Rewards to university investment in research*

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Abstract

This paper investigates whether universities benefit from their research activity. Specifically, we examine whether the ability of universities to attract the best performing students is related to the strength of their academic research. Using the population of bachelor's degrees offered by Spanish public universities for the period 2007-2017, we document a positive relationship between admission cutoff scores and academic research, which suggest that research intensive universities benefit from enrolling the best ability students. We observe heterogeneity, however, across fields of study, as the positive association between research and admission cutoffs holds for the areas engineering and social sciences, but not for the fields of health, humanities, and sciences. In these later areas, we find that admission cutoff scores are unrelated to research, which suggests that, in these fields, academic research neither helps, nor hinders, the ability of universities to attract the best performing students.

Keywords: academic research, admission cutoff scores, best ability students, university reputation

"The sums of public money spent on research are now huge and it is both inevitable and appropriate that questions should be asked about the efficiency and effectiveness of such expenditures." (Hopwood, 2008, p. 93)

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, Bennis and O'Toole, 2005). 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 hindering teaching quality (e.g. Besancenot *et al.*, 2009).

Whether teaching activities benefit from or are hampered by research has led the development of an extensive line of research which evidence is far from conclusive. Early revisions of the literature, carried out in the late eighties and nineties, suggest that there is a close to zero (although generally positive) relationship between research performance and teaching effectiveness (e.g. Feldman, 1987, Hattie and Marsh, 1996). More recent studies generally provide evidence supporting the complementarity between research and teaching (e.g. Galbraith and Merrill, 2012, Rodriguez and Rubio, 2016, Cadez *et al.*, 2017, Moschieri and Santalo, 2018), although there are papers documenting non-linearities in the association between research performance and teaching effectiveness (e.g. García-Gallego *et al.*, 2015, Artés *et al.*, 2017), or showing that the positive association between teaching and research holds only under certain conditions (e.g. Arnold, 2008, Carter, 2016, Palali *et al.*, 2018). Finally, evidence consistent with teaching and research being mutually exclusive and competing activities is rare, but it exists (e.g. Porter and Toutkoushian, 2006, Bak and Kim, 2015, Berbegal-Mirabent *et al.*, 2016).

The present study seeks to contribute to this line of research by examining the relationship between teaching and research from a different angle. Most prior studies focus on students' and/or peers' ratings of teaching quality and develop the analysis at the instructor level, to examine whether teaching ratings differ between researchers and non-researchers (e.g. Carter, 2016, Artés *et al.*, 2017, Moschieri and Santalo, 2018). Our study looks at the aggregate of students' choices and the analysis is performed at the university level with the objective of investigating whether universities benefit from their research activity. Whenever funding is related to research achievements, research performance 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, Hoekstra, 2009, Canaan and Mouganie, 2018, Zimmerman, 2018), 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 barely 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 ability) students might incentivize a research orientation in universities.

Using data on the admission cutoff scores for the bachelor's degrees offered by Spanish public universities in the period 2007-2017, we find that admission cutoffs are positively and significantly related to university research activity (i.e. number of publications in first quartile journals, number of citations, and total number of publications). The evidence suggests that research provides universities with a significant competitive advantage that allows them to enrol the best ability students.

The role played by research varies, however, across fields of study; the positive association between scientific research and admission cutoffs documented for the full sample holds for the fields of engineering and social sciences, but not for humanities, health, and science. These findings are consistent with prior literature showing a significant earnings premium to college or university selectivity that, nonetheless, is heterogeneous across disciplines. Specifically, the university selectivity premium tends to vanish for disciplines with the highest level of post-graduation earnings (e.g. medicine), as well as for fields with the lowest level of earnings (e.g. arts and humanities) (e.g. Hastings *et al.*, 2013, Walker and Zhu, 2018). The lack of an association between research and admission cutoffs observed in our study for the fields of health and humanities is in line with the aforementioned documented absence of an earnings return to university selectivity in disciplines with the highest and the lowest level of post-graduation earnings.

The study contributes to prior literature in two main different respects. First, our findings suggest that, in the fields of engineering and social sciences, universities benefit from their research activity, as research performance allows them to enrol the best ability students. These results suggest that universities compete for the best ability students and research provides them with a significant competitive advantage.

Second, we provide evidence, although indirect, relating to the research-teaching nexus. In the areas of engineering and social sciences, 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). Choices made by the best ability students 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 the best ability students 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.

In the rest of the fields, we do not observe a significant association between research and admission grades but, even in these areas, we do not have evidence suggestive of teaching being hampered by the research orientation of the university.

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, Zhang, 2005, Black and Smith, 2006, Broecke, 2012), and their promotion is quicker (e.g. Thomas and Zhang, 2005, 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.

Although most studies on this topic refer to the US and the UK, the labour market returns to university prestige are not limited to these countries. In a recent study, Zimmerman (2018) documents that the 1.8 per cent of students admitted to three business-focused majors at the two most selective universities in Chile account for 41 per cent of leadership positions (directors and top managers) in publicly traded corporations, and 39% of top 0.1 per cent of the income distribution. Positive labour market returns to university prestige are documented for other countries, such as Colombia (e.g. MacLeod *et al.*, 2017), France (e.g. Canaan and Mouganie, 2018), Italy (e.g. Anelli, 2016), Japan (e.g. Araki *et al.*, 2016), or Norway (Kirkeboen *et al.*, 2016).

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 (e.g. Farber and Gibbons, 1996, Pallais, 2014), they are likely to take the reputation of the university in which the upcoming employee graduated as a signal of her/his ability and productivity (e.g. Drydakis, 2016, MacLeod *et al.*, 2017). 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, Dale and Krueger, 2014). 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.

The positive association between university reputation and students' labour outcomes suggests that the best ability students will seek to be enrolled at the most prestigious universities and they are likely to use university rankings and league tables as a source of information when assessing the quality of higher education institutions (e.g. Mueller and Rockerbie, 2005, Griffith and Rask, 2007, Gibbons *et al.*, 2015, Chevalier and Jia, 2016). 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, Siemens et al. (2005) document that research productivity explains almost 60 per cent of the variance in popular press rankings of undergraduate business programs. 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).

Based on the abovementioned literature, we expect that academic research helps in enhancing the reputation of the university which, in turn, will contribute to improve the labour payoffs for its graduates.

A more direct test of the link between university research and students' labour outcomes is provided by O'Brien *et al*. (2010), who document that research conducted at business schools add economic value for students in the form of higher long-term salaries. They caution, however, that the value added might diminish under an excessive level of research activity. Along the same line, Drydakis (2016) documents that universities' research intensity positively affects their graduates' labour outcomes (i.e. they receive more invitations to interview and the entry-level salary is higher).

The direct and indirect evidence on the role played by academic research in graduates' labour payoffs suggest that research will help universities in attracting the best ability students. Following the Resource Based View (RBV) theory (e.g. Barney, 1991, Peteraf, 1993), academic research conducted at universities could be seen as a strategic resource which holds the potential to lead the university to achieve a sustainable competitive advantage. For this to occur, the resource needs to be valuable, rare, and difficult to imitate, and academic research meets the three qualities. First, apart from its contribution to university funding, research is crucial for university prestige and reputation. Second, academic research is not a commodity that can be easily acquired by universities. On the contrary, it takes a long time to create and consolidate a research group that achieves high levels of scientific research and, because of this, scientific research outputs are rare and difficult to imitate[1]. Therefore, academic research could be considered as a strategic resource for universities that helps them in enrolling the best ability students. Based on the above discussion and evidence, we state the following hypothesis to be tested in this study:

[1] Refer, for example, to the discussion offered by Hopwood (2008) on the efforts made by certain European higher education institutions to strength their research activity with the aim of gaining prominence in international rankings.

H1: Research intensive universities enrol the best ability students.

