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Essays on the Economics of Higher Education

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A Dissertation carried out on the PhD in Economics, under the supervision of Professor Gianni De Fraja and Dr Alex Possajennikov

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Abstract

This thesis focus on the choice of university admission requirements. The first chapter studies which admission requirements to Higher Education are better predictors of students' success. More specifically, I explore the differences in national high-stake exams and teacher scores used by Economics and Management degrees. I find that the teacher scores are a stronger predictor of students' performance at university. In the second chapter, I study whether universities should select their students only using specialised subject-specific tests, or on the basis of a broader set of skills and knowledge. The empirical analysis is guided by a theoretical framework. The theoretical model shows that although broader skills are not improving graduates' outcomes in the labour market, the university chooses to use them as a criterion for selection alongside the mastery of more subject-specific tools. This is so because broader skills allow the university to select candidates who are on average abler. I test the model on a large administrative dataset of Portuguese students. My central finding is that, on average, universities with less specialised admission policies admit a pool of students who obtain a higher final GPA.

Keywords: National Exams; Teacher Scores; Admission Tests; General Skills.
JEL Classification: I20, I21, I23, I24, I28, J24

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Contents

Introduction **1**

Chapter 1 – Student Selection and Performance in Higher Education: Admission Exams vs. High School Scores **5**

1 Introduction 6
2 Institutional Setting and Data Set 9
3 Estimation Strategy 14
4 Results 17
4.1 GPA 17
4.2 Dropout 25
5 Conclusions 28

Appendix of Chapter 1 **31**

A1 Appendix: Data and Results 33

Chapter 2 – The impact of university admission policies on academic performance **39**

1 Introduction 40
2 The Model and Basic Assumptions 45
2.1 Ability and Admission Tests 45
2.2 Labour Market and Wages 46
2.3 University 47
2.4 Students 47
3 Equilibrium 48
3.1 Effort of Students 48
3.2 University Choice 50

3.3 Interpreting the Results . . . 51
3.4 Government Policy . . . 53
4 Admission Policies in Portugal . . . 54
4.1 Centralized allocation of candidates: the role of the government . . . 55
4.2 The university problem in practice . . . 56
4.3 The student problem in practice . . . 58
5 Datasets . . . 58
6 Empirical Set-up: Admission Tests and Performance . . . 63
6.1 Outcomes . . . 63
6.2 T_2 in practice: the Portuguese exam . . . 66
6.3 Selection into Treatment . . . 69
7 Heterogeneity of Skills . . . 72
7.1 Estimation Strategy: sharp RDD . . . 72
7.2 Results . . . 73
8 Genalists vs Specialists . . . 76
8.1 Estimation Strategy: Partial equilibrium analysis . . . 76
8.2 Results . . . 80
8.3 Discussion and mechanisms . . . 83
9 Conclusion . . . 85

Appendix of Chapter 2 **89**

A1 Appendix: Model Derivations . . . 91
A1.1 Proof of Proposition 1 . . . 91
A1.2 Convolution of the errors . . . 93
A1.3 Derivation of Lemma 1 . . . 94
A1.4 Proof of Theorem 2 . . . 98
A1.5 Proof of Theorem 3 . . . 98
A1.6 Disagreement on λ . . . 99
A2 Appendix: Datasets . . . 101
A3 Appendix: Groups Identification . . . 107
A3.1 Example with observed partial scores . . . 107
A3.2 Missing at random . . . 108
A3.3 Imputation of application score . . . 109

A4 Appendix: Results 111

Bibliography **129**

List of Figures

1 Kernel density estimates for the two admission criteria 13

1 Optimal effort level in the admission tests. 49

2 Student's test scores distribution. Shadowed area represents half of the population, which is admitted to university. 52

3 Different groups of students within the same programme 70

4 Difference on Skills 75

5 Distribution of application scores by groups - without imputation 79

A1 Density function of combined scores from two tests 91

A2 Error terms distribution 94

A3 Definition of $\tilde{\lambda}$ 95

A4 Variation on the number of admitted students for $0 < \lambda < \tilde{\lambda}$. 96

A5 Variation on the admitted students for $\tilde{\lambda} < \lambda < 1$. 97

A6 University and Government Payoffs 100

A7 Distribution of application scores by groups - with imputation 110

A8 Programmes that allow for PT ranked by threshold in the overall distribution of programmes (quartiles) 117

A9 Enrolled students in programmes allow for PT ranked by ability in the overall distribution of student's ability (quartiles) 117

A10 Number of students and programmes by field of study 118

List of Tables

1 Candidates vs. Students in the application process 11
2 Descriptive Statistics (% for three cohorts) 12
3 Final Status of Enrolled Students 14
4 Predictors of Final GPA; Sample: Students that were graduated (OLS estimation) 18
5 Predictors of Final GPA; Sample: Applicant students (OLS and Heckman selection model, MLE) . . . . . .
6 Predictors of Final GPA, with High School fixed effects; Sample: Applicant students (OLS and Heckman selection model, two-step estimation) . . . . .
7 Predictors of Final GPA; Sample: Enrolled students (Heckman selection model, MLE) 24
8 Predictors of Dropout; Sample: Enrolled Students (Probit) 25
9 Predictors of Dropout; Sample: Applicant students (Probit and Heckman selection model, MLE) . . . . . .
A1 Description of the variables 33
A2 Number of non missing observations 33
A3 Structure of the Economics Track at High School 34
A4 Predictors of GPA in four courses; Sample: Applicant students (OLS and Heckman selection model, MLE) . . . . . .

1 First Cycle Degrees in Public HEIs, 2018 55
2 National Exams at High School (according to the academic track) 57
3 Descriptive Statistics, Full Population at Public HEIs, **Application Dataset**(1) 60

4 Descriptive Statistics, Full Population at Public HEIs, **Performance Dataset** . . . 61
5 Descriptive Statistics, Full Population at Public HEIs, **Graduation Dataset** . . . 62
6 Descriptive Statistics, Analysis Population according to the **Outcomes** . 65
7 Example with Two Students, Two Universities . . . 67
8 No. of exam combinations by programme-year . . . 68
9 Exam and application scores . . . 69
10 Descriptive statistics on the Portuguese exam . . . 72
11 Individuals around the assignment rule . . . 73
12 Difference on Skills . . . 76
13 Comparison groups in the overall distribution and around the threshold (shares) . . . 78
14 At the margin of gaining entry in HE . . . 82
A1 Measure of admitted students . . . 98
A2 Parameter Values of Example 1 . . . 99
A3 Summary of original variables in the Application dataset . . . 101
A4 Summary of original variables in the Performance dataset . . . 102
A5 Summary of original variables in the Graduation dataset . . . 102
A6 Broad Fields of Study . . . 103
A7 Diploma types . . . 104
A8 Descriptive Statistics, Analysis Population, **Linked Dataset** . . . 105
A9 Analysis dataset according to all contraints$^{(a)}$ . . . 106
A10 Observed partial scores . . . 107
A11 Group classification missing at random . . . 108
A12 Imputation of the counterfactual application score . . . 109
A13 Differences on Skills (detailed version) . . . 111
A14 At the margin of gaining entry in HE (considering groups C and D jointly) - detailed version . . . 112
A15 At the margin of gaining entry in HE (with Inputation) - detailed version 113
A16 At the margin of gaining entry in HE (without Inputation) - detailed version 114
A17 T test between groups C and D . . . 115

A18 Final GPA for those that completed the degree on time 115
A19 Heckman Selection model, by MLE (with Imputation) 116
A20 Analysis by Field (with Imputation) 119

Introduction

"Asking whether standardized tests are good is much like asking whether cars are good. If they're constructed well and used intelligently, they can be very valuable. Some are just plain bad. Even good ones can be harmful if misused. None are perfectly reliable"

(Zwick, 2017)

The general use of admission tests has been under the spotlight and the public eye over the last decades. There is no consensus in the literature if such tests are effective in spotting the future outstanding students at university. When university capacity is limited, admitting one extra person as a student means excluding another. The way that colleges and universities solve this problem is usually through the use of admission tests. In this thesis, I present two studies that, from different perspectives, analyse the role of university admission tests.

The goal of the first chapter is to understand which admission requirements seem to be the best explanatory factors of future student performance. In several countries, students' selection by HEIs is primarily based on their academic achievements at high school, which are measured by scores provided by teachers and/or obtained in the final exams. The first chapter compares the effectiveness of these two measures in predicting students' success in HE. Specifically, I explore possible differences in the influence of national high-stake exams (i.e. A-levels) and high school teacher scores on student's performance in Economics and Management degrees. Accounting for sample selection problems, I find that the high school teacher scores are a more reliable predictor of students' performance at university. However, the score obtained in the national exam still adds information. I conclude that both measures are complementary, a result that is relevant for university recruitment and selection policies.

In the second chapter, I extend the study of college admission to all degrees. I test

whether the diversification on the nature of high-stake exams generates a better pool of selected students, as measured by their future performance. In other words, I study whether universities should pick their students only using specialised subject-specific tests, or based on a broader set of skills and knowledge. I built a theoretical model, which shows that the use of a broader set of tests, even if not directly related to the field of study, is successful in attracting a better pool of incumbents. I test the model using Portugal as a case study, as I have an extremely rich and large dataset of Portuguese students. In Portugal, with some exceptions, HEIs have multiple tracks of admission for each degree. They either require a subject-specific set of exams or rank students according to the better off among the subject-specific set of exams and a broader set of exams. Due to this design, I observe students being to the same programme (pair of institution/degree) based on performance in different exam sets. In my empirical analysis, I exploit the variation between a specific and non-specific set of exams, using a Regression Discontinuity approach. My central finding is that, on average, universities with less specialised admission policies admit a pool of students who obtain a higher final grade point average (GPA).

My results have substantial implications for university admission practices. Firstly, universities should consider teacher scores alongside admission exams. Even controlling for high school fixed effects and self-selection issues, teacher scores seem to be a stronger predictor of student performance than national exam scores. Secondly, I find evidence that universities that rank candidates based on a broader set of exams, rather than field-specific exams only, benefit at the margin of admission. They select candidates who are on average abler. One possible interpretation surrounds the role of field-specific exams, as they may not be effective at testing the specialist skills associated with high achievement at university. As a result, universities should either consider a broader set of exams in their admission requirements or rethink the design of field-specific exams.

Chapter 1

Student Selection and Performance in Higher Education: Admission Exams vs. High School Scores

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1 Introduction

In many countries, students are ranked and selected into higher education institutions on the basis of their achievement in high school. This performance is typically measured by one or a combination of the two following measures: scores given at the school level by the teachers of the student throughout the years of high school and scores obtained on final exams, usually exclusively written, and often national (all students take the same exam, independently of their school of origin).[1] Different educational systems attach different weights to each of these measures. Understanding each of these pieces of evaluation in terms of their ability to predict success in higher education is a relevant issue for the definition of adequate University recruitment policies.

The use of national/central examinations in the admission process to public higher education institutions is common in many countries (e.g. Portugal, Brazil, Colombia, Denmark, Hungary, Italy and Spain). The ranking of students for the purpose of placement in Portuguese public higher education institutions relies on a weighted average of these two scores - national exams and high school scores - and, within some limits, universities are free to choose their weights. In our case study, the weight given to the national exam is set at the maximum permitted level, 50%. Thus, prior to our analysis, we were expecting the national exam score to be a stronger predictor of student's performance rather than the high school score which usually is prone to teacher grade inflation.

Our paper compares these two measures of performance at high school in terms of their ability to predict students' performance in higher education at a top Business and Economics public school in Portugal. We account for students' socio-economic characteristics and measure their educational success at higher education by the bachelor's final GPA and by dropout. Our sample includes three cohorts of more than 1,500 students per year who applied to this school. Out of these, only around 400 students per year were accepted. We only observe the performance results of those students who actually

[1] These two measures of performance are used in many countries as documented in OECD (2017): "For entry into public tertiary institutions, grade point averages from secondary school are used in one-third of countries (with either open or selective admission systems), with a further quarter of countries reporting that institutions have autonomy over their use. However, this factor was considered to be of moderate or high importance in determining the success of a student's application in over half of these countries". It is also mentioned that "National/central examinations (standardised tests that have a formal consequence for students) at the end of upper secondary level are administered in most countries with available data (27 countries)" and "In nearly two-thirds of countries, the completion of national/central examinations is compulsory to enter most or all fields of study in public tertiary institutions".

enrolled in the school. Thus, we have to take into account the role of admission criteria for the selection of students into higher education institutions in a setting of scarcity of vacancies relative to applications. Additionally, we also need to take into consideration that not all students that were admitted actually finished their degree, such as those that dropped out.

