4,019
Wald Chi-Squared	1,093	628	611	592	3,292
P-value	0.000	0.000	0.000	0.000	0.000

Table 5 (continued)

Panel B: Second-stage regression

	Engineering	Sciences	Humanities	Health	Social Sc.
L1.Abn_First quartile	0.457***	0.227**	0.034	0.008	0.485***
	(3.654)	(2.027)	(0.372)	(0.050)	(9.189)
Abn Tuition fee	-0.049	0.058	-0.170***	-0.03	0.007
	(-1.308)	(1.317)	(-4.018)	(-0.619)	(0.286)
2nd enrolment premium	-0.014	-0.12	0.158	0.174**	0.244***
	(-0.155)	(-1.210)	(1.619)	(2.035)	(4.297)
Ln No places offered	-0.111***	-0.131*	0.062	-0.121*	-0.048
	(-2.806)	(-1.709)	(1.155)	(-1.794)	(-1.477)
L1.Tenured staff (%)	1.196***	0.228	-0.255	1.514***	0.850***
	(3.277)	(0.508)	(-0.607)	(3.298)	(3.224)
L1.Student-to-staff ratio	-0.041	-0.093	-0.091	-0.174***	-0.240***
	(-1.085)	(-1.471)	(-1.611)	(-3.560)	(-7.827)
Ln University enrolment	0.314***	0.462***	0.273***	0.487***	0.499***
	(5.057)	(4.743)	(3.417)	(5.271)	(8.756)
Ln University age	0.013	-0.068	-0.047	-0.091**	-0.083***
	(0.337)	(-1.604)	(-1.430)	(-2.157)	(-3.219)
Ln Population	0.003	0.05	-0.044	0.110**	0.032
	(0.067)	(1.160)	(-1.272)	(2.311)	(1.108)
Constant	4.901	-26.300*	-3.947	-2.824	-1.15
	(0.409)	(-1.683)	(-0.254)	(-0.206)	(-0.128)
Time effects	Yes	Yes	Yes	Yes	Yes
Observations	3,228	1,461	1,719	1,552	4,019
Wald Chi-Squared	76.25	45.84	44.76	74.96	228.7
P-value	0.000	0.000	0.000	0.000	0.000
R-Sq overall	0.072	0.105	0.087	0.183	0.199
Sargan-Hansen test	2.313	1.125	2.334	8.823	5.359
P-value	0.51	0.771	0.506	0.032	0.147

The sample comprises 11,979 university-degree-year observations for the period 2007-2017. *Admission grade* is the cut-off grade to be admitted in a given grade and university; *First quartile* is the total number of papers published with the affiliation of the university in the first quartile of the respective Journal of Citation Reports*; 1st enrolment fee* is the tuition fee per ECTS (in euros); *2nd enrolment premium* is the ratio of second to first enrolment fees*; Ln No places offered* is the natural logarithm of the number of places offered*; Tenured staff* (%) is the proportion of tenured staff; *Student-to-staff ratio* is the ratio of the total number of first-year students to the total academic staff of the university*; Ln University enrolment* is the natural logarithm of the total number of first-year students enrolled at the university; *Ln University age* is the natural logarithm of the age of the university; *Ln Population* is the natural logarithm of the population (data in thousands) of the city in which the university is headquartered; *State grants* is the number of research grants received from the central government; *EU grants* is the number of research grants received from the EU; *Research internship* is the number of research internship positions in the university; *University internship* is the number of university internships in the university. The prefix *Abn* means that the variable is standardized (i.e. we subtract its country-year mean and divide all by its country-year standard deviation). Student related variables are disaggregated at the university-degree level, whereas the research variable is measured at the university-field of knowledge level. Research variable, as well as the student-to-staff ratio, and the percentage of tenured staff are lagged one year, and instrumental variables are lagged two years. Models are estimated using the random effects technique, year dummies are omitted from the table, and *t*-statistics are shown in parentheses. ***, **, * = statistically significant at the 1%, 5%, and 10% levels, respectively.