Returns to attending a selective university are not homogeneous, neither across students, nor across disciplines. Prior research shows that the labour market premium linked to graduation from a prestigious university varies depending on certain students' characteristics, such as gender, socioeconomic background, or ethnicity (e.g. Loury and Garman, 1995, Dale and Krueger, 2014, Zimmerman, 2014, Canaan and Mouganie, 2018), and what is more relevant to our study, labour market outcomes also vary across fields of study (e.g. Kirkeboen *et al.*, 2016, Witteveen and Attewell, 2017). Extant literature provides evidence showing that graduates from health (arts and humanities) disciplines earn significantly higher (lower) wages than graduates from other fields of study (e.g. James *et al.*, 1989, Finnie and Frenette, 2003, Thomas and Zhang, 2005, Kelly *et al.*, 2010). Furthermore, research suggests that the labour market premium to attending a prestigious university vanishes for disciplines with the highest level of post-graduation earnings (e.g. medicine), but also for fields with the lowest wages (e.g. arts and humanities) (e.g. Hastings *et al.*, 2013, Walker and Zhu, 2018). In the case of medicine, for example, graduates tend to earn higher wages than students from other areas, and this is independent from the prestige of the university they attended to; that is to say, medicine graduates typically earn high wages, even when they graduated from a low reputed university. At the other extreme of the earnings spectrum, arts and humanities students usually get the lowest wages, as compared to graduates from other disciplines, and there is no labour market premium from attending to a prestigious university, either.

Given the documented differences across disciplines in the labour market outcomes associated with graduation from a prestigious university, we expect that the ability of research intensive universities to enrol the best ability students will vary across disciplines. This is the second hypothesis to be tested in this study:

H2: The role played by university research in attracting the best ability students varies across fields of 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[2]. Data on the number of students enrolled, admission cutoff

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

scores, and number of places offered per degree and university were downloaded from the website of the Spanish Ministry of Education, Culture, and Sports (Ministerio de Educación, Cultura y Deporte). Whenever a university offers the same program 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 study level. As for admission cutoff scores, we computed a weighted average across all campuses using the number of students enrolled as weights.

Data on academic research (i.e. number of first quartile publications, number of citations, and total number of publications) and research grants for Spanish public universities were gathered from the website of the IUNE Observatory (www.iune.es). Academic research data are disaggregated by field of study, whereas information on research grants is only accessible at the university level. In both cases, data are available since 2005 and, as we need up to two lags of the research variables, our analysis is restricted to the period 2007-2017.

3.2. Dependent variable

The dependent variable in our study is the admission cutoff score for a given bachelor's degree-university-year[3]. Admission cutoffs largely vary across disciplines 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 programs (e.g., medicine), whereas in others it is far below one. Specifically, the demand approximates (multiplies by almost four) the number of places offered in the fields of engineering and humanities (health). As a result, cutoff scores in engineering and humanities are, on average, close to five, the minimum score required to be admitted in a Spanish public university, whereas in the field of health the average cutoff score is above eight.

Apart from the differences between disciplines, admission cutoffs for a given program 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 cutoff scores across programs and universities, we decided to compute a measure of the abnormal admission cutoff for a given degree, university, and year:

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

[3] The application process in Spanish public universities is centrally (regionally) administered and admission outcomes are determined exclusively by students' pre-entry marks.

Where the subscript *ijt* stands for the degree i in university j and period t. We standardize this variable by subtracting from the admission cutoff 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 cutoff*) indicate that the cutoff score 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 cutoff* 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 variable

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-field of study academic research[4]. To account for the size of the university, we scale the academic research variable by the total number of tenured staff. The research activity largely varies across areas and because of this, we standardize the research variable by subtracting its country-year mean and dividing all by its country-year standard deviation. Specifically, we compute the abnormal academic 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, field of study, and year, respectively. The abnormal academic research variable (i.e. *Abn_First quartile*) reflects the research strength of university j, in the field of study k, as compared to the same area in the rest of the Spanish public universities.

3.4. Control variables

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

[4] The information is disaggregated by area and this is the reason to define the variable at the university-field of study 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.

Tuition fees – When making their choice between different universities offering the same program, students are likely to consider the amount of tuition fees (e.g., Mueller and Rockerbie, 2005, Soo and Elliott, 2010, Dwenger *et al.*, 2012, Walsh *et al.*, 2015). To control for this potential factor, we add the *Abn_Tuition 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_Tuition fee* variable we require that the program is offered by a minimum of three universities. Tuition fees are set at the region level and they are updated every year[5]. By computing the *Abn_Tuition 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 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 cutoff scores will rise as the number of places offered decreases, *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.

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

University age – The attractiveness of universities for students might vary depending on their age. Some students might appreciate being enrolled at a university with a long history, whereas others will prefer young universities specialised in certain fields of study. 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. Weiler, 1996, Soo and Elliott, 2010) and because of this 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 cutoff scores between the observations included in our sample. Cutoff scores are measured at the degree-university-year level. The minimum is five (5), which is the entry requirement to be admitted in any bachelor degree in a public university in Spain, disregarding whether the program has a restricted number of places or not. By examining Table 1, it can be observed that the admission cutoff score is five (5) for almost half of the observations in our sample. Cutoff scores 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 cutoff scores, 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 cutoffs 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.

[Insert Table 2 about here]

Table 2 presents the correlation matrix where we can observe that admission cutoff scores 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 cutoff scores 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.

4.2. Regression analyses

4.2.1. Association between academic research and admission cutoff scores

We start the multivariate analysis by testing whether admission cutoff scores are related to the research activity conducted at the university. With this aim we estimate the following equation:

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

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

Academic research is not an strictly exogenous variable and because of this we estimate a two-stage regression model[6]. In the first stage, we regress *Abn_First quartile* 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 as instruments for the number of first quartile publications. The instrumented variable (*Abn_First quartile*) is lagged one year, whereas the instrumental variables are lagged two years. State and EU research grants are correlated with the research proxies, but they are not expected to affect admission cutoff

[6] There might be unobservable characteristics of universities that are correlated with both admission cutoff scores and the research activity of the university.

scores, 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.

[Insert Table 3 about here]

By examining Table 3 it can be observed that the coefficients of the instruments included in the first stage are significantly different from zero and the Sargan-Hansen test indicates that the null of exogenous instruments is not rejected (p=0.706), thereby suggesting that *State grants* and *EU grants* are valid instruments for the research activity conducted at universities.

As for the results of the second stage regression, we find that prior year first quartile publications are positively and significantly related to current admission cutoff scores (p=0.000)[7]. Results indicate that cutoff scores are significantly higher in research intensive universities, which suggests that they are attracting the best ability students. This evidence is consistent with our first hypothesis. The magnitude of the coefficient indicates that universities with a ratio of first quartile publications to tenured academic staff that is ten per cent over the field mean, enjoy admission cutoff scores that are three per cent over cutoffs corresponding to universities with research levels in line with the field average.

Regarding the control variables, we find that admission cutoffs are positively related to the second enrolment premium, the proportion of tenured staff, university 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. Regarding 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, but given the heterogeneity (across disciplines) of labour market

[7] 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.

payoffs to graduation, we expect that the role played by research in attracting the best ability students also varies across fields of study. Prior to re-estimating Equation (1) for each of the main fields, we examine the descriptive statistics for admission cutoff scores and academic research disaggregated by area. These data are presented in Table 4.

[Insert Table 4 about here]

Panel A in Table 4 disaggregates the descriptive statistics of the admission cutoffs variable by areas. As it can be observed, in the field of health, admission cutoff scores are well above the minimum score to be admitted in a public university, whereas in humanities the cutoff score is five for almost 75 per cent of the observations in our sample. These differences between areas are consistent with the widely documented dissimilarities across disciplines in the labour market outcomes for graduates, already discussed in Section two.

Regarding the research activity, Panel B in Table 4 also shows large dissimilarities between the main fields of study. 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.

Now, we re-estimate Equation (1) for each of the main fields of study. Table 5 reports the results of these re-estimations under the headings of Engineering, Health, Humanities, Sciences, and Social Sc., respectively.