In our context, selection plays a dual role: (1) only the top applicants can be selected into the limited number of vacancies available and (2) students are free to select the universities they want to apply to. Additionally, students can also dropout of the course after being enrolled. This generates a problem of self-selection in our sample, which we solve by using the Heckman (1979) sample selection model. In particular, we use student preferences when applying to higher education as an exclusion restriction variable. We find that the high school teacher score is a stronger predictor of students' performance at university than the national mathematics exam score. Also, we find that dropout is not correlated with either of these measures of past performance.

Our paper contributes to the literature that evaluates the role of high stakes assessment versus teacher assessment on the access to higher education degrees. A possible explanation for the use of these two measures is that they are complementary, they may influence students' decisions to apply to Higher Education (Papay et al., 2016), and they can be both used as predictors of students' future performance (Kobrin et al., 2008). However, there are advantages and disadvantages associated with both measures.

The use of high school scores as an admission criteria conveys a message that academic performance at high school matters. It is a cumulative measure that incorporates different dimensions and subjects of a student's knowledge. However, even when it is a good predictor of students' success, there are some distortions that can be associated with the use of high school scores (Zwick, 2013): i) it is not helpful in distinguishing top students at the high end of the scale; and ii) the grading standards can vary across schools. It is often believed that teacher scores are more vulnerable to teachers' evaluation of particular student characteristics other than the potential or actual academic success. High school scores are affected by the context in which they are assigned and by the "teacher judgement" as well (Willingham et al., 2002). Factors such as class behaviour, attendance, participation in extra curricular activities, among others, can affect those scores (e.g. McMillan et al. (2002); Diamond and Persson (2016); Koretz (2002); Campbell

(2015)).

Conversely, national exams are able to provide cleaner signals on that issue. Fairness issues also constitute an important dimension to be considered, which would favour the use of national exams; in particular, when there are concerns that high school teachers may inflate the scores they give to their students with the objective of helping them obtain a better chance at entering the university of their choice. Detractors of using national exam evaluations, in turn, claim that exams, relying on a single observation in time, may be noisier and vulnerable to external shocks. As pointed by (Zwick, 2017), admission to universities exclusively based on test scores may generate classes that are less diverse and have worse first year college grades. Although high stakes exams allow for an efficient comparison, they can also reinforce pre-existing inequalities between specific groups, namely in terms of ethnicity, gender, geographical location, high school attended, or economic status, that usually are associated with differences in performance on those exams (e.g. Card and Rothstein (2007); Pop-Eleches and Urquiola (2013); Neal and Schanzenbach (2010)).

Additionally, our paper also contributes to the literature that evaluates the determinants of success at higher education that have been studied in several papers, such as Smith and Naylor (2001); Gutiérrez et al. (2007); Thiele et al. (2016); Leão and Lopes (2008). There is a remarkable lack of consensus about these predictors of academic achievement. One issue commonly referred to in the literature is the socio-economic background of the student. From Tinto (1975) to Nicpon et al. (2006), the vast majority of authors agree that high levels of social support can allow for faster student's progression, especially for those students from lower social backgrounds (Delaney et al., 2011). We find no evidence of this. In line with Smith and Naylor (2005); Hoare and Johnston (2011); Nata et al. (2014), we find some differences in performance for students coming from different types of high schools (in our case public vs. private).

Smith and Naylor (2001); McKenzie and Schweitzer (2001); Gutiérrez et al. (2007), and more recently Thiele et al. (2016) also investigated the role of high school results, family, and social background on the success of British and Spanish university students. The common conclusion is the relevance of prior achievement (measured by A-level results for the UK and Selectivity for Spain). Opposite to what we found, McNabb et al. (2002) present evidence of better performance of women at university and a high correla-

tion between parents' academic or professional background and undergraduates' success. Additionally, these papers support evidence that students who live with their parents and those who receive social support perform better.

The rest of the paper is organized as follows. In the next section, we present our case study and describe our data set. Section 3 describes the estimation strategy, while Section 4 presents the results. In the last section we provide some concluding remarks.

2 Institutional Setting and Data Set

Admission Process to Higher Education Institutions in Portugal

The Portuguese tertiary education system is composed of Polytechnics and Universities. When students complete their secondary education they can apply to public higher education through a national contest run by the Ministry for Higher Education. In that process students indicate their preferences for up to six different programs (combination of degree/university) ranked by order of preference. Each higher education institution has, for each degree, a limited number of vacancies, determined by the Ministry.

In each yearly national contest there are three rounds of applications. The majority of institutions only have two rounds. The number of vacancies available to the second round depends on the number of vacancies that were not fulfilled in the 1st round.

The selection of students into each degree in each higher education institution is made according to students' preferences, and based on an admission score which is a weighted average of the final high school score and national exam scores. Schools decide which national exams (up to two) are taken into account in the applications for each of their degrees and they also choose the weight of the set of national exams from a range of 35% to 50%.[2]

The minimum application score for admission is not set *a priori* as this is the result of the algorithm that allocates all the applicants to all degrees amongst the different higher education institutions taking into account their preferences, their admission scores to the different degrees, and the number of slots available for each degree in each institution. However, applicants have information about the minimum admission score needed in

[2]Only Medicine takes into account three national exams: Mathematics, Biology & Geology, and Physics & Chemistry.

previous years as this is made public by the Ministry after the end of each contest. Thus, they can take this information into account when deciding where to apply.

The Ministry allocates each applicant to the program that ranks highest in her preferences and for which she has an application score higher than the minimum admission score. Thus, students' preferences play a meaningful role in the outcome of the admission contest and we will take advantage of this in our strategy to overcome the potential selection bias in our initial results.

Data

This study examines data from Nova SBE, a top Business and Economics School in Portugal, for the academic years of 2008/2009, 2009/2010, and 2010/2011. When applying to this school the high school score has a weight of 50% and the national Mathematics exam accounts for the remaining 50%, for both the Bachelor in Economics and the Bachelor in Management. The process of application and admission of students and the structure of the degrees underwent no changes during this period. Both degrees have a duration of three years.

The database used was extracted from different sources. We aggregate two databases, one that is internal to the school and that provides administrative data regarding the performance and personal characteristics of enrolled students and another with information about all the candidates that applied to the school.[3]

For enrolled students we have data on 1130 undergraduate students of Economics and Management, who were admitted through the national contest described above in the academic years of 2008/2009, 2009/2010, and 2010/2011[4]. Regarding applications, there are 9015 observations for these three cohorts. Each candidate could have applied to both the Bachelor in Economics and the Bachelor in Management. However, if applying to both degrees that would count as two of the six preferences that they could rank in their application to higher education. Most applicants included the two degrees in their preferences, counting in our dataset as two applications. For example, in the 1st round of applications of 2008/2009, 49% of the students applied to both degrees (see Table 1).

[3]SIGES/CSE is the internal database of the school and CNA/DGES (Contingente Geral de Acesso) is the database of applications provided by the Ministry. Furthermore, for those students who enrolled in the school we gathered information about the social support given by the Rectory - SAS.

[4]For the purpose of this study, only students who were admitted to Nova SBE through the national contest were included. There is a reduced number of students who may obtain admission through special regimes like the one that applies to federated athletes.

Table 1: Candidates vs. Students in the application process

	Number of Applications			Number of Students that Applied			% of Students that Applied to Both Degrees		
	2008/09	2009/10	2010/11	2008/09	2009/10	2010/11	2008/09	2009/10	2010/11
1st Round	3011	2086	2498	2018	1366	1659	49.2	52.7	50.6
2nd Round	351	420	440	225	263	283	56.0	59.7	55.4
3rd Round	-	107	102	-	63	59	-	69.8	72.8

For each individual that enrolled at the school, the relevant information can be divided into five categories: (i) *Personal information*: which includes gender, age, and distance from home; (ii) *Academic history*: type of high school (public or private), previous track at high school (can be economics, science, arts, or humanities), final high school score, and the national mathematics exam score;[5] (iii) *Social and Economic Background*:[6] parents' educational level, if the student applied to receive social support, and if the student received social support. In case the student received social support there is also information about the value of the scholarship received, the average income per year and the number of scholarships that the student received over the period that they have been enrolled. (iv) *Academic outcomes*: academic situation in 2015 (graduated, dropped out, transferred, still studying) and final GPA.[7] (v) *Other information*: bachelors' degree (Economics or Management) and order of preference of application. A more complete description of all the variables is presented in the Appendix (Table A1).

Table 5 presents some descriptive statistics of students' characteristics.[8] The number of students enrolled in Economics and Management is roughly the same, most students (94%) have regular age, 50% are non local students and 74.6% come from public high schools. Around 70% of the students had at least one parent with higher education, only 14% applied to receive social support, and an even lower percentage, 8%, received it. Around two thirds of the students come from the Economics track and one third from Sciences. Finally, around 90% of the students are enrolled in the degree they chose as

[5]In Portugal there are three different national exams in Mathematics: Mathematics A, Mathematics B, and Applied Mathematics. In this paper only Mathematics A is considered, as this is the exam required for admission to Nova SBE.

[6]These variables are available only for enrolled students.

[7]The Final GPA (Grade Point Average) is calculated as the average of the scores obtained in all courses taken during the degree program. All course scores are given on a scale from a minimum of 0 to a maximum of 200. Course instructors use a variety of methods to assess students, including class participation, midterm exams, in-class tests, group work, take home assignments, class presentations, etc. A final exam is mandatory for all courses, covering the entire span of the course, and its weight in the course final score varies between 30% and 70%.

[8]Additional details regarding the number of non missing observations for each variable is presented in Table A2.

their first preference.

Table 2: Descriptive Statistics (% for three cohorts)

	Applications				Enrolments		
	Econ.	Man.	Both	Total	Econ.	Man	Total
Male	54.1	51.8	55.1	52.9	50.4	48.0	49.2
Regular Age (<=18)	83.5	81.2	80.2	82.2	94.5	92.8	93.6
Non Local Students (> 40km)							
Originally from Urban Areas	37.7	36.9	34.0	37.3	40.4	32.9	36.7
Originally from Non-Urban Areas	13.6	11.7	10.2	12.6	15.4	9.1	12.2
Track at High School							
Economics	58.3	53.1	61.3	55.4	67.3	62.5	64.9
Science	31.1	34.5	28.1	33.0	29.5	32.7	31.2
Other	10.6	12.4	10.7	11.6	3.2	4.7	4.0
Public High School	74.2	74.9	-	74.6	75.1	74.1	74.6
Socio-Economic Background							
Parents with HE (at least one)	-	-	-	-	69.6	70.0	69.7
Applied for Maintenance Grant	-	-	-	-	15.0	13.5	14.2
Received Maintenance Grant	-	-	-	-	7.7	7.9	7.8
Stated Nova SBE Econ./Manag. as 1st Option	31.0	39.6	-	34.7	91.9	89.1	90.7
Enrolled in 1st Round of Applications	-	-	-	-	88.0	82.0	85.0
No. Observations	(4054)	(4961)	(3795)	(9015)	(559)	(571)	(1130)

Notes: In "Applications" we analyse the number of applications and not the number of students. Although not reported here, the descriptive statistics per cohort are very similar to each other.

Comparing enrolled students with applicants, we observe that the proportion of enrolled students under regular age is higher than this proportion among applicants. The percentage of enrolled students that followed the Economics track at high school is also higher than this proportion among applicants. Also, the percentage that chose the respective degree as first preference is also very different for the two groups. Thus, we may conclude that the group of students that enrolled in the school is different from the group of students that applied to the school. This difference could bias our results when we look at predictors of students' outcomes, which, of course, can only be done using data for enrolled students. We will take this into account when designing our estimation strategy.

The difference between the set of applicants and the set of enrolled students arises because there are not enough places for all the applicants and thus, some of them are not admitted to Nova SBE. It may also happen that an applicant who was allocated to the school decides not to enrol. This may happen for instance if she chooses to study at a private institution or in a different country.

The main objective of this paper is to understand how the two measures of achievement at high school that are used to select students into the two degree programs, the high school score and the score in the national Mathematics exam, perform in terms of

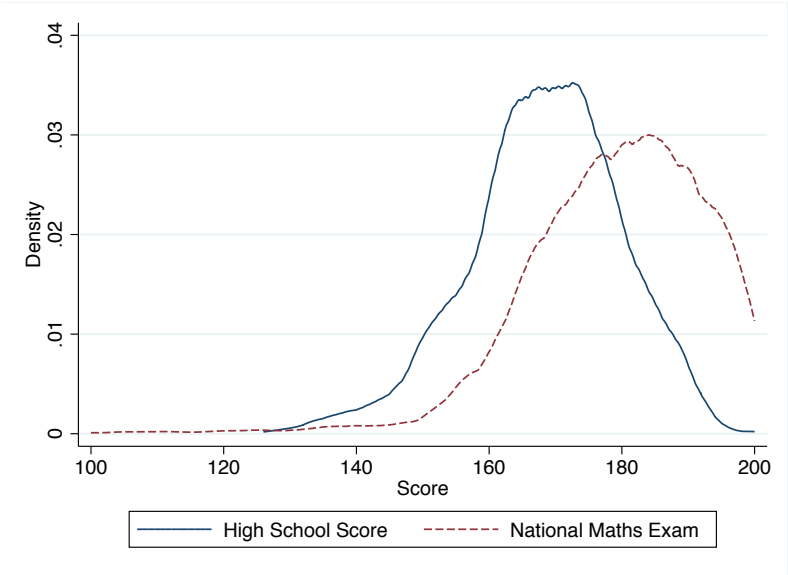


Figure 1: Kernel density estimates for the two admission criteria

predicting students' performance during their Bachelors in Economics and Management.

Figure 1 presents the distribution of these two potential predictors of students' outcomes for Nova SBE students. We observe that the national mathematics exam has a higher average than the high school score. Also, the national exam presents a standard deviation of 13.25, compared to the 11.41 standard deviation of the high school score distribution.

The two measures are different in their nature. The high school score is an average of all the courses' scores obtained during high school (from 10th to 12th grades). During the three years of study the courses taken by each student vary according to the track chosen.[9] Students must take two national exams at the end of the 11th grade and another two exams at the end the 12th grade (typically when students are 16 and 17 years old, respectively). The Mathematics exam is always taken at the end of the 12th grade. The national exams' scores provide a snapshot of the student's performance. Over the last decades there have been proposals for universities to increase the weight associated with national exams in their admission criteria. One argument is that although high school scores reflect both educational achievement and non cognitive factors, such as effort, conformity, and motivation (Stiggins et al., 1989), they are sensitive to the 'teachers' judgement". The national exams instead are believed to represent a fair and comparable measure of students' knowledge and cognitive skills in specific subject matters. In any

[9]See table 2 in appendix for the courses included in the Economic track at high school.

case, they measure different dimensions of students' performance in high school.

Our aim is to compare these two measures of performance at high school in terms of their ability to predict students' success in higher education. This is especially relevant in our case study where both measures are equally weighted in order to be admitted to higher education (50/50).

In our case study, we observe individuals at different stages: i) when they apply to higher education; ii) when they enrol after being admitted to university; iii) if they dropout or are transferred to another university; and iv) when they graduate. In fact, according to Table 3, 10% of the enrolled students in the sample dropped out of their degree within the first three years. There are still 8% of the enrolled students that, at the time of the data collection, had not finished their degree yet. These differences in the final status of the students will be important later on when defining our estimation strategy.

Table 3: Final Status of Enrolled Students

	Economics		Management		Total	
Final Status	No.	%	No.	%	No.	%
Dropout	54	9.7	64	11.2	118	10.4
In the 1st year	23	4.1	30	5.3	118	4.7
In the 2nd year	21	3.8	20	3.5	41	3.6
In the 3rd year	7	1.3	10	1.8	17	1.5
After 3 years	4	0.7	4	0.7	8	0.7
Transferred	2	0.4	5	0.9	7	0.6
Graduated	470	84.1	448	78.5	918	81.2
In 3 years	300	53.7	236	41.3	536	47.4
In more than 3 years	170	30.4	212	37.1	382	33.8
Did not finish yet	33	5.9	54	9.5	87	7.7
Enrolled students	559	100	571	100	1130	100

Notes: This status pertains to the time when the data were collected (Jan 2015).

3 Estimation Strategy

In this section we present our estimation strategy. We analyse the relationship between an outcome variable, denoted by y_i, and its predictors. We consider two different outcome variables: i) the final GPA (Final GPA) of the student; and ii) a dropout dummy variable (Dropout) equal to one if the student dropped out of the program and zero otherwise.[10]

[10]Dropout equals 1 for students who left the university without completing their Bachelors (in the 1st three years) and 0 for those who graduate.

The Final GPA is standardized by subtracting the mean and dividing by the standard deviation. The two predictors of interest that we want to evaluate are the High School Score ($HSScore$) and the National Maths Exam ($MathsExam$), and are also standardized.

Because of the application process, we separate Economics from Management. As mentioned in Section 2, we have 9015 applications over the period of analysis, representing however a smaller number of students due to the fact that the majority of them applied to both degrees. Hence, our regression models are estimated separately for Economics and Management in order to avoid a double counting problem.

The baseline regression model is the following:

$$y_i = \beta_0 + \beta_1 \times HSScore_i + \beta_2 \times MathsExam_i + X_i'\beta_3 + u_i$$

where X_i is a vector of controls and u_i is the error term. $HSScore_i$ and $MathsExam_i$ are included in the regressions both separately and jointly in order to analyse which is a better predictor of y_i. When the outcome variable is the Final GPA, the model is estimated by Ordinary Least Squares (OLS) using the sample of students that finished their degree. In the case of Dropout we estimate a Probit model using the sample of students that were admitted and enrolled in university.[11]

In the presence of sample selection, the OLS and Probit estimations have the potential risk of providing inconsistent estimates.[12] In fact, one characteristic of our dataset is that we observe Dropout for only those students that were admitted and enrolled in university, while the Final GPA is observed for only those students that graduated. Furthermore, the particular school that we are analysing attracts very good students, many of whom with very high admission scores. The vast majority of them applied to the school as their first preference. Consequently, as mentioned above, the characteristics of those students for whom we observe the outcome variables are different from the overall higher education "population", and more specifically from applicants, leading to potential sample selection biases.

To address the problem of selection bias we estimate a Heckman (1979) selection model according to the following specification of the outcome and selection equations:

[11] We also estimated Logit models and the results were very similar.

[12] This is also known as the incidental truncation problem.

Outcome Equation:

$$y_i = \beta_0 + \beta_1 HSScore_i + \beta_2 MathsExam_i + Z_i'\beta_3 + V_i'\beta_4 + \beta_5\lambda_i + u_i \quad (1)$$

where Z_i includes the following control variables: dummies per cohort, gender, non-local students (from urban/non-urban areas), rounds of application, public high school, parents' education, previous track at high school, and age; V_i is a dummy variable equal to one if the student applied to a maintenance grant and zero otherwise; and λ_i is the inverse Mills ratio obtained from the selection equation.

Selection Equation:

$$Pr(Selected_i) = \gamma_0 + \gamma_1 HSScore_i + \gamma_2 MathsExam_i + \gamma_3 Preference_i + Z_i'\gamma_4 + \epsilon_i \quad (2)$$

where the variable *Preference* is decomposed into dummies indicating the order with which each student applied to that degree.[13] The coefficients in the selection equation should be interpreted as affecting the probability of observing the outcome variable, y_i, of the students in the sample.

From a technical point, the coefficients of the outcome equation in the Heckman selection model are identified due to the nonlinearity of the inverse Mills ratio, even when we have the same regressors in the selection and outcome equations. However, the precision of the coefficient estimators can be improved if at least one regressor in the selection equation does not enter the outcome equation. In our case, we can consider that the order of preference stated when students apply to higher education has an influence only on the likelihood of being admitted, and not on the outcome. This fact is particularly relevant to those students who have high admission scores, as it is the order of preference that ultimately determines whether they are admitted or not. For instance, some students in our sample were not admitted since they had a different first option, such as medicine. Thus, the order of preference in the majority of the cases is essential to determine the admission but not the outcome. The *Preference* variable is therefore included only in the

[13]Notice that the admission grade is 50% for the maths exam and 50% for the high school score. In that sense we should not include the two admission criteria as regressors in the selection equation. However, the correlation between each admission criterion and the admission status is only around 25%. This occurs because, as we will see later, the order of preference plays an important role in the admission process. In any case, we estimated the model without including the two admission criteria in the selection equation and the results were very similar.

selection equation.

The Heckman selection models for the Final GPA were estimated using the maximum likelihood estimation (MLE) with bootstrap standard errors. For the case of the Dropout outcome variable we used the Heckman Probit model. We compared the MLE estimations with the Heckman two-step procedures (without bootstrapping) and the results were always very similar.

4 Results

4.1 GPA

We first consider the final GPA of students that were graduated as the outcome variable. Table 4 presents the OLS estimation results of the outcome equation for the samples of Economics and Management students separately. In the first two regressions (columns (1) and (2) for Economics and (6) and (7) for Management), we separate the effect of the national maths exam from the high school score and include dummies per cohort. In columns (3) and (8) we include the two variables at the same time. In columns (4) and (9) we add several control variables.[14]

In all regressions, the high school score and the national maths exam variables are statistically significant. Moreover, the results suggest that the high school score is a stronger predictor of final GPA than the national maths exams. For instance, in the case of Economics, according to column (4), an increase of one standard deviation in high school score is associated with an average increase of 0.66 of a standard deviation in final GPA, while the effect of the national maths exam is only 0.45 of a standard deviation. For Management, as can be seen in column (9), the difference is even larger: the estimated effect in the final GPA of the high school score is 0.64 while the effect of the maths exams is only 0.25.

A standard finding in the literature is that parental education has substantial effects on student performance. However, in columns (5) and (10), where we added the $ParentsHE$ variable, it comes out has not statistically significant. Actually, similarly to Cerdeira et al. (2018), that effect may not be evident in our estimates because it is already captured by

[14] In columns (4) and (9) the reference group is composed of female students from the cohort 2008/2009 that live no more than 40km from Lisbon, who studied at a private high school, and that did not apply for (and did not receive) any maintenance grant.

the variables that account for the university entrance criteria; and that is probably why we do not observe statistical significance. Thus, since we lose some observations due to missing data in this variable, hereafter we will not include it in our regressions.

Table 4: Predictors of Final GPA; Sample: Students that were graduated (OLS estimation)

	Economics					Management				
Final GPA	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
High School Score	0.68***		0.61***	0.66***	0.67***	0.64***		0.61***	0.64***	0.70***
	(0.05)		(0.05)	(0.06)	(0.06)	(0.06)		(0.06)	(0.07)	(0.07)
National Maths Exam		0.60***	0.43***	0.45***	0.47***		0.35***	0.25***	0.25***	0.31***
		(0.08)	(0.07)	(0.07)	(0.07)		(0.09)	(0.08)	(0.08)	(0.10)
Non Local Student (> 40 km)										
From Urban Area				-0.16*	-0.18**				-0.27***	-0.22**
				(0.08)	(0.08)				(0.09)	(0.10)
From Non-Urban Area				0.02	0.03				-0.50***	-0.46***
				(0.13)	(0.13)				(0.17)	(0.17)
Male				0.33***	0.31***				0.12	0.09
				(0.08)	(0.08)				(0.09)	(0.09)
Previous Track: Econ.				0.06	0.07				-0.09	-0.09
				(0.08)	(0.08)				(0.09)	(0.09)
Public High School				-0.05	-0.02				0.08	0.08
				(0.09)	(0.10)				(0.09)	(0.09)
Parents HE					0.02					-0.02
					(0.10)					(0.13)
Age				Yes	Yes				Yes	Yes
Applied for Maintenance				Yes	Yes				Yes	Yes
Application Rounds FE				Yes	Yes				Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.43***	-0.68***	-0.85***	0.67	0.79	-0.36***	-0.44***	-0.60***	-2.03	-2.02
	(0.07)	(0.10)	(0.10)	(1.19)	(1.19)	(0.08)	(0.13)	(0.12)	(1.18)	(1.17)
N	470	470	470	463	448	448	448	448	440	418
Adj. R^2	0.28	0.13	0.33	0.37	0.38	0.22	0.07	0.25	0.26	0.28

Notes: Robust standard errors in parentheses and statistical significance of $*p < .1$, $**p < .05$, $***p < .01$. The variables Final GPA, High School Score, and National Maths Exam were standardized and all coefficients should be interpreted as standard deviation changes. In columns (4) and (5) the number of observations decrease from 470 to 463 and 448 due to missing information regarding the non local student and the parents HE variables, respectively. Due to the same reason, in columns (9) and (10) the number of observations decrease from 448 to 440 and 418, respectively.