[Insert Table 5 about here]

Panel A in Table 5 reports the first stage results, whereas the second stage findings are presented in Panel B. In line with the evidence reported in Table 3, the research instruments are significantly related to the instrumented variable (i.e. *Abn_First quartile*) in all five fields of study, and the Sargan-Hansen test indicates that the null of exogenous instruments cannot be rejected (p>0.5). Therefore, *State grants* and *EU grants* can be considered as valid instruments for research in all five areas[8].

[8] Data on state grants and EU grants is only available at the university level (i.e. it is not disaggregated by field of study). In spite of this limitation, the evidence reported in Table 5 suggests that research grants are valid instruments for the research activity conducted in each main area.

When we examine the second stage results, we find that the coefficient of the *Abn_First quartile* variable is positive and statistically significant in the fields of engineering and social science. This evidence is consistent with the findings reported in Table 3 for the full sample. Results for these two areas suggest that the best ability students prefer to enrol at research oriented universities. In the rest of the fields, however, the coefficient of *Abn_First quartile* is statistically indistinguishable from zero. The coefficient is positive (negative) in the areas of sciences (health and humanities), but it is statistically insignificant in all three cases. Hence, we do not have evidence that admission cutoff scores are affected (either positively or negatively) by the research performance of the university in these three areas.

As for the field of science, Table 4 shows that all universities achieve a relatively high number of first quartile publications per academic staff and this might explain the lack of an association between research performance and admission cutoffs. In the health area, the number of first quartile publications is also high in most universities and this research performance is accompanied by a strong demand for the degrees offered in this field. When the number of places available in the whole country is far below the total number of applications received, as in the case of the health field, cutoff scores 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 slot in one of the universities offering the program. In such a competitive environment for students, the characteristics of the university offering the degree might become of second order of importance. This result is in line with the evidence reported by Hastings *et al.* (2013), who show that earnings gains from crossing the threshold to be admitted in a degree program in the health area in Chile are large, both in high and low selectivity programs. If there is no labour market premium to being graduated from a prestigious university, the best ability students have less incentives to struggle to enrol at the most reputed institutions. Furthermore, a large proportion of Spanish graduates in the health area end up working for the public health system, the entry requirements of which are based on students' performance and ignore the university where they graduated.

Quite different is the situation in the humanities field. We also find that admission cutoff scores are unrelated to the university research activity, but the underlying reason for this finding is likely to be different from that explaining the results for the health area. Prior research shows that earnings are significantly lower for arts and humanities graduates than for students from other disciplines (e.g. James *et al.*, 1989, Thomas, 2000, Kelly *et al.*, 2010), and the evidence gathered in prior studies indicates that unlike other fields, in the area of arts and humanities, there is not an earnings return to attending a prestigious university (e.g. Hastings *et al.*, 2013, Walker and Zhu, 2018). This might explain the lack of an association between research and admission grades observed in this study for this field. If the arts and humanities students cannot benefit, at least in terms of salaries, from enrolling at a prestigious university, their choices might be guided by factors other than university reputation. In line with this argument, Table 5 shows that the coefficient of the abnormal tuition fee variable 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.

Overall, we document a positive association between the research orientation of the university and admission cutoff scores in the fields of engineering and social science. In these two areas, research intensive universities are attracting the best performing students. In the rest of fields (i.e. health, humanities, and sciences), however, we do not have evidence of admission grades being affected by the university research performance, neither positively, nor negatively. These dissimilarities across fields of study are consistent with our second hypothesis. Furthermore, the evidence gathered in this paper suggests that, in the fields of engineering and social sciences, research helps universities in enrolling the best ability students. Such a reward is not expected in the fields of health, humanities, and sciences, but from the lack of an association between research and admission grades in these areas we can infer that research is not discouraging the best performing students, either. Should the research orientation of the university be perceived as detrimental for its teaching activity, we would observe a negative association between research and admission cutoff scores and this is not what we find in this study.

4.3. Testing for non-linearities in the association between research and admission cutoff scores

When estimating Equation (1), we were assuming that the relationship between research performance and admission cutoff scores is linear (i.e. the higher the level of research productivity, the stronger the ability of the university to attract the best performing students). The possibility exists, however, that universities benefit from a research orientation (by enrolling the best performing students) whenever research activity is below a certain threshold, beyond which the excessive emphasis on research might discourage the best ability students (e.g. if they perceive that teaching quality is compromised because of the disproportionate attention paid to research). Prior literature documents non-linearities in the relationship between research productivity and teaching quality in investigations conducted at the instructor level (e.g. García-Gallego *et al.*, 2015, Artés *et* *al.*, 2017). Furthermore, there is also evidence of non-linearities in the association between university research activity and students' future salaries (O'Brien *et al.*, 2010).

If beyond a certain level research hinders teaching, we should observe an inverted U-shape relationship between research and admission cutoff scores. To allow for this possibility, we add a quadratic term to Equation (1) and estimate the following equation:

$$Abn\_Admission\ cutoff_{ijt} = \alpha + \beta_1\ Abn\_First\ quartile_{kjt-1} + \beta_2\ Abn\_First\ quartile_{kjt-1} * Abn\_First\ quartile_{kjt-1} + \beta_3\ Abn\_Tuition\ fee_{ijt} + \beta_4\ 2^{nd}\ enrolment\ premium_{ijt} + \beta_5\ Ln\ No\ places\ offered_{ijt} + \beta_6\ Tenured\ staff_{jt-1} + \beta_7\ Student\text{-}to\text{-}staff\ ratio_{jt-1} + \beta_8\ Ln\ University\ enrolment_{jt} + \beta_9\ Ln\ University\ age_{jt} + \beta_{10}\ Ln\ Population_{jt} + Time\ effects + \varepsilon_{ijt} \quad (2)$$

All variables are defined in Section 3. In the same way as when estimating Equation (1), we use state and EU research grants as instruments for the research variable (i.e. *Abn_First quartile*) but, when estimating Equation (2), the squared of the research variable needs also to be instrumented. This is why we add the square of the *State grants* and *EU grants* variables as further instruments. Table 6 presents the results of the estimation of Equation (2) for the full sample, as well as for each of the main fields of study. Panels A1 and A2 (B) report the results of the first stage (second stage) estimation.

[Insert Table 6 about here]

As it can be observed, the coefficient of the quadratic term of the research variable is insignificantly different from zero in the full sample, as well as in all subsamples (i.e. fields of study). Therefore, we do not have evidence that research performance, even at high levels, deters the best ability students. If prospective students feared that an excessive research orientation in certain universities or fields could damage teaching quality, the best ability students would not be willing to enrol at these universities and we should observe an inverted U-shape relationship between research and admission cutoff scores (i.e. the coefficient of the quadratic term would be negative). Nonetheless, our evidence is not consistent with this hypothesis.

4.4. The role played by the country-level demand-to-supply ratio

The evidence presented in Table 5 shows a lack of an association between research performance and admission cutoff scores in those fields of study with either extremely high or low demand for their degrees (i.e. health and humanities). In this section, we check whether the relationship between research performance and students' decisions varies depending on the country-level demand-supply ratio. As discussed previously, the possibility exists that in the case of programs for which de number of applications received in the whole country largely exceeds the number of places offered (e.g. medicine), there is little room for admission cutoffs to be affected by the research productivity of the university. The reduced total number of places offered by Spanish public universities, compared to the number of applications received, guarantees high cutoff scores in all universities, disregarding their research performance.

The contrary is expected in low demanded degrees. Students that did not get a place in the program they were interested in, might end up opting for a low demanded degree. Even if the university was able to attract a number of high performing students, the admission cutoff score would be low because of the enrolment of low performing students that were not admitted in the program of their preference.

To check whether our findings are affected by the demand-supply ratio, we split the sample into deciles according to the ratio (for each degree-year) of total number of applications received to the total number of places offered in the whole country. The demand-supply ratio is computed at the country-level because we are interested in the attractiveness of programs for students, disregarding the characteristics of the universities offering these degrees. Table 7 presents the results of the re-estimation of Equation (1) for each decile.