From the results in Table 4, we can equally conclude that being a non local student is statistically significant in Management. Non local students from non urban areas tend to have minus half of a standard deviation in final GPA, when compared with local students. There is also evidence that, on average, male students in Economics end up obtaining a higher final GPA than their female counterparts. In addition, the effect of a student coming from a public school is not statistically significant. Previous track does not influence the final result either.

To sum up, the high school score, the national maths exam, gender, and being a non local student should be taken into consideration when one wants to predict the final GPA, and the high school score is a stronger predictor than the national maths exam.

Table 5: Predictors of Final GPA; Sample: Applicant students (OLS and Heckman selection model, MLE)

	Economics		**Management**	
	(1)	(2)	(3)	(4)
	Heckman	OLS	Heckman	OLS
Outcome Eq. (Final GPA)	(Boot. S.E)	(Robust S.E.)	(Boot. S.E)	(Robust S.E.)
High School Score	0.70***	0.66***	0.62***	0.64***
	(0.07)	(0.06)	(0.08)	(0.07)
National Maths Exam	0.53***	0.45***	0.21**	0.25***
	(0.08)	(0.07)	(0.11)	(0.08)
Non Local Student (> 40 km)				
from Urban Area	-0.16*	-0.16*	-0.26**	-0.27***
	(0.08)	(0.08)	(0.10)	(0.09)
from Non-Urban Area	0.03	0.02	-0.50***	-0.50***
	(0.13)	(0.13)	(0.17)	(0.17)
Male	0.32***	0.33***	0.12	0.12
	(0.08)	(0.08)	(0.08)	(0.09)
Previous Track: Economics	0.08	0.06	-0.11	-0.09
	(0.08)	(0.08)	(0.10)	(0.09)
Public High School	-0.03	-0.05	0.07	0.08
	(0.08)	(0.09)	(0.09)	(0.09)
Age	Yes	Yes	Yes	Yes
Applied for Maintenance	Yes	Yes	Yes	Yes
Application Rounds FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Selection Eq. (Prob. of applicant students enrolling and finishing the degree)				
High School Score	0.05***		0.05***	
	(0.01)		(0.00)	
National Maths Exam	0.08***		0.07***	
	(0.01)		(0.00)	
Preference 2	-0.21***		-0.20***	
	(0.01)		(0.015)	
Preference 3	-0.21***		-0.20***	
	(0.02)		(0.03)	
Preference 4	-0.26		-0.19***	
	(0.18)		(0.02)	
Preference 5	-0.82***		-0.19***	
	(0.05)		(0.07)	
Preference 6	-0.81***		-0.25	
	(0.05)		(0.15)	
Non Local Student (> 40 km)				
from Urban Area	-0.01*		-0.01*	
	(0.01)		(0.01)	
from Non-Urban Area	-0.01		-0.03*	
	(0.01)		(0.00)	
Previous Track: Economics	0.00		0.01	
	(0.01)		(0.01)	
Public High School	0.02*		0.03***	
	(0.01)		(0.01)	
Male	-0.01		-0.01*	
	(0.01)		(0.01)	
Age	Yes		Yes	
Application Rounds FE	Yes		Yes	
Cohort FE	Yes		Yes	
Number of Obs.	3821		4676	
Uncensored Obs.	463	463	440	440
ρ	0.19		-0.06	
Indep. test ($\rho = 0$) p-value	0.09	(No bias)	0.60	(No bias)
Wald test for HSScore and Maths	Prob> χ^2=0.00		Prob> χ^2=0.00	

Notes: *$p < .1$, **$p < .05$, ***$p < .01$. Robust s.e. for OLS, Bootstrap s.e. for Heckman. The variables Final GPA, High School Score, and National Maths Exam were standardized and all coefficients should be interpreted as standard deviation changes. For the selection equation we report average marginal effects.

Table 5 presents the first set of results when correcting for sample selection. For comparison purposes we also include in the table the results obtained using OLS. The selection equation models the probability of a student having a Final GPA (i.e. being admitted, enrol, and finish the degree) among all the applicant students. It is important to emphasize that there are several variables in the selection equation that are statistically significant. Based on columns (1) and (3) we can conclude that the admission criteria and the order of preference affect the probability of observing the Final GPA, that is, of a student finishing the degree. That probability also tends to increase by around 2 percentage points if the student comes from a public school. The evidence also suggests that being a non local student has a negative effect on this probability.

However, our focus of interest is the outcome equation, and we wish to understand which factors *a priori* can be used to predict a better performance at university. The first main conclusion is that, even after controlling for selection using the Heckman selection model, the high school score remains a stronger predictor of the final GPA than the national maths exam.[15] In Economics, one standard deviation increase in the high school score leads to an increase of 0.70 standard deviations in the final GPA, on average, whereas the effect of the national maths exam is only 0.53. The difference between these two admission criteria is even greater in Management, where the coefficient of the national maths exam is relatively small.[16] This difference between Economics and Management itself could be explained by the fact that Management is traditionally viewed as having a lower mathematical content. Nevertheless, it is still remarkable that the high school teachers' assessment, even if eventually subject to teachers' judgement biases, is a good predictor of performance in higher education.

Regarding other predictors of student's success, the evidence also suggests that in Economics, male students obtain a better score than their female counterparts. Specifically, the former obtain more 0.32 of a standard deviation in final GPA when compared with the latter. As far as Management is concerned, unlike what we see in Economics, a non local student that comes from a non-urban area loses, on average, 0.50 of a standard

[15] We also considered as an alternative outcome the average of core courses in the first year of the undergraduate program and the conclusions remain the same. The results are available in Table A4 in the appendix.

[16] We also performed a Wald test of the joint significance of the two admission criteria and, since we reject the null hypothesis, that leads us to conclude that both criteria should be included as predictors in the regression.

deviation in Final GPA. In fact, we verify that non-local students display significantly lower performance in Management. The structure of the Economics and Management degrees might be one of the possible reasons for these results. Management students have to do more group works than Economics students, and non local students may find it more difficult to conciliate that with the need to occasionally go home for the weekend. Also, the quality of transports in some rural areas is poor, which increases the time that a student from a rural area needs to visit her family. These factors imply that being a non local student negatively affects performance at university because they have less time to focus on the work than do local students.

The results in Table 5 suggest the absence of bias in the original OLS estimations.[17] This could be due to the fact that 90% of the admitted students were admitted to their first preference. This means that, looking only at the students that were admitted, there is no large variation in the 'preference" variable that we used as one of the exclusion restrictions in the context of the Heckman selection model. However, we argue that there might exist an unobserved variable, such as unobserved ability, that affects the preference order and the outcome simultaneously. We believe that this last point is not a major concern in our case.

[17] According to the results in Table 5, the correlation ρ between the error terms in the outcome and selection equations is not statistically significant for both Economics and Management.

Table 6: Predictors of Final GPA, with High School fixed effects; Sample: Applicant students (OLS and Heckman selection model, two-step estimation)

	Economics		**Management**	
	(1)	(2)	(3)	(4)
	Heckman	OLS	Heckman	OLS
Outcome Eq. (Final GPA)	(Two Step)	(Robust S.E.)	(Two Step)	(Robust S.E.)
High School Score	0.82***	0.76***	0.61***	0.59***
	(0.06)	(0.08)	(0.07)	(0.09)
National Maths Exam	0.48***	0.38***	0.25***	0.21*
	(0.08)	(0.10)	(0.09)	(0.11)
Non Local Student (> 40 km)				
from Urban Area	-0.03	-0.02	-0.20	-0.19
	(0.13)	(0.16)	(0.12)	(0.16)
from non Non-Urban Area	-0.09	-0.07	-0.55*	-0.55
	(0.21)	(0.29)	(0.29)	(0.37)
Male	0.32***	0.33***	0.08	0.09
	(0.07)	(0.11)	(0.08)	(0.11)
Previous Track: Economics	0.06	0.03	-0.25**	-0.28**
	(0.09)	(0.13)	(0.10)	(0.12)
High School FE	Yes	Yes	Yes	Yes
Age	Yes	Yes	Yes	Yes
Applied for Maintenance	Yes	Yes	Yes	Yes
Application Rounds FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Selection Eq. (Prob. of applicant students enrolling and finishing the degree)				
High School Score	0.003***		0.019***	
	(0.001)		(0.002)	
National Maths Exam	0.005***		0.027***	
	(0.001)		(0.003)	
Preference 2	-0.015***		-0.048***	
	(0.002)		(0.005)	
Preference 3	-0.004***		-0.027***	
	(0.001)		(0.003)	
Preference 4	-0.004***		-0.026***	
	(0.001)		(0.003)	
Preference 5	-0.009***		-0.022***	
	(0.002)		(0.003)	
Preference 6	-0.008***		-0.024***	
	(0.001)		(0.004)	
Non Local Student (> 40 km)				
from Urban Area	-0.001*		-0.005*	
	(0.001)		(0.003)	
from Non-Urban Area	-0.000		-0.008**	
	(0.001)		(0.004)	
Previous Track: Economics	0.000		0.002	
	(0.001)		(0.003)	
Public High School	0.001**		0.010***	
	(0.001)		(0.003)	
Male	-0.001		-0.005*	
	(0.001)		(0.003)	
Age	Yes		Yes	
Application Rounds FE	Yes		Yes	
Cohort FE	Yes		Yes	
Number of Obs.	3821		4676	
Uncensored Obs.	463	463	440	440
Mills Ratio	0.19**	(Bias)	0.08	(No bias)
Wald test for HSScore and Maths	Prob> χ^2=0.00		Prob> χ^2=0.00	

Notes: *$p < .1$, **$p < .05$, ***$p < .01$. Robust s.e. for OLS, Bootstrap s.e. for Heckman. The variables Final GPA, High School Score, and National Maths Exam were standardized and all coefficients should be interpreted as standard deviation changes. For the selection equation we report average marginal effects.

One possible concern that could arise from the previous estimations is the fact that we did not account for many other specific school characteristics. To deal with this, we include high school fixed effects in the outcome equation. The estimation results are presented in Table 6. In this case there is now evidence of selection bias in the OLS estimates, at least for Economics. More importantly, the conclusions in terms of predictors of success are unchanged. In fact, the difference between the high school score and the national maths exam coefficients becomes even larger. One minor difference, is that being a non local is almost statistically insignificant except for the case of non-urban areas. The main conclusion remains the same: the high school score is a stronger predictor of future student's performance than the national maths exam score.

Finally, we consider one more alternative approach to account for possible sample selection biases. We estimate the Heckman selection model using only the sample of students that enrolled. In this case, the selection equation models the probability that an enrolled student completes the degree. It considers situations where the Final GPA is not observed, namely dropouts, transfers, or students that have not finished their degree yet. As can be checked from Table 3 the majority of these cases correspond to dropouts. Estimation results are presented in Table 7. The conclusions are the same as before in terms of the relative importance of high school score and national maths exam score as predictors of the final GPA.[18]

[18]We note that in this case we do not have an exclusion restriction. It is almost impossible to present a variable that would affect the probability of not dropping out and not influence the student's performance in terms of final GPA. As a further robustness check, we re-estimated these models considering only the students with a final GPA and the dropout students. Our main conclusions remain unchanged.