[Insert Table 7 about here]

Results show that the coefficient of the research variable is positive and statistically significant in all subsamples except for the first and tenth deciles. That is to say, in the bottom and top deciles of the distribution of the demand-to-supply ratio, we find that admission cutoff scores are not related to research performance. Therefore, in the case of programs with either extremely low or extremely high levels of the demand-to-supply ratio, research performance is not likely to make a difference in the ability of universities to attract the best performing students. This evidence suggests that the lack of an association observed between research and admission cutoff scores observed in the field of health (humanities) could at least be partially explained by the high (low) demand for most of the degrees in this field.

4.5. Robustness checks

4.5.1. Other proxies for the research variable

In prior sections, research performance is proxied by the total number of papers published with the affiliation of the university in the first quartile of the respective *Journal of Citation Reports*. Now, we check the robustness of our results to the use of the total number of citations and the total number of publications as proxies for research. Each of these measures captures a different dimension of the research activity of the university. The number of first quartile publications could be seen as an indication of research quality, the number of citations informs about the impact of research, and the number of publications provides a quantitative measure of research that ignores the quality and impact of publications.

In spite of the differences between the three proxies, they are highly correlated ($\rho>0.87$) and when we re-estimate our models using the *Abn_Citations* and the *Abn_Publications* variables as proxies for research, the results are qualitatively the same as those obtained when using the *Abn_First quartile* measure[9]. The high correlation between the three proxies suggests that universities with an outstanding number of first quartile publications receive also a high number of citations, and achieve a remarkable quantity of publications. This explains why our findings are not sensitive to the research proxy.

4.5.2. Estimation method

Results presented in previous sections were obtained by estimating a random effects model, which takes into account both the cross-sectional and time series variation of data. Nonetheless, when examining the descriptive statistics presented in Table 1, we observed that the research activity is rather stable over time and the variability observed mainly comes from differences between universities. That is to say, cross-sectional is far more important that time series variation in our data and because of this we check the robustness of our findings by re-estimating our models using the between effects technique. The between effect estimator averages the data for each panel unit (i.e. degree-university) to eliminate the time component of the data. Stated in other words, this estimator ignores the time variation of the data and uses only the cross-sectional information. Although there is an information loss, the between effects estimator allows us to examine the effect of research on admission cutoff scores when research changes between universities. This might be particularly useful in our study because of the stability of research over time. Table 8 reports the results of the re-estimation of Equation (1) for the full sample and for each of the main areas using the between effects technique.

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[9] For the sake of brevity, we do not tabulate these results, but they are available from the authors.

[Insert Table 8 about here]

Results are largely consistent with those obtained from the estimation of a random effects model, the only difference being that, in the field of science, the coefficient of the research variable becomes statistically significant ($p<0.5$). As for the rest of the fields and the full sample, results are in line with the evidence provided in Tables 3 and 5; we find a positive association between research and admission cutoff scores in the full sample, as well as in the subsamples of engineering and social sciences. The magnitude of the coefficient of the research variable (i.e. *Abn_First quartile*) is close to that obtained from the random effects models and it is statistically significant ($p<0.01$) in all three cases. Also in line with the evidence reported in Table 5, we do not find a significant association between research and admission cutoff scores in the areas of health and humanities.

4.5.3. The potential effect of outliers

The evidence gathered in prior sections could be unduly affected by outliers. Admission cutoff scores for certain degree-university observations reach extremely high values and the same occurs with research in specific area-universities. To check whether our findings are driven by these exceptional observations, in this section we re-estimate our models after trimming the admission cutoff scores and research variables at the top one and five per cent of their distribution. Results, untabulated[10], are totally consistent with those reported previously. Therefore, we do not have evidence that our findings are driven by outliers (i.e. degrees (universities) with exceptionally high admission cutoff scores (levels of research)).

5. Discussion and conclusions

This paper investigates whether academic research helps universities in attracting the best ability students. Using data on the admission cutoff scores for the bachelor's degrees offered by Spanish public universities, we document a positive association between university research and admission cutoff scores. When we investigate each field of study separately, the positive association between research and admission cutoffs holds for the areas of engineering and social sciences, which altogether account for 60% of the observations in our sample and over two thirds of the first-year students enrolled at Spanish public universities. In the fields of health, humanities, and sciences, however, our results show that students' choices are unrelated to research performance. Therefore, the evidence gathered in this paper suggests that the role played by research in attracting the best

[10] Results are available from the authors.

ability students varies across fields of study. In the areas of engineering and social sciences, research intensive universities are enrolling the best ability students (i.e. admission grades are significantly higher in research oriented universities), whereas in the fields of health, humanities, and sciences, we find that students' choices are unrelated to the research performance of the university. Nonetheless, we do not obtain evidence consistent with the best ability students being discouraged by the research performance of the university in any of the fields of study. From these findings we infer that the research orientation of the university in the areas of engineering and social sciences (health, humanities, and science) enhances (does not hamper) the attractiveness of the university for prospective students, at least in the case of Spanish public universities.

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 in the areas of engineering and social sciences 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 performance, either directly or via university rankings, is being 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.

As for the rest of the areas, our findings do not support neither the teaching-research complementarity, nor the existence of conflicts between the two activities. The lack of association between research and admission cutoff scores could be indicative of teaching and research being unrelated activities (i.e. the efforts devoted to research are neither beneficial, nor detrimental to teaching).

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Table 1. Descriptive statistics

		Mean	Dev	Min	Max	P25	P50	P75
Dependent variable								
Admission cutoff	overall	6.617	2.069	5	13.667	5	5.53	7.817
	between		1.842					
	within		0.529					
Abn_Admission cutoff		0.039	0.959	-4.065	5.499	-0.571	-0.259	0.613
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		0.084	0.973	-1.558	6.173	-0.435	-0.190	0.283
Control variables								
Tuition fees (€/ECTS)		17.668	7.065	7.9	39.53	12.62	14.99	22.93
Abn_Tuition fee		0.040	0.965	-2.620	2.953	-0.764	-0.054	0.828
2nd enrolment premium		1.589	0.324	1	2.257	1.235	1.500	1.999
No places offered		125	107	10	950	60	85	150
Ln No places offered		4.561	0.719	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		2.234	0.608	0.522	5.734	1.862	2.109	2.465
University enrolment		5,326	2,901	378	12,684	3,026	4,480	7,075
Ln University enrolment		8.426	0.572	5.935	9.448	8.015	8.407	8.864
University age		187	244	9	799	25	40	470
Ln University age		4.300	1.349	2.197	6.683	3.219	3.689	6.153
Population (thousands)		592	849	29	3,265	138	230	666
Ln Population		5.662	1.155	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	0.109	0.002	0.004	0.007

Data corresponds to the 47 Spanish public universities with face-to-face teaching and the sample comprises 12,016 university-degree-year observations for the period 2007-2017. *Admission cutoff* is the cutoff score for admission to a given program 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. 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, the research variable (i.e. *First quartile)* is measured at the university-field of study level, and the instrumental variables are defined at the university 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_T. fee*	*2nd enrol premium*	*No places offered*	*Tenured staff*	*Student-to-staff*	*Enrolment*	*University age*	*Ln Population*	*L2.State grants*
L1.Abn_First quartile	0.151										
	(0.000)										
Abn_Tuition fee	0.061	0.334									
	(0.000)	(0.000)									
2nd enrolment premium	-0.013	-0.121	-0.253								
	(0.175)	(0.000)	(0.000)								
Ln No places offered	0.039	0.091	0.028	0.047							
	(0.000)	(0.000)	(0.004)	(0.000)							
L1.Tenured staff (%)	0.000	-0.352	-0.355	0.198	0.043						
	(0.990)	(0.000)	(0.000)	(0.000)	(0.000)						
L1.Student-to-staff ratio	-0.081	-0.280	-0.346	0.342	0.037	0.228					
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
Ln University enrolment	0.230	-0.049	0.019	0.067	0.250	0.174	0.165				
	(0.000)	(0.000)	(0.052)	(0.000)	(0.000)	(0.000)	(0.000)				
Ln University age	0.107	-0.058	-0.006	0.103	0.119	0.272	-0.166	0.606			
	(0.000)	(0.000)	(0.517)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
Ln Population	0.171	0.109	0.092	0.111	0.177	0.201	-0.080	0.335	0.354		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
L2.State grants	0.112	0.551	0.361	-0.304	0.040	-0.461	-0.337	-0.039	0.023	0.101	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.018)	(0.000)	
L2.EU grants	0.110	0.497	0.359	-0.069	0.045	-0.340	-0.320	-0.011	-0.026	0.108	0.491
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.266)	(0.009)	(0.000)	(0.000)

Table 2 (continued)

The sample comprises 12,016 university-degree-year observations for the period 2007-2017. *Admission cutoff* is the cutoff score for admission to a given program 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 study 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 cutoff scores on research activity for the full sample

	First-stage regression	**Random-effects IV regression**
Dependent variable	*L1.Abn_First quartile*	*Abn_Admission cutoff*
L1.Abn_First quartile		0.308***
		(6.828)
Abn_Tuition fee	0.105***	-0.044***
	(11.73)	(-2.829)
2nd enrolment premium	-0.022	0.115***
	(-0.96)	(3.225)
Ln No places offered	0.058***	-0.053***
	(4.85)	(-2.756)
L1.Tenured staff (%)	-1.479***	0.652***
	(-17.79)	(4.014)
L1.Student-to-staff ratio	-0.063***	-0.123***
	(-5.55)	(-6.968)
Ln University enrolment	-0.013	0.347***
	(-0.63)	(11.010)
Ln University age	-0.082***	-0.053***
	(-9.11)	(-3.628)
Ln Population	0.122***	0.041**
	(12.96)	(2.493)
L2. State grants	8.842***	
	(26.16)	
L2. EU grants	14.254***	
	(20.3)	
Constant	-32.617***	-4.665
	(-8.98)	(-0.860)
Time effects	Yes	Yes
Observations	12,016	12,016
Wald Chi-Squared	3,619	270
P-value	0.000	0.000
R-Sq within		0.002
R-Sq between		0.094
R-Sq overall		0.086
Sargan-Hansen test		0.142
P-value		0.706

Table 3 (continued)

The sample comprises 12,016 university-degree-year observations for the period 2007-2017. *Admission cutoff* is the cutoff score for admission to a given program 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. 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, the research variable is measured at the university-field of study level, and the instrumental variables are defined at the university level. The research variable and the instrumental variables are scaled by the university total number of tenured staff. The research variable, 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 study

Panel A: Admission cutoff scores disaggregated by field of study

Area	Obs.	Mean	Dev	Min	Max	P10	P25	P50	P75	P90
Engineering and architecture	3,242	5.956	1.665	5	13.356	5	5	5	6.260	8.441
Health sciences	1,558	8.959	2.130	5	13.110	6.12	7.339	8.770	10.696	11.999
Humanities	1,720	5.604	1.264	5	12.300	5	5	5	5.477	7.293
Sciences	1,463	7.016	2.392	5	13.667	5	5	5.840	8.598	11.070
Social sciences	4,033	6.531	1.746	5	12.942	5	5	5.889	7.595	9.180

Panel B: First quartile publications disaggregated by field of study

Area	Obs.	Mean	Dev	Min	Max	P10	P25	P50	P75	P90
Engineering and architecture	3,242	0.150	0.086	0.023	0.440	0.061	0.086	0.130	0.192	0.277
Health sciences	1,558	0.163	0.149	0.003	1.072	0.043	0.072	0.120	0.187	0.329
Humanities	1,720	0.012	0.012	0.000	0.119	0.002	0.004	0.008	0.014	0.023
Sciences	1,463	0.214	0.138	0.033	0.678	0.089	0.125	0.161	0.271	0.409
Social sciences	4,033	0.038	0.043	0.000	0.381	0.011	0.018	0.028	0.042	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 cutoff scores on research activity for the main areas

Panel A: First-stage regression

	Engineering	Health	Humanities	Sciences	Social Sc.
Abn_Tuition fee	0.159***	0.139***	0.198***	0.083***	-0.002
	(7.87)	(7.19)	(6.97)	(3.8)	(-0.2)
2nd enrolment premium	0.196***	-0.036	-0.076	0.102**	-0.171***
	(3.25)	(-0.87)	(-0.98)	(2.03)	(-6.02)
Ln No places offered	0.115***	0.123***	0.096**	0.165***	0.024
	(4.54)	(3.91)	(2.31)	(4.36)	(1.45)
L1.Tenured staff (%)	-1.687***	-1.328***	-1.541***	-1.180***	-1.967***
	(-9.47)	(-7.25)	(-5.38)	(-5.69)	(-17.81)
L1.Student-to-staff ratio	-0.188***	-0.065***	-0.066	0.011	0.105***
	(-8.31)	(-2.7)	(-1.46)	(0.35)	(6.93)
Ln University enrolment	-0.148***	0.064	0.329***	-0.018	-0.115***
	(-3.64)	(1.42)	(5.34)	(-0.36)	(-4.03)
Ln University age	-0.201***	0.046**	-0.059**	-0.047**	-0.024*
	(-10.51)	(2.27)	(-2.3)	(-2.17)	(-1.82)
Ln Population	0.212***	0.083***	-0.129***	0.045**	0.153***
	(10.38)	(3.72)	(-4.82)	(2.07)	(11.39)
L2. State grants	4.987***	7.033***	13.341***	10.748***	10.303***
	(6.71)	(9.46)	(10.79)	(11.8)	(24.94)
L2. EU grants	11.010***	14.628***	13.305***	17.179***	14.714***
	(7.19)	(8.07)	(4.82)	(6.28)	(18.89)
Constant	-35.423***	-27.790***	-5.315	-19.908**	-47.401***
	(-4.19)	(-3.88)	(-0.42)	(-2.32)	(-9.98)
Time effects	Yes	Yes	Yes	Yes	Yes
Observations	3,242	1,558	1,720	1,463	4,033
Wald Chi-Squared	1,077	563	569	485	2,693
P-value	0.000	0.000	0.000	0.000	0.000

Table 5 (continued)

Panel B: Random effects IV regression

	Engineering	**Health**	**Humanities**	**Sciences**	**Social Sc.**
L1.Abn_First quartile	0.374***	-0.126	-0.031	0.180	0.457***
	(2.801)	(-0.788)	(-0.303)	(1.315)	(7.592)
Abn_Tuition fee	-0.036	-0.005	-0.155***	0.064	0.007
	(-0.934)	(-0.106)	(-3.519)	(1.416)	(0.306)
2nd enrolment premium	0.010	0.173**	0.153	-0.111	0.241***
	(0.110)	(2.009)	(1.574)	(-1.120)	(4.258)
Ln No places offered	-0.100**	-0.103	0.071	-0.122	-0.048
	(-2.554)	(-1.498)	(1.329)	(-1.559)	(-1.487)
L1.Tenured staff (%)	1.040***	1.281***	-0.443	0.148	0.786***
	(2.741)	(2.734)	(-1.008)	(0.312)	(2.837)
L1.Student-to-staff ratio	-0.057	-0.179***	-0.094*	-0.095	-0.237***
	(-1.494)	(-3.641)	(-1.673)	(-1.504)	(-7.645)
Ln University enrolment	0.300***	0.490***	0.292***	0.463***	0.491***
	(4.857)	(5.281)	(3.651)	(4.784)	(8.545)
Ln University age	-0.005	-0.083*	-0.050	-0.071*	-0.083***
	(-0.118)	(-1.932)	(-1.547)	(-1.677)	(-3.213)
Ln Population	0.024	0.123**	-0.049	0.053	0.038
	(0.547)	(2.545)	(-1.442)	(1.235)	(1.305)
Constant	5.337	-2.292	-1.076	-24.557	-0.419
	(0.451)	(-0.166)	(-0.069)	(-1.561)	(-0.047)
Time effects	Yes	Yes	Yes	Yes	Yes
Observations	3,242	1,558	1,720	1,463	4,033
Wald Chi-Squared	73	76	46	44	200
P-value	0.000	0.000	0.000	0.000	0.000
R-Sq within	0.001	0.000	0.000	0.009	0.003
R-Sq between	0.077	0.155	0.133	0.107	0.229
R-Sq overall	0.083	0.147	0.104	0.113	0.204
Sargan-Hansen test	0.129	0.304	0.163	0.201	0.247
P-value	0.719	0.581	0.686	0.654	0.619

Table 5 (continued)

The sample comprises 12,016 university-degree-year observations for the period 2007-2017. The dependent variable is *Admission cutoff*, the cutoff score for admission to a given program 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. 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, the research variable is measured at the university-field of study level, and the instrumental variables are defined at the university level. The research variable and the instrumental variables are scaled by the university total number of tenured staff. The research variable, 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 *z*-statistics are shown in parentheses. ***, **, * = statistically significant at the 1%, 5%, and 10% levels, respectively.