Table 7: Predictors of Final GPA; Sample: Enrolled students (Heckman selection model, MLE)

	Economics	**Management**
	(1)	(2)
	Heckman	Heckman
Outcome Eq. (Final GPA)	(Boot. S.E)	(Boot. S.E)
High School Score	0.71***	0.74***
	(0.06)	(0.08)
National Maths Exam	0.48***	0.32***
	(0.08)	(0.10)
Non Local Student (> 40 km)		
from Urban Area	-0.27***	-0.35***
	(0.09)	(0.10)
from Non-Urban Area	-0.04	-0.66***
	(0.14)	(0.19)
Male	0.27***	0.05
	(0.08)	(0.10)
Previous Track: Economics	0.15*	0.05
	(0.09)	(0.10)
Public High School	0.03	0.22**
	(0.10)	(0.10)
Age	Yes	Yes
Applied for Maintenance	Yes	Yes
Application Rounds FE	Yes	Yes
Cohort FE	Yes	Yes
Selection Eq. (Prob. of enrolled students finishing the degree)		
High School Score	0.07***	0.09**
	(0.02)	(0.02)
National Maths Exam	0.05**	0.09***
	(0.03)	(0.03)
Non Local Student (> 40 km)		
from Urban Area	-0.08**	-0.02
	(0.03)	(0.04)
from Non-Urban Area	- 0.03	-0.06
	(0.05)	(0.06)
Male	-0.01	-0.02
	(0.03)	(0.03)
Previous Track: Economics	0.07**	0.10 ***
	(0.03)	(0.03)
Public High School	0.06**	0.09**
	(0.03)	(0.04)
Age	Yes	Yes
Application Rounds FE	Yes	Yes
Cohort FE	Yes	Yes
Number of Obs.	548	558
Uncensored Obs.	463	440
ρ	0.84	0.88
Indep. test ($\rho = 0$) p-value	0.00 (Bias)	0.00 (Bias)
Wald test for HSScore and Maths	Prob> χ^2=0.00	Prob> χ^2=0.00

Notes: *$p < .1$, **$p < .05$, ***$p < .01$. Robust s.e. for OLS, Bootstrap s.e. for Heckman. The variables Final GPA, High School Score, and National Maths Exam were standardized and all coefficients should be interpreted as standard deviation changes. For the selection equation we report average marginal effects.

4.2 Dropout

As an alternative measure of students' performance in higher education we now consider dropout. As mentioned above, around 10% of the enrolled students have dropped out of the program (see Table 3). Accounting for the fact that dropout is a binary outcome we use a Probit model. As before, we estimate separate models for Economics and Management. We also estimate models including the high school score and the national maths exam separately and jointly, and including several control variables. Table 8 presents the corresponding estimation results.

Table 8: Predictors of Dropout; Sample: Enrolled Students (Probit)

	Economics				**Management**			
Dropout	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
High School Score	-0.05***		-0.05***	-0.02	-0.04**		-0.03**	-0.03
	(0.02)		(0.02)	(0.02)	(0.02)		(0.02)	(0.02)
National Maths Exam		-0.02	-0.01	-0.02		-0.05**	-0.04**	-0.04**
		(0.02)	(0.02)	(0.02)		(0.02)	(0.02)	(0.02)
Non Local Student (> 40 km)								
from Urban Area				0.05**				0.02
				(0.03)				(0.03)
from Non-Urban Area				-0.02				0.09*
				(0.04)				(0.03)
Male				0.07***				0.04*
				(0.03)				(0.03)
Previous Track: Econ.				-0.07***				-0.05*
				(0.03)				(0.03)
Public High School				-0.03				-0.07**
				(0.03)				(0.03)
Age				Yes				Yes
Applied for Maintenance				Yes				Yes
Application Rounds FE				Yes				Yes
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	559	559	559	548	571	571	571	558
Pseudo R^2	0.03	0.00	0.03	0.10	0.02	0.02	0.03	0.09

Notes: $^*p < .1$, $^{**}p < .05$, $^{***}p < .01$. Table reports average marginal effects. The variables High School Score and National Maths Exam were standardized and all coefficients should be interpreted as standard deviation changes. A student is considered non local if his home town is more than 40 km from Lisbon. In columns (4) and (8) the number of observations decreases from 559 and 571 to 548 and 558, respectively, due to missing information regarding the non local student variable.

The high school score is statistically significant at the 5% level in terms of predicting a dropout but only if no control variables are included. On the other hand, there are factors such as gender and the previous track in high school that appear to have a statistically significant impact on the probability of dropout of Economics students. In contrast with the previous estimates, which demonstrated that male students tend to perform better in Economics in terms of final GPA, male students are more likely to dropout.

Following the same analysis as in Section 4.1, to account for possible selection bias, we estimate the Heckman selection model in which the selection equation gives the probability that an applicant student is admitted and enrols in the program.

Regarding our variables of interest, according to Table 9, neither the high school score nor the national exam score are statistically significant. We conclude that although both variables help to predict the students' final GPA, none of them have predictive power regarding dropout.[19]

[19] As a further robustness check, we re-estimated these two Heckman selection models excluding students that were transferred or that have not finished their degree yet. The main conclusions remain unchanged.

Table 9: Predictors of Dropout; Sample: Applicant students (Probit and Heckman selection model, MLE)

	Economics		**Management**	
Average Marginal Effects	(1)	(2)	(3)	(4)
	Heckman Probit	Probit	Heckman Probit	Probit
Outcome Eq. (Prob. of dropout)	(Boot. S.E.)	(Rob S.E.)	(Boot. S.E.)	(Rob S.E.)
High School Score	-0.02	-0.02	-0.03	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)
National Maths Exam	-0.01	-0.02	-0.03	-0.04 **
	(0.03)	(0.02)	(0.03)	(0.02)
Non Local Student (> 40 km)				
from Urban Area	0.05**	0.05**	0.02	0.02
	(0.02)	(0.03)	(0.03)	(0.03)
from Non-Urban Area	-0.02	-0.02	0.08	0.09*
	(0.04)	(0.04)	(0.05)	(0.03)
Male	0.07***	0.07***	0.04	0.04*
	(0.02)	(0.03)	(0.03)	(0.03)
Previous Track: Economics	-0.06**	-0.07***	-0.05	-0.05*
	(0.03)	(0.03)	(0.03)	(0.03)
Public High School	-0.03	-0.03	-0.06*	-0.07**
	(0.03)	(0.03)	(0.03)	(0.03)
Age	Yes	Yes	Yes	Yes
Applied for Maintenance	Yes	Yes	Yes	Yes
Application Rounds FE	Yes	Yes	Yes	Yes
Cohort	Yes	Yes	Yes	Yes
Selection Eq. (Prob. of applicant students enrolling)				
High School Score	0.05***		0.05***	
	(0.01)		(0.01)	
National Maths Exam	0.09***		0.08***	
	(0.01)		(0.01)	
Preference 2	-0.23***		-0.23***	
	(0.01)		(0.01)	
Preference 3	-0.25***		-0.23***	
	(0.03)		(0.02)	
Preference 4	-0.33**		-0.25***	
	(0.15)		(0.03)	
Preference 5	-0.38		-0.25***	
	(0.23)		(0.05)	
Preference 6	-0.32*		-0.26***	
	(0.17)		(0.06)	
Non Local Student (> 40 km)				
from Urban Area	0.00		-0.01	
	(0.01)		(0.01)	
from Non-Urban Area	0.00		-0.01	
	(0.01)		(0.01)	
Previous Track: Economics	-0.10		-0.00	
	(0.01)		(0.01)	
Public High School	0.01		0.03***	
	(0.01)		(0.01)	
Male	-0.01		-0.01	
	(0.01)		(0.01)	
Age	Yes		Yes	
Application Rounds FE	Yes		Yes	
Cohort FE	Yes		Yes	
ρ	0.12		0.067	
Number of Obs.	3821		4676	
Uncensored Obs.	548	548	558	558
Indep. test ($\rho = 0$) p-value	0.44	No bias	0.68	No bias
Wald test for HSScore and Maths	Prob> χ^2=0.00		Prob> χ^2=0.00	

Notes: *$p < .1$, **$p < .05$, ***$p < .01$. Table reports average marginal effects. Robust s.e. for Heckman. The variables High School Score and National Maths Exam were standardized and all coefficients should be interpreted as standard deviation changes.

5 Conclusions

In several countries students are ranked and selected into higher education institutions on the basis of their achievement in high-school, typically measured by a combination of the following two measures: scores given by the teachers in high school and scores obtained on national access exams.

By looking at student level data we compare the strength of these two measures in terms of predicting student performance at the university. Our approach also takes into account differences in students' socio-economic characteristics and corrects for any selection biases that might accrue because of the fact that the outcome variables can only be observed for some of the students. Dropout is only observed for students that were admitted and enrolled in university. Final GPA is only observed for those that finished their degree.

One of the main conclusions of our empirical analysis is that the high school score is a stronger predictor of a student's Final GPA in university than the national maths exam score taken at the end of high school. This difference in predictive ability is larger in the case of the Management degree (compared to Economics), which is not surprising as it has a lower mathematical content. One possible explanation for this result is that exams, relying on a single observation in time, are more vulnerable to noise and external shocks. Moreover, teachers' scores, being based on a variety of assessment methods, also allow for a more comprehensive student assessment.

In any case, our study also concludes that both measures are relevant predictors of student achievement. In fact, it is often believed that teacher scores are more vulnerable to the teachers' evaluation of characteristics other than the potential or actual academic success, whereas national exams are able to provide cleaner signals on those issues. In this sense, both measures can be considered as complementary to each other.

Our results are therefore especially important for the discussion of appropriate admission criteria in higher education, and the relevance of considering both measures of achievement in high school. Finally, our results also suggest that the two measures of performance in high school do not help in terms of predicting dropout in university. This has significant implications for the importance of searching for other indicators of future student performance, especially when universities want to implement monitoring strategies to identify students at risk of dropping out.

Appendix of Chapter 1

A1 Appendix: Data and Results

Table A1: Description of the variables

variables	Description	Sources
Panel A: dependent variables		
Final GPA	Grade Point Average, the average of all courses at university, measured between 0 and 200	Nova SBE
Dropout	Dummy=1 if the student dropped out in the first 3 years of university	Nova SBE
Average 4 courses	The average score in four core courses: Principles of Macro, Micro, Management and Calculus 1	Nova SBE
Panel B: control variables		
High School Score	Average of the 3 years at high school (measured between 0 and 200)	CNA/DGES
National Maths Exam	Grade of the national maths exam (between 0 and 200)	CNA/DGES
Non local dummies	Dummies=1 if the student comes from more than 40 km away (per urban/non-urban areas)	Nova SBE
Male	=1 if it is male	CNA/DGES
Previous Track	The track at high school (=1 if the students came from economics)	CNA/DGES
Age	Age	CNA/DGES
Preference Dummies	Order of preference in which the student chose that course	CNA/DGES
Public High School	Dummy =1 if the student studied at a public high school	CNA/DGES
Applied for Maintenance	Dummy =1 if the student applied for a maintenance grant	SAS/UNL
Parents HE	=1 if at least one parent studied at university (self-reported)	Nova SBE
Application rounds	Dummies per round of application at CNA	CNA/DGES
Dummies per cohort	Years fixed effects	CNA/DGES
School FE	Dummies per high school	CNA/DGES

Table A2: Number of non missing observations

	Applications			**Enrolments**		
	Eco.	Man.	Total	Eco.	Man	Total
Male	4054	4961	9015	559	571	1130
Regular Age (<=18)	4054	4961	9015	559	571	1130
Non Local Students (> 40km)						
Originally from Urban Areas	3873	4739	8612	548	558	1106
Originally from Non-Urban Areas	4054	4961	9015	559	571	1130
Track at High School	4054	4961	9015	559	571	1130
Public High School	3954	4840	8794	559	571	1130
Socio-Economic Background						
Parents with HE (at least one)	-	-	-	526	518	1044
Applied for Maintenance Grant	-	-	-	559	571	1130
Received Maintenance Grant	-	-	-	559	571	1130
No. Observations	(4054)	(4961)	(9015)	(559)	(571)	(1130)

Table A3: Structure of the Economics Track at High School

	Grades	Subject to a National Exam [1]
A. General Courses		
Foreign Language I, II or III	10th, 11th	No
Philosophy	10th , 11th	Yes
Portuguese	10th, 11th, 12th	Yes
Sports	10th, 11th, 12th	No
B. Field Specific Courses		
Mathematics A	10th, 11th, 12th	Yes
Two optional courses from:	10th, 11th	Yes
Economics		
Geography		
History		
Two optional courses from:[2]	12th	No
Set A		
Chemistry		
Economics		
Geography		
Sociology		
Set B [3]		
Anthropology		
Classics of Literature		
Foreign Language I, II and III		
Greek		
Informatics		
Law		
Political Science		
Psychology		

Notes: (1) The national exams are taken in the last year of the course. For instance, the Philosophy national exam is taken at the end of the 11th grade while the Portuguese national exam is performed at the end of the 12th grade. (2) At least one of the two courses must be from set A. (3) Subject to availability within the school.