Table 6. Regression of admission cutoffs on research activity after adding a quadratic term

Panel A1: First-stage regression (Instrumented variable: *L1.Abn_First quartile*)

	Full sample	**Engineering**	**Health**	**Humanities**	**Sciences**	**Social Sc.**
Abn_Tuition fee	0.102***	0.147***	0.136***	0.183***	0.085***	0.001
	(11.49)	(7.43)	(7.06)	(6.5)	(3.9)	(0.09)
2nd enrolment premium	-0.035	0.161***	-0.050	-0.128*	0.080	-0.166***
	(-1.53)	(2.72)	(-1.2)	(-1.67)	(1.61)	(-5.87)
Ln No places offered	0.058***	0.113***	0.123***	0.090**	0.160***	0.019
	(4.87)	(4.57)	(3.95)	(2.21)	(4.22)	(1.18)
L1.Tenured staff (%)	-1.469***	-1.673***	-1.328***	-1.570***	-1.034***	-2.020***
	(-17.74)	(-9.53)	(-7.26)	(-5.55)	(-4.95)	(-18.43)
L1.Student-to-staff ratio	-0.065***	-0.196***	-0.064***	-0.047	0.011	0.103***
	(-5.7)	(-8.56)	(-2.67)	(-1.04)	(0.36)	(6.89)
Ln University enrolment	-0.016	-0.165***	0.060	0.319***	-0.002	-0.109***
	(-0.8)	(-4.15)	(1.34)	(5.25)	(-0.03)	(-3.85)
Ln University age	-0.076***	-0.197***	0.050**	-0.045*	-0.042*	-0.018
	(-8.54)	(-10.61)	(2.48)	(-1.75)	(-1.94)	(-1.39)
Ln Population	0.118***	0.198***	0.084***	-0.119***	0.044**	0.148***
	(12.8)	(10.04)	(3.82)	(-4.5)	(2)	(11.06)
L2. State grants	6.765***	12.388***	4.113***	5.580**	-1.194	5.150***
	(10.76)	(9.06)	(2.96)	(2.44)	(-0.51)	(6.75)
L2. State grants^2	15.331***	-60.234***	24.103**	47.230***	114.632***	35.911***
	(3.9)	(-6.81)	(2.35)	(3.25)	(5.33)	(8.44)
L2. EU grants	20.499***	24.861***	20.169***	35.428***	20.163***	10.601***
	(17.05)	(9.92)	(7.35)	(7.65)	(3.7)	(7.24)
L2. EU grants^2	-72.743***	-220.089***	-83.950**	-285.612***	-228.159	59.692***
	(-5.36)	(-7.15)	(-2.48)	(-5.61)	(-0.97)	(3.98)
Constant	-31.508***	-43.059***	-26.725***	0.784	-16.191*	-40.762***
	(-8.52)	(-5.03)	(-3.7)	(0.06)	(-1.91)	(-8.53)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,016	3,242	1,558	1,720	1,463	4,033
Wald Chi-Squared	3,928	1,286	589	637	498	2,821
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Table 6 (continued)

Panel A2: First-stage regression (Instrumented variable: *L1.Abn_First quartile^2*)

	Full sample	Engineering	Health	Humanities	Sciences	Social Sc.
Abn_Tuition fee	0.128***	0.254***	0.297***	0.365***	0.087**	-0.105**
	(4.26)	(5.49)	(6.08)	(3.6)	(1.99)	(-2)
2nd enrolment premium	-0.267***	0.024	-0.514***	0.185	0.273***	-0.628***
	(-3.48)	(0.17)	(-4.85)	(0.67)	(2.7)	(-4.9)
Ln No places offered	0.096**	0.130**	0.201**	0.329**	0.142*	0.153**
	(2.4)	(2.26)	(2.54)	(2.23)	(1.84)	(2.07)
L1.Tenured staff (%)	-3.040***	-2.308***	-2.057***	-3.849***	-1.264***	-4.370***
	(-10.92)	(-5.63)	(-4.43)	(-3.77)	(-2.99)	(-8.77)
L1.Student-to-staff ratio	0.145***	-0.006	0.070	0.145	-0.085	0.482***
	(3.8)	(-0.12)	(1.16)	(0.89)	(-1.3)	(7.08)
Ln University enrolment	-0.305***	-0.116	0.219*	0.548**	0.329***	-1.294***
	(-4.6)	(-1.25)	(1.93)	(2.5)	(3.24)	(-10.01)
Ln University age	-0.109***	-0.189***	0.007	-0.077	-0.063	-0.058
	(-3.67)	(-4.35)	(0.14)	(-0.84)	(-1.43)	(-0.96)
Ln Population	0.331***	0.348***	0.122**	-0.613***	-0.179***	0.997***
	(10.66)	(7.56)	(2.17)	(-6.44)	(-4.05)	(16.43)
L2. State grants	-9.389***	8.040**	-2.256	-4.400	-37.411***	-8.416**
	(-4.44)	(2.52)	(-0.64)	(-0.53)	(-7.86)	(-2.43)
L2. State grants^2	278.594***	-47.564**	155.294***	428.521***	522.967***	323.886***
	(21.06)	(-2.3)	(5.96)	(8.17)	(11.99)	(16.74)
L2. EU grants	41.255***	29.968***	45.588***	66.112***	16.074	53.005***
	(10.2)	(5.12)	(6.55)	(3.95)	(1.45)	(7.97)
L2. EU grants^2	215.057***	-289.322***	-104.617	-1005.397***	171.154	502.033***
	(4.71)	(-4.03)	(-1.22)	(-5.47)	(0.36)	(7.36)
Constant	-36.941***	-41.235**	-43.527**	18.757	79.921***	-101.850***
	(-2.97)	(-2.06)	(-2.38)	(0.41)	(4.66)	(-4.69)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,016	3,242	1,558	1,720	1,463	4,033
Wald Chi-Squared	2,852	304	435	524	476	2,652
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Table 6 (continued)