Table A4: Predictors of GPA in four courses; Sample: Applicant students (OLS and Heckman selection model, MLE)

	Economics		**Management**	
	(1)	(2)	(3)	(4)
	Heckman	OLS	Heckman	OLS
Outcome Eq.(GPA in 4 courses)	(Boot. S.E)	(Robust S.E.)	(Boot. S.E)	(Robust S.E.)
High School Score	0.60***	0.59***	0.63***	0.62***
	(0.06)	(0.06)	(0.07)	(0.06)
National Maths Exam	0.60***	0.60***	0.48**	0.44***
	(0.09)	(0.07)	(0.10)	(0.07)
Non Local Student (> 40 km)				
from Urban Area	-0.15*	-0.15*	-0.25**	-0.25***
	(0.08)	(0.08)	(0.09)	(0.09)
from Non-Urban Area	0.04	0.03	-0.31***	-0.31*
	(0.13)	(0.13)	(0.17)	(0.17)
Male	0.38***	0.38***	0.26***	0.27***
	(0.07)	(0.08)	(0.08)	(0.08)
Previous Track: Economics	0.07	0.07	-0.09	-0.10
	(0.09)	(0.08)	(0.09)	(0.09)
Public High School	0.05	0.05	0.12	0.11
	(0.09)	(0.09)	(0.10)	(0.09)
Age	Yes	Yes	Yes	Yes
Applied for Maintenance	Yes	Yes	Yes	Yes
Application Rounds FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Selection Eq. (Prob. of applicant students enrolling and finishing the 4 courses)				
High School Score	0.05***		0.05***	
	(0.01)		(0.01)	
National Maths Exam	0.08***		0.07***	
	(0.01)		(0.01)	
Preference 2	-0.21***		-0.26***	
	(0.01)		(0.02)	
Preference 3	-0.23***		-0.21***	
	(0.02)		(0.03)	
Preference 4	-0.27		-0.20***	
	(0.17)		(0.03)	
Preference 5	-0.79***		-0.20*	
	(0.05)		(0.11)	
Preference 6	-0.80***		-0.26	
	(0.05)		(0.20	
Non Local Student (> 40 km)				
from Urban Area	-0.01		-0.01	
	(0.01)		(0.01)	
from Non-Urban Area	-0.00		-0.02*	
	(0.01)		(0.01)	
Male	-0.01		-0.01	
	(0.01)		(0.01)	
Previous Track: Economics	0.00		0.01	
	(0.01)		(0.01)	
Public High School	0.02**		0.03***	
	(0.01)		(0.01)	
Age	Yes		Yes	
Application Rounds FE	Yes		Yes	
Cohort FE	Yes		Yes	
Number of Obs.	3821		4676	
Uncensored Obs.	478	478	456	456
ρ	0.01		0.06	
Indep. test ($\rho = 0$) p-value	0.90	(No bias)	0.70	(No bias)
Wald test for HSScore and Maths	Prob> χ^2=0.00		Prob> χ^2=0.00	

Notes: *$p < .1$, **$p < .05$, ***$p < .01$. Robust s.e. for OLS, Bootstrap s.e. for Heckman. The variables GPA in 4 courses, High School Score, and National Maths Exam were standardized and all coefficients should be interpreted as standard deviation changes. The outcome corresponds to the average of the grades in Principles of Micro, Principles of Macro, Principles of Management, and Calculus 1.

Chapter 2

The impact of university admission policies on academic performance

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1 Introduction

Which university entrance criteria matter for the academic performance of the students admitted? Most higher education institutions (HEIs) rely on standardized tests as the primary mechanism to select their students. Additionally, they can activate a second source of information. In some cases, the institution considers student essays, interviews, as well as information on students' extracurricular activities and experience. Other HEIs design their own entrance exams as a complement to standardized tests. The purpose is to obtain a more comprehensive assessment of higher education (HE) applicants (for reviews see, e.g., Hoxby, 2009, and Zwick, 2017). However, how broad the admission criteria should be is a question that has been given little attention in the literature.

I study the role of specialisation of the admission criteria as a choice variable used by HEIs to maximise their objective function of admitting the best pool of students possible. These are expected to have better academic performance, better placement after degree completion, and better future labour market achievement. As a result, HEIs benefit from improvements in their own reputation.

The central finding of this paper is that universities with less specialised admission policies admit a pool of students who perform better at university by the end of the degree (namely, they obtain a higher final GPA on average). This is a surprising and relevant result. Many universities operate under the assumption that candidates who perform better at a subject-specific test, will go on to perform better in that subject at university. For instance, in Physics Sciences, maths is often perceived as a relevant *field-specific skill*, while languages convey information on broader cognitive skills. I define *general skills* as those that are not directly rewarded by the field of study. Strong emphasis on field-specific skills rewards students that specialise early at high school rather than cultivate a more versatile portfolio of skills.

In my theoretical model, I consider a single university and a continuum of students. The university's objective is to admit the best pool of students possible. In turn, students aim to maximise an utility function that depends on their own future performance and the effort level exerted into the university admission tests. I assume that the university can select students based on a wider and broader set of tests. Of the tests available, some tests measure skills that will be considered specialised, while others are tests of skills that have no direct influence on future student performance (the general skills) but serve solely

as a signal of ability. Thus, the university must decide how to set its admission criteria, either i) using only a field-specific test; or ii) combine it with a test of a more general nature. In the latter case, the university gains additional information about student's ability. However, in return, it must contend with less effort being put by students into the specialised test, because students optimally re-allocate the effort. In the case of a single field-specific test, the students' effort would be directed solely towards acquiring knowledge and preparing the exam that contributes to future academic performance and is is directly valued in the labour market (see, e.g., Card et al., 2018).

From a theoretical point of view, I find that the university chooses to use a general skill test as a criterion for selection alongside a test to evaluate subject-specific skills. Although, in equilibrium, students deviate effort from the field-specific test (the productive test) to the general skill test, a different set of students (more able on average) is admitted and ultimately performs better than when only a field-specific requirement is in place.

In my empirical analysis, I test the model using Portugal as a case study. The admission process in Portugal to public universities is comparable to several other countries (e.g. Spain, Brazil, Colombia, Hungary and Denmark). Admission to public HEIs in Portugal is centralized and managed by the government. HEIs choose their admission requirements. Students, in turn, can apply to up to six HE programmes (pairs institution-degree), ranked by order of preference. Although the Portuguese system has specificities, the lessons one learns from it provide generalizable insights to any HE system that considers at least one of two different metrics in the admission process: one that matches closely to what the student actually learns in the subject of study (a field-specific test for instance); and another one that conveys information of a more generic nature, not directly rewarded by the field of study.

I rely on an extremely rich administrative dataset of the population of HE applicants, from 2008 to 2018. Over that period, I observe approximately 800 thousand students' applications to the first year of a HE programme. For each applicant, there is information regarding personal characteristics, socio-economic background, previous academic achievement, the application process (including all programme preferences stated with the corresponding overall application score and each exam score), and the HE placement. Moreover, for five years, I have information on students' performance at HE for each year of their degree, and subsequent graduation information (namely, the graduation date and

the final GPA).

I consider the Portuguese exam as a general skill test. Given that this is a compulsory exam common to all academic tracks at high school, the performance in this exam is available for all applicants to HE. With some exceptions, most programmes have multiple tracks of admission. They either require a subject-specific set of exams as admission criteria or a broader set of exams. The student will be ranked according to whichever set of exams yields the highest overall application score. For instance, suppose that a student applies to an Economics degree at a particular university. The score that determines the ranking in the application process is either the Mathematics exam score or the average of Mathematics and Portuguese exam scores, depending on which generates the highest application score and hence the highest feasible position in the ranking. The Mathematics exam is considered to be the field-specific requirement, while the Portuguese exam is the general skill test. However, not all HE programmes consider a non-specific set of exams as an admission criterion. Thus, I perform my empirical analysis on HE programmes that include the general skill test (the Portuguese exam) in broader set of exams.[1] Therefore, my results do not apply to highly specialised subjects, such as Medicine.

Due to this admission criteria design, I observe students being admitted to the same programme based on performance in different exam sets. In my empirical analysis, I exploit the variation between specific and non-specific exam sets. My estimation strategy follows the Regression Discontinuity (RD) approach proposed by Hahn et al. (2001), where the treatment is the inclusion of the Portuguese exam as an admission criterion at university.

However, I define exposure in two ways. Firstly, I group students within programmes based on whether the Portuguese exam was considered in their ranking, and therefore in their admission. In doing so, I compare students whose general skills were slightly better than field-specific skills with students whose general skills were slightly worse. In other words, I am able to identify a local treatment effect for individuals around the discontinuity point on skill differences. I find no evidence that students admitted with slightly better general skills performed overall differently at university. In the first year, students admitted with relatively better general skills tend to fail more than their peers.

[1]Note that although the definition of a general skill test may be context-dependent, I exclude from my analysis all programmes for which the Portuguese exam is a mandatory admission criterion (such as linguistic degrees). Later in this paper, I discuss differences across fields of study as a robustness check.

However, the effect disappears by the end of the HE programme.

Secondly, I focus my analysis around the programme admission threshold (the admission score of the last admitted student). Within each programme, I define three categories of admitted students: the *specialists* (those admitted with a field-specific test and whose general skills would not have been enough to gain entry in HE), the *generalists* (those admitted purely based on their performance on the general skill test who would not have been admitted only based on the field-specific test result), and the *all-rounders* (those that could have been admitted with each one of the two types of tests). I observe differences in academic student performance across the different groups at distinct landmarks of the academic programme. In particular, I find that: i) the *generalists* perform no worse than their *specialist* peers, by the end of the first academic year; and ii) by the end of the programme the *specialists* are outperformed by the *all-rounders* and the *generalists*.

My results have substantial implications for university admission practices. Universities that include a general skill test in their entrance set of exams benefit at the margin of admission, as this has a positive effect on the average student performance. Although this effect is not observable by the end of the first year, towards the end of the programme students admitted based on a broader set of skills and knowledge perform better on average.

An additional policy implication surrounds the role of the field-specific exam, as it may or not be fit for purpose. Differences in student performance across groups suggest that the field-specific exam is not an effective test of the specialist skills associated with high achievement at university, which is the main policy message of my paper. Although I find evidence that the field-specific exam is a predictor of student performance by the end of the first academic year, the exam is not informative of overall performance. Thus, the field-specific exam does not guarantee that those that perform well on it, will go on to perform better at university.

I contribute to two main strands of literature. First, my paper contributes to the body of work that seeks to evaluate the role of standardized tests in the admission process to HE (e.g., Rothstein, 2004; Zwick and Green, 2007). Examples of standardized tests include A-levels in the UK and SAT/ACT in the US. The widespread use and reliance of these tests has been criticised in the literature for favouring ethnicity (e.g., Bridgeman et al., 2000; Freedle, 2003), gender (e.g., Leonard and Jiang, 1999) or socio-economic background (e.g.,

Zwick, 2019). Despite a lack of consensus in the literature on whether such tests predict performance at university (e.g., Burton and Ramist, 2001; Kuncel and Hezlett, 2007; Radunzel and Noble, 2012), they are the most common instrument used to admission. In this paper, I conclude that admission tests indeed help to predict student performance at university. Namely, the non-specific tests are informative of overall performance while the specific tests only predict performance in the first year of the HE programme.

Secondly, my paper contributes to the literature on the effects of broadening admission criteria in HE (e.g., Sternberg, 2010; Sternberg et al., 2012; Stemler, 2012; Schmitt, 2012; Niessen and Meijer, 2017). Some HEIs rely on a second source of information. For instance, in the US, some Ivy League universities rely on interviews. In the UK, Oxford and Cambridge establish their own entrance exams for some degrees. Often, this extra step in admission broadens the type of information gathered about the student by the institution. My work suggests that broadening the nature of cognitive admission tests leads to increased performance at university because abler students are admitted. Nevertheless, the general admission test should be considered as a complement to field-specific requirements.

Finally, my work relates to literature in the field of economics of HE. While previous work has focused on different aspects of admission to HE, such as the role of student portfolios, admission tuition, or college choice and selectivity (e.g., Epple et al., 2006; Avery and Levin, 2010; Avery et al., 2012; Hoxby et al., 2013), my paper focuses on one novel aspect of the admission process to HE — the choice of the examination structure, namely how specific should be the admission exams. Even under the assumption that some skills have no direct influence on student performance, and thus evaluating them may distract from learning more productive skills, I prove that the best way for the university to resolve the resulting trade-off is to have a non-zero weight on the general skill test. My empirical evidence also shows that universities with broader admission exams select a better pool of incumbents.

The remainder of the paper proceeds as follows. Section 2 sets up the model and its assumptions. Section 3 defines the equilibrium in the two stages: the students' effort and the university's choice of admission criteria. In that section, I also consider an extension of the model where the social planner plays a role. Section 4 describes the Portuguese institutional setting and section 5 presents the datasets. Section 6 presents the empirical

set-up and describes how I translate the theoretical model to the empirical analysis. Section 7 presents the estimation strategy and results to address the question from the perspective of applicants' marginal difference in skills, while in section 8 I focus at the margin of admission into HE. Section 9 concludes.

2 The Model and Basic Assumptions

The design of admission policies aims at overcoming problems of imperfect information (Stiglitz, 2000), namely information asymmetries (Teixeira et al., 2006) that characterize HE markets, given that it is not possible to directly observe a candidate's ability.[2] The key finding highlighted before is that HEIs should use a combination of field-specific and general admission requirements to overcome these problems. In this section, I build a simple model to illustrate that point.

In my model, I focus on the choice of the examination structure in HE during the process of admission.[3] I study a single university (or college) offering a single degree. A continuum of individuals of measure 1 want to apply to university. However, there are more applicants than university places. I assume that only half of the applicants are able to be admitted to the university. The time of the sequential game that I model below is as follows: the university sets the admission exams required to get admission, and then students decide the amount of effort to exert on each exam. The text below describes the two types of admission exams considered, the goals of each one of the agents, and the key assumptions of the model.

2.1 Ability and Admission Tests

Students are identical in every respect except their innate ability, and there are two levels of ability, the low type α_L and the high type α_H. I follow MacLeod and Urquiola (2015) and Gary-Bobo and Trannoy (2008) by assuming that students do not observe their own ability. Both types of students have the same expectation of their own ability,[4] $\overline{\alpha}$. In

[2]For a review of the student portfolio problem see, e.g., Araujo et al. (2007); Chade et al. (2014); Che and Koh (2016).

[3]To simplify the analysis, I ignore the student choice of subjects as well as the existence of competition effects between universities. For a survey of the literature on returns to curriculum and college major choices see, e.g., Bound and Turner (2011), Altonji et al. (2012), and Patnaik et al. (2020).

[4]Albeit her expectation might not be the correct one, I assume that the expectation is constant for simplicity purposes.

order to be admitted to university, each student needs to perform on two admission tests. I assume that the observed score T_i on the admission test $i \in \{1, 2\}$ provides a noisy measure of ability and effort:

$$T_i = \alpha + e_i + \epsilon_i, \tag{1}$$

where e_i is the effort the student put into studying for test i, and α denotes the innate ability of each student. Additionally, I assume that the two tests are independent, ϵ_1 follows the uniform distribution $[0, a]$, where $a < 1$, and ϵ_2 follows the uniform distribution $[0, 1]$. Thus, T_1 is more precise than T_2. Think on T_1 as a field-specific exam and T_2 as a general admission test.

2.2 Labour Market and Wages

Similarly to Gary-Bobo and Trannoy (2008), I assume that there are two categories of workers only, the graduates from the university (the skilled ones) and the ones that did not study at university (unskilled). I assume that an individual's wage, w, depends on individual's innate ability,[5] and on the effort exerted for T_1. The individual's wage is given by the following relation:

$$w = \begin{cases} \gamma\alpha + e_1, & \text{if the individual attends university} \\ \beta\alpha + e_1, & \text{if the individual does not attend university} \end{cases}. \tag{2}$$

The presence of the term e_1 in both equations indicates that T_1 (the field-specific exam) has a long term benefit to the individual. T_1 is assumed to be strongly related to potential future labour market performance. Nevertheless, both admission tests produce a signal of ability which affect wages. There is an increment in wages from attending university, $v\alpha = (\gamma - \beta)\alpha$, which is proportional to the individual's ability. I assume that $v = \gamma - \beta$ is positive. Students with higher ability are expected to earn higher wages and to benefit more from attending university.

For clarity, labour market potential performance will be a function of student's innate ability, α, and of e_1, which can be perceived as of labour market skills. As opposed

[5] Following the neoclassical framework proposed by Becker (2009) and Mincer (1974).

to ability α, which is time-invariant, e_1 is acquired with maturity. Therefore, even if the student does not attend university, those skills have an impact on students' future performance.[6]

2.3 University

The university needs to determine the weight which it allocates to each admission test. Let λ be the normalized weight of T_2. The goal of the university is to maximise the total wage of its own students by using λ as an instrument, such that all students with $T_1 + \lambda T_2 \geq \tau^*$ are admitted, where τ^* is an endogenous threshold. τ^* it is the minimum admission score of the weighted average of the two tests scores among the admitted students. Considering that the university admits half of the population, τ^* is the median of the weighted average of the two admission tests. I assume that there are as many low ability students as high ability students in the population and, the university is not able to distinguish between high and low ability students. Depending on λ, measures n_H of high ability and n_L of low ability, students will be admitted to the university.

2.4 Students

In the model, the track of a student is as follows: a student leaves the High School, and she applies to the university. Conditional on passing the admission tests she is accepted at university. Otherwise, she goes directly to the labour market. A student's objective function is the maximisation of the difference between her future wage and effort cost. When applying to university she knows λ and she exerts effort $\mathbf{e} = (e_1, e_2) \subseteq R^2$ on the two admission tests. The effort has a utility cost measured by $C(\mathbf{e})$, increasing and convex. In the model, I assume the cost function to be[7] $C(e_1, e_2) = \frac{1}{2}(e_1^2 + e_2^2) + \delta e_1 e_2$ with $0 < \delta < 1$.

By exerting effort the student knows that with probability Π she would pass the admission threshold (where $\Pi = Prob(T_1 + \lambda T_2 \geq \tau^*)$). The benefit to the student of attending university is that her wage will be boosted. The potential increase in earnings

[6]For a review regarding the impact of tests scores on labour market outcomes, and national income see Chetty et al. (2014) and Hanushek and Woessmann (2010).

[7]The parameter δ measures the interaction between the two efforts. If I assume that they are complements, δ would be negative. However, that would drive me to the solution where the student should only exert effort to one test. A more interesting case is when δ is positive, which means that the marginal cost of one type of effort is not independent of the other type.

will be proportional to the student's ability. The student's ability is revealed when she leaves university.

3 Equilibrium

In this section, I find the equilibrium by first determining the student's optimal level of effort exerted in the two admission tests and then incorporating that into the university's admission problem.

3.1 Effort of Students

In equilibrium, each student knows the effort distribution of the entire cohort. As so, each student takes as given the effort choice of all her fellow students (e_1^*, e_2^*), thus τ^* is a function of (e_1^*, e_2^*).

The assumptions that all students have the same expectation about their ability, and ability is revealed in the job market implies that the student expected wage is as follows:

$$w = (\gamma\overline{\alpha} + e_1)\Pi + (\beta\overline{\alpha} + e_1)(1 - \Pi) = v\overline{\alpha}\Pi + e_1 + \beta\overline{\alpha}. \tag{3}$$

where $\Pi = Prob(T_1 + \lambda T_2 \geq \tau^*)$. The student's objective function is the maximisation of the difference between the expected wage and cost of effort. The maximization problem of a student is given by:

$$\underset{e_1,e_2}{\text{Max}} \quad v\overline{\alpha} \times Prob(T_1 + \lambda T_2 \geq \tau^*) + e_1 + \beta\overline{\alpha} - C(e_1, e_2). \tag{4}$$

The solution of the student's problem is stated in the following result.[8]

Proposition 1. *The optimal effort* $\mathbf{e}^*(\lambda) = (e_1^*, e_2^*)$ *is:*

[8] In a Nash Equilibrium every student tries to manipulate her scores and therefore all students exert the same level of effort, $(e_1, e_2) = (e_1^*, e_2^*)$, and no student is able to manipulate their test scores (see De Fraja and Landeras, 2006).

$$
(5) \qquad
e_1^*(\lambda) = \begin{cases} \frac{v\overline{\alpha}}{a(1-\delta^2)}(1-\lambda\delta) + \frac{1}{1-\delta^2}, & \text{if } \delta\hat{\lambda} \leq \lambda < \frac{\hat{\lambda}}{\delta} \\ \frac{v}{a}\overline{\alpha} + 1, & \text{if } \lambda < \delta\hat{\lambda} \end{cases}
$$

$$
e_2^*(\lambda) = \begin{cases} \frac{v\overline{\alpha}}{a(1-\delta^2)}(\lambda-\delta) - \frac{\delta}{1-\delta^2}, & \text{if } \delta\hat{\lambda} \leq \lambda < \frac{\hat{\lambda}}{\delta} \\ 0, & \text{if } \lambda < \delta\hat{\lambda} \end{cases}.
$$

where $\hat{\lambda} = 1 + \frac{a}{v\overline{\alpha}}$.

Proof. Available in appendix A1.1. □

According to Proposition 1, for small values of λ I obtain a partial corner solution (for $\lambda < \delta\hat{\lambda}$) and thereafter I have an interior solution (for $\lambda > \delta\hat{\lambda}$). In other words, when the weight on T_2 is too small the student would not exert effort for that test and e_1 is constant on λ.[9]

As a result, the optimal amount effort varies with λ as follows:[10]

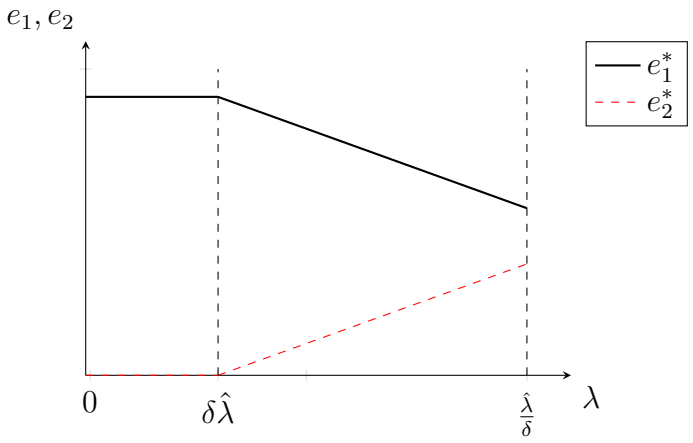


Figure 1: Optimal effort level in the admission tests.

Figure 1 represents the optimal student's strategy in a Nash Equilibrium. For low values of λ, the student would not change her decision when compared to the case where $\lambda = 0$. The same occurs if the cost of switching from one test to another is too high

[9] Similarly, for $\frac{\lambda}{\delta} > \frac{\hat{\lambda}}{\delta^2}$ the converse situation occurs. The student will exert effort only in the second test, $(e_2 > 0)$ and $e_1 = 0$. For simplicity I neglect that case. I am only interested on showing that $\lambda = 0$ is not necessarily optimal for the university.