Panel B: Random effects IV regression

	Full sample	Engineering	Health	Humanities	Sciences	Social Sc.
L1.Abn_First quartile	0.271***	0.654*	-0.294	0.063	0.192	0.423**
	(2.944)	(1.953)	(-0.526)	(0.348)	(0.707)	(2.075)
L1.Abn_First quartile^2	0.007	-0.276	0.050	-0.025	-0.022	0.006
	(0.263)	(-0.784)	(0.228)	(-0.609)	(-0.173)	(0.159)
Abn_Tuition fee	-0.042***	-0.009	0.005	-0.164***	0.068	0.008
	(-2.605)	(-0.169)	(0.105)	(-3.630)	(1.447)	(0.340)
2nd enrolment premium	0.117***	-0.020	0.191	0.171*	-0.104	0.240***
	(3.263)	(-0.209)	(1.571)	(1.678)	(-1.023)	(4.226)
Ln No places offered	-0.051***	-0.096**	-0.090	0.071	-0.123	-0.048
	(-2.696)	(-2.443)	(-1.233)	(1.329)	(-1.508)	(-1.494)
L1.Tenured staff (%)	0.599***	0.950**	1.137**	-0.387	0.102	0.735**
	(3.635)	(2.376)	(2.050)	(-0.905)	(0.214)	(1.969)
L1.Student-to-staff ratio	-0.127***	-0.010	-0.193***	-0.088	-0.091	-0.236***
	(-6.354)	(-0.141)	(-2.771)	(-1.544)	(-1.406)	(-7.661)
Ln University enrolment	0.358***	0.340***	0.489***	0.277***	0.461***	0.496***
	(11.322)	(5.429)	(5.143)	(3.306)	(4.389)	(7.610)
Ln University age	-0.057***	-0.009	-0.074	-0.048	-0.071	-0.083***
	(-3.951)	(-0.275)	(-1.419)	(-1.467)	(-1.639)	(-3.217)
Ln Population	0.044***	0.063	0.131**	-0.054	0.050	0.037
	(2.752)	(0.876)	(2.536)	(-1.548)	(0.906)	(1.193)
Constant	-4.722	3.771	-2.743	-0.880	-21.872	-0.645
	(-0.863)	(0.300)	(-0.196)	(-0.057)	(-1.134)	(-0.072)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,016	3,242	1,558	1,720	1,463	4,033
Wald Chi-Squared	290	86	76	46	41	204
P-value	0.000	0.000	0.000	0.000	0.000	0.000
R-Sq overall	0.089	0.076	0.122	0.093	0.111	0.202
Sargan-Hansen test	3.539	0.812	2.376	0.118	1.396	0.292
P-value	0.171	0.666	0.305	0.943	0.498	0.864

Table 6 (continued)

The sample comprises 12,016 university-degree-year observations for the period 2007-2017. The dependent variable is *Admission cutoff*, the cutoff score for admission to a given program 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. 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, the research variable is measured at the university-field of study level, and the instrumental variables are defined at the university level. The research variable and the instrumental variables are scaled by the university total number of tenured staff. The research variable, 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 *z*-statistics are shown in parentheses. ***, **, * = statistically significant at the 1%, 5%, and 10% levels, respectively.

Table 7. Regression of admission cutoffs on research activity by quintiles of the country-level demand-to-supply ratio

Panel A: First stage regression

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Abn_Tuition fee	0.072**	0.103***	0.074***	0.102***	0.061**	0.109***	0.080***	0.111***	0.153***	0.072***
	(2.56)	(3.43)	(2.97)	(4.19)	(2.41)	(4.23)	(3.08)	(4.58)	(5.56)	(3.29)
2nd enrolment premium	0.348***	0.242**	-0.061	-0.031	-0.068	-0.109	-0.144**	-0.328***	-0.154**	-0.050
	(2.75)	(2.12)	(-0.79)	(-0.45)	(-0.96)	(-1.46)	(-2.11)	(-4.41)	(-2.4)	(-0.99)
Ln No places offered	0.000	0.110***	0.110***	0.129***	0.092***	0.105***	0.086**	0.088***	0.099**	0.089***
	(-0.01)	(2.81)	(3.18)	(3.38)	(2.62)	(2.95)	(2.51)	(2.81)	(2.41)	(2.98)
L1.Tenured staff (%)	-0.677**	-1.255***	-0.588**	-0.832***	-1.131***	-1.134***	-1.190***	-0.842***	-1.301***	-1.416***
	(-2.15)	(-4.11)	(-2.33)	(-3.64)	(-4.5)	(-4.68)	(-4.99)	(-3.8)	(-5.43)	(-6.8)
L1.Student-to-staff ratio	-0.593***	-0.280***	-0.154***	-0.105***	-0.125***	-0.110***	-0.070**	-0.039	0.003	-0.051*
	(-8.22)	(-5.67)	(-3.91)	(-3.3)	(-3.03)	(-3.02)	(-2.13)	(-1.21)	(0.11)	(-1.8)
Ln University enrolment	0.170***	-0.056	0.061	-0.063	-0.044	0.022	-0.091*	0.035	-0.041	0.051
	(2.67)	(-0.9)	(1.1)	(-1.21)	(-0.84)	(0.43)	(-1.8)	(0.66)	(-0.63)	(1.02)
Ln University age	-0.182***	-0.125***	-0.098***	-0.097***	-0.094***	-0.106***	-0.056**	-0.086***	-0.069**	-0.002
	(-7.25)	(-4.77)	(-4.14)	(-4.35)	(-4)	(-4.36)	(-2.37)	(-3.72)	(-2.31)	(-0.1)
Ln Population	0.024	0.091***	0.057**	0.074***	0.102***	0.122***	0.127***	0.099***	0.143***	0.083***
	(0.93)	(3.42)	(2.44)	(3.25)	(4.31)	(5.02)	(5.37)	(4.38)	(4.96)	(3.59)
L2. State grants	14.079***	14.570***	15.366***	11.732***	14.851***	9.332***	10.433***	10.461***	9.900***	10.813***
	(9.13)	(10.33)	(10.83)	(10.41)	(13.14)	(8.56)	(9.21)	(10.86)	(11.75)	(12.04)
L2. EU grants	29.941***	14.416***	25.112***	19.102***	19.600***	24.446***	20.505***	14.639***	11.819***	21.987***
	(6.52)	(4.2)	(7.59)	(8.17)	(8.4)	(10.08)	(9.05)	(8.19)	(7.79)	(10.92)
Constant	6.590	-34.158*	-66.751***	-38.074***	-59.704***	-65.053***	-48.913***	-45.684***	-50.551***	-39.012***
	(0.35)	(-1.75)	(-4.46)	(-3.09)	(-4.11)	(-4.57)	(-3.8)	(-4.04)	(-4.76)	(-4.29)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,217	1,224	1,168	1,226	1,194	1,189	1,212	1,183	1,208	1,195
Wald Chi-Squared	637	629	673	596	844	699	597	610	536	664
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7 (continued)

Panel B: Random effects IV regression

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
L1.Abn_First quartile	-0.040	0.387***	0.299***	0.306***	0.381***	0.375***	0.503***	0.260**	0.334***	0.031
	(-0.443)	(3.893)	(3.301)	(2.616)	(4.777)	(3.930)	(4.915)	(2.338)	(3.482)	(0.305)
Abn_Tuition fee	-0.199***	-0.159***	-0.075*	-0.022	0.005	0.007	0.000	0.007	-0.007	-0.082*
	(-5.816)	(-3.889)	(-1.884)	(-0.476)	(0.141)	(0.161)	(0.004)	(0.159)	(-0.171)	(-1.954)
2nd enrolment premium	0.265*	0.074	0.063	0.007	0.139	0.353***	0.331***	0.309**	-0.002	0.234**
	(1.760)	(0.511)	(0.544)	(0.062)	(1.366)	(3.127)	(3.142)	(2.442)	(-0.025)	(2.511)
Ln No places offered	0.041	-0.093*	-0.048	-0.072	-0.033	-0.046	-0.132**	-0.100*	-0.173***	-0.062
	(0.983)	(-1.817)	(-0.896)	(-1.076)	(-0.644)	(-0.851)	(-2.502)	(-1.959)	(-3.062)	(-1.138)
L1.Tenured staff (%)	-0.858**	0.803*	0.797**	0.781*	1.030**	0.950**	0.872**	0.473	0.990***	1.178***
	(-2.188)	(1.752)	(1.999)	(1.833)	(2.557)	(2.367)	(2.131)	(1.214)	(2.625)	(2.654)
L1.Student-to-staff ratio	-0.283***	-0.124*	-0.165***	-0.108**	-0.223***	-0.221***	-0.164***	-0.255***	-0.175***	-0.177***
	(-2.744)	(-1.844)	(-2.717)	(-1.970)	(-3.789)	(-4.067)	(-3.327)	(-5.088)	(-4.416)	(-3.412)
Ln University enrolment	0.320***	0.216***	0.398***	0.525***	0.466***	0.489***	0.556***	0.751***	0.510***	0.481***
	(4.278)	(2.701)	(4.760)	(5.882)	(6.216)	(6.432)	(7.130)	(9.098)	(5.725)	(5.229)
Ln University age	-0.118***	-0.066*	-0.072**	-0.076*	-0.074**	-0.057	-0.050	-0.139***	-0.035	-0.082**
	(-3.641)	(-1.953)	(-2.019)	(-1.950)	(-2.156)	(-1.538)	(-1.398)	(-3.662)	(-0.864)	(-1.978)
Ln Population	-0.061**	0.052	0.015	0.021	0.025	0.000	0.049	0.097**	0.104**	0.142***
	(-1.986)	(1.428)	(0.411)	(0.506)	(0.686)	(0.006)	(1.208)	(2.470)	(2.398)	(3.228)
Constant	14.740	26.682	10.582	-1.141	-12.960	15.176	3.830	-25.254	-19.612	13.589
	(0.695)	(1.088)	(0.475)	(-0.056)	(-0.630)	(0.712)	(0.201)	(-1.464)	(-1.400)	(0.861)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,217	1,224	1,168	1,226	1,194	1,189	1,212	1,183	1,208	1,195
Wald Chi-Squared	75	53	47	51	98	94	123	142	91	90
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-Sq within	0.000	0.003	0.000	0.001	0.003	0.007	0.001	0.007	0.001	0.002
R-Sq between	0.098	0.056	0.087	0.084	0.134	0.136	0.140	0.222	0.237	0.227
R-Sq overall	0.096	0.056	0.071	0.075	0.141	0.136	0.151	0.206	0.205	0.230
Sargan-Hansen test	0.318	1.630	0.359	3.462	0.053	1.361	0.031	0.415	0.543	2.357
P-value	0.573	0.202	0.549	0.063	0.818	0.243	0.860	0.519	0.461	0.125

Table 7 (continued)

The full sample comprising 12,016 university-degree-year observations for the period 2007-2017 is split into deciles according to the country-level ratio of applications to number of places offered for each degree. The dependent variable is *Admission cutoff*, the cutoff score for admission to a given program 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. 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, the research variable is measured at the university-field of study level, and the instrumental variables are defined at the university level. The research variable and the instrumental variables are scaled by the university total number of tenured staff. The research variable, 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 *z*-statistics are shown in parentheses. ***, **, * = statistically significant at the 1%, 5%, and 10% levels, respectively.

Table 8. Between effects regression of admission cutoff scores on research activity

Panel A: First-stage regression

	Full sample	Engineering	Health	Humanities	Sciences	Social Sc.
Abn_Tuition fee	0.050***	0.075**	0.013	0.164***	0.068**	-0.091***
	(3.47)	(2.44)	(0.33)	(4.61)	(2.06)	(-6.09)
2nd enrolment premium	0.238***	0.312***	-0.493***	0.425***	0.212*	0.232***
	(4.26)	(2.68)	(-3.17)	(3.12)	(1.66)	(4.04)
Ln No places offered	0.039**	0.085**	0.104**	0.035	0.029	0.026
	(2.36)	(2.22)	(2.05)	(0.74)	(0.58)	(1.53)
L1.Tenured staff (%)	0.174	-0.679**	-0.890**	0.218	0.530	-0.178
	(1.12)	(-2.03)	(-2.11)	(0.55)	(1.44)	(-1.1)
L1.Student-to-staff ratio	-0.259***	-0.671***	-0.099	-0.406***	-0.181**	0.182***
	(-9.63)	(-11.69)	(-1.27)	(-4.83)	(-2.54)	(6.79)
Ln University enrolment	0.110***	-0.030	0.142*	0.648***	0.122*	-0.034
	(3.64)	(-0.44)	(1.71)	(8.56)	(1.79)	(-1.1)
Ln University age	-0.102***	-0.254***	-0.021	-0.118***	-0.092***	0.019
	(-7.97)	(-8.89)	(-0.6)	(-4.05)	(-3.24)	(1.36)
Ln Population	0.016	0.110***	0.066*	-0.197***	-0.028	0.019
	(1.24)	(3.63)	(1.94)	(-6.94)	(-1.06)	(1.45)
L2. State grants	19.360***	14.807***	36.219***	15.228***	33.330***	19.606***
	(18.3)	(6.06)	(9.65)	(6.16)	(13.72)	(18.33)
L2. EU grants	51.040***	20.018***	-2.060	75.455***	11.491	67.295***
	(18.01)	(3.03)	(-0.18)	(10.43)	(1.24)	(24.47)
Constant	0.429	-49.650**	-162.945***	95.738***	-59.361**	22.474**
	(0.04)	(-2.19)	(-5.18)	(3.57)	(-2.5)	(1.97)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,016	3,242	1,558	1,720	1,463	4,033
Wald Chi-Squared	3,041	916	341	467	362	966
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Table 8 (continued)

Panel B: Between effects IV regression

	Full sample	Engineering	Health	Humanities	Sciences	Social Sc.
L1.Abn_First quartile	0.319***	0.397***	-0.023	-0.062	0.230**	0.421***
	(10.220)	(3.895)	(-0.207)	(-0.885)	(2.178)	(10.612)
Abn_Tuition fee	-0.099***	-0.062*	-0.048	-0.215***	-0.042	-0.040
	(-5.337)	(-1.713)	(-0.848)	(-4.654)	(-0.739)	(-1.266)
2nd enrolment premium	0.200***	0.208	0.163	0.369**	-0.069	0.208*
	(2.867)	(1.594)	(0.699)	(2.314)	(-0.323)	(1.741)
Ln No places offered	-0.057***	-0.126***	-0.114	0.069	-0.091	-0.063*
	(-2.710)	(-2.865)	(-1.519)	(1.225)	(-1.069)	(-1.763)
L1.Tenured staff (%)	0.527***	1.241***	2.403***	-0.836*	-0.144	0.320
	(2.798)	(3.037)	(3.746)	(-1.829)	(-0.243)	(0.923)
L1.Student-to-staff ratio	-0.166***	-0.104	-0.251**	-0.319***	-0.304**	-0.212***
	(-4.754)	(-1.090)	(-2.237)	(-3.136)	(-2.488)	(-3.666)
Ln University enrolment	0.516***	0.540***	0.662***	0.524***	0.601***	0.605***
	(13.494)	(7.252)	(5.539)	(5.713)	(5.231)	(9.207)
Ln University age	-0.090***	-0.059	-0.149***	-0.111***	-0.107**	-0.098***
	(-5.639)	(-1.505)	(-2.970)	(-3.166)	(-2.246)	(-3.331)
Ln Population	0.030*	-0.009	0.090*	-0.062*	0.049	0.042
	(1.842)	(-0.230)	(1.773)	(-1.838)	(1.087)	(1.473)
Constant	19.257	38.117	9.353	34.606	-12.163	26.795
	(1.509)	(1.574)	(0.219)	(1.152)	(-0.319)	(1.195)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,016	3,242	1,558	1,720	1,463	4,033
Wald Chi-Squared	386.2	109.3	85.99	77.08	56.19	268.3
P-value	0.000	0.000	0.000	0.000	0.000	0.000
R-Sq overall	0.098	0.055	0.202	0.152	0.119	0.239
Sargan-Hansen test	0.01	1.335	0.943	0.615	0.43	0.028
P-value	0.92	0.248	0.332	0.433	0.521	0.867

The sample comprises 12,016 university-degree-year observations for the period 2007-2017. The dependent variable is *Admission cutoff*, the cutoff score for admission to a given program 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. 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, the research variable is measured at the university-field of study level, and the instrumental variables are defined at the university level. The research variable and the instrumental variables are scaled by the university total number of tenured staff. The research variable, 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 between effects technique, year dummies are omitted from the table, and *z*-statistics are shown in parentheses. ***, **, * = statistically significant at the 1%, 5%, and 10% levels, respectively.