[10] From proposition 1 I infer that $\mathbf{e}^*(\lambda)$ is a continuous function on its domain, $D = [0, \frac{1}{\delta}\hat{\lambda}]$. Additionally, it is differentiable on its domain except at $\frac{\lambda}{\delta} = \hat{\lambda}$. $\mathbf{e}^*(\lambda)$ is a smooth function on its domain except at $\delta\hat{\lambda}$.

(which means high value for δ). Alternatively, when the university increases the weight on T_2, for values of $\lambda > \delta\hat{\lambda}$, the student reallocates effort from T_1 to T_2. Thus, under some conditions, allowing for a second exam deviates effort from the productive test (T_1). From a student's perspective, this would be the optimal strategy to maximise the difference between expected wage and costs.

3.2 University Choice

In this subsection, I prove that not considering the second test ($\lambda = 0$) is generally not optimal for the university. I normalize the high ability level to $\alpha_H = 1$ and, consequently, $\alpha_L < 1$.

The university cares about the wage of their own students. Let λ_U^* be the solution of the university problem and $(n_H(\lambda), n_L(\lambda))$ the measure of high and low ability students admitted at university. The maximization problem of the university is as follows:

$$\begin{aligned} \underset{\lambda}{\text{Max}} \quad & \Pi_U = (\gamma\alpha_H + e_1^*) \times n_H(\lambda) + (\gamma\alpha_L + e_1^*) \times n_L(\lambda) \\ \text{s.to} \quad & n_H(\lambda) + n_L(\lambda) = \frac{1}{2} \end{aligned} \tag{6}$$

In equilibrium, the university takes the student's optimal effort in consideration to maximise students' wage for those they admit.[11] As a result, the payoff function is $(\gamma\alpha_H + e_1^*)n_H + (\gamma\alpha_L + e_1^*)n_L$. The university payoff function is a function of e_1^* (defined on proposition 1) and $(n_H(\lambda), n_L(\lambda))$. The measure of admitted students is determined in the following lemma.

Lemma 1. *The measure n_H of high ability students admitted at university is:*[12]

$$n_H(\lambda) = \begin{cases} [\frac{1+a-\alpha_L}{2} + \frac{\lambda}{2}(1-\alpha_L)] \times \frac{1}{2a}, & \text{if } \lambda \leq \tilde{\lambda} \\ [a - \lambda\frac{\alpha_L^2}{8} - \frac{\alpha_L}{4}(a+\alpha_L-1) - \frac{(a+\alpha_L-1)^2}{8\lambda}] \times \frac{1}{2a}, & \text{if } \tilde{\lambda} < \lambda \leq 1 \end{cases} \tag{7}$$

[11] According to Hoxby (2009) and MacLeod et al. (2017), for instance, universities care about reputation issues which translates on student's lifetime wage. However, for simplifications purposes, I focus on the wage immediately after the job market. For research on labour market returns to school identity see, for example, Dale and Krueger (2002) on college selectivity, Author et al. (2014) on skills formation, and MacLeod and Urquiola (2019) on school choice.

[12] The increase of high ability students admitted to university when λ changes is equal to the change on the number of low ability students (in absolute value).

with $\tilde{\lambda} = \frac{a+\alpha_L-1}{2-\alpha_L}$.

Proof. Available in appendix A1.3. □

Instead of determining λ_U^*, I prove that the optimal solution is not zero. The main result is presented in the next theorem.

Theorem 1. *If* $a > 1 - \alpha_L$*, the solution of the university's problem is* $\lambda_U^* > 0$.

Proof. The university chooses λ to maximise its payoff. According to the result presented on proposition 1, e_1^* is a continuous function on λ. Following lemma 1, I can also verify that the measure of admitted students is a continuous function on λ.[13] Additionally, e_1^* is not differentiable at $\delta\hat{\lambda}$ and $n_H(\lambda)$ is not differentiable at $\tilde{\lambda}$ (for $\lambda < 1$). Thus, Π_U is continuous on λ and differentiable at its domain except at $\delta\hat{\lambda}$ and $\tilde{\lambda}$.

Given that I know the payoff function (π_U), the number of admitted students ($n_H(\lambda), n_L(\lambda)$), and the student's optimal effort ($e_1^*(\lambda)$), I can determine the first derivative of the payoff function. Namely,

$$\frac{\partial \pi_U}{\partial \lambda} = \gamma(\alpha_H - \alpha_L)\frac{\partial n_H}{\partial \lambda} + \frac{N}{2}\frac{\partial e_1^*}{\partial \lambda} \tag{8}$$

For $\lambda \in]0, min\{\delta\hat{\lambda}, \tilde{\lambda}\}[$ I have $\frac{\partial e_1^*}{\partial \lambda} = 0$ (according to proposition 1) and $\frac{\partial n_H}{\partial \lambda} > 0$ (according to lemma 1). That implies that $\frac{\partial \pi_U}{\partial \lambda} > 0$ and $\lambda = 0$ is not a solution of the university problem. □

3.3 Interpreting the Results

I model the university admission problem with the focus on two aspects: the noise and the nature of the admission tests. Figure 2 presents the two test scores distribution for students of both abilities. On the horizontal axis, I have the test scores distribution of T_1 and the test scores distribution of T_2 are represented on the vertical axis. Ability is fixed for each student type, and (e_1, e_2) is also fixed in the equilibrium. Given that the two idiosyncratic terms of both tests follow a uniform distribution, the shape of the

[13] According to Table A1 in appendix A1.3, the limit of the number of admitted students when $\lambda \to \tilde{\lambda}^+$ is equal to the limit when $\lambda \to \tilde{\lambda}^-$.

distribution is rectangular. Besides the gap on ability, the noise of the two tests is a key factor in both distributions.[14]

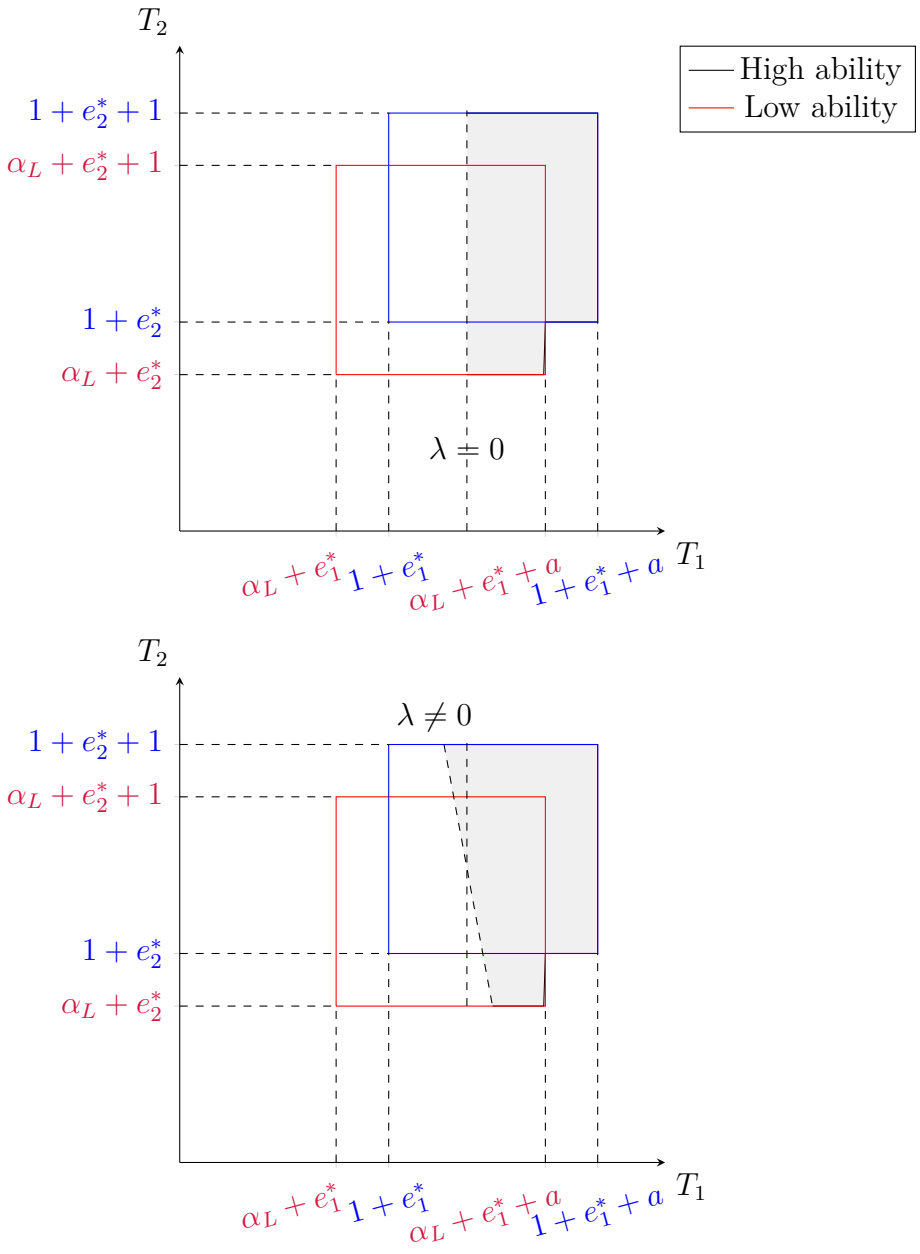


Figure 2: Student's test scores distribution. Shadowed area represents half of the population, which is admitted to university.

According to Figure 2, when λ increases, the university can select more high ability students.[15] The increment in λ is illustrative of the following: if a university is faced

[14] According to Figure 2, if $a < 1 - \alpha_L$ the two test score distributions will not overlap, and that would mean that university would use a very precise test and, with that, they can admit only high ability students. I preclude that case by imposing $a > 1 - \alpha_L$. The case of low noise is not very interesting because one test is enough to completely separate students by ability.

[15] Notice that when λ increases to values higher than $\delta\hat{\lambda}$ the two rectangles move on the Northwest

with two students with the same score on T_1, the university should select the one with the highest score on T_2. Indeed, as argued by Hölmstrom (1979), additional information would allow to a more accurate judgement of student's performance. For students with the same score on T_1, the university would like to pick the ones that are also good on T_2 (even if T_2 conveys less relevant skills).

The other important feature of my model is the nature of the second test. In my model, I assume that there are no administrative costs of introducing a second test. However, there is an inefficiency associated to that test: it reduces the productive effort, e_1 (see Figure 1).[16] The cost of running a less relevant test (the general admission exam) is a decrease in student's future productivity, which reduces the university payoff.

Hence, when the university is deciding about introducing a second admission test, they face a trade-off between gaining new information about the student's ability and losing productive effort. On the one hand, geometrical intuition shows that by increasing λ the university is able to increase the number of high ability students. On the other hand, from Figure 1, I conclude that an increase of λ has a detrimental effect on e_1, which has a negative impact on student's future wage. The two effects move in opposite directions.

Nevertheless, in theorem 1, I have proven that the overall effect of introducing a second admission test is positive. Even if students deviate effort from the relevant test, the university still benefits from including a general admission exam on its admission criteria.[17] A separated question is whether that is socially desirable.

3.4 Government Policy

I take an utilitarian approach to government intervention. The government's goal is to maximise the unweighted sum of wages of all individuals, internalizing the cost of effort exerted in the two admission tests. This approach is common in the literature since Arrow (1971). The maximization problem of the social planner is as follows:

$$\begin{aligned} \max_{\lambda} \quad & \Pi_S = v(\alpha_H n_H(\lambda) + \alpha_L n_L(\lambda)) + e_1^* + (\frac{1}{2})\beta(\alpha_H + \alpha_L) - C(e_1, e_2) \\ \text{s.to} \quad & n_H(\lambda) + n_L(\lambda) = \frac{1}{2} \end{aligned} \tag{9}$$

direction, but the two areas do not change.

[16] That occurs when $\lambda > \delta\hat{\lambda}$. I believe that small values of δ are more realistic than high values.

[17] This idea traces back to the debate in Italy about the survival of the *liceo classico* and the role of skills. It has been suggested that learning classic languages (e.g., Latin and Ancient Greek) is useful because those who studied at *liceo classico* do better in life (e.g., obtain higher earnings on average).

The government is interested in maximizing the total wage of the society, taking into consideration individuals that do not attend university and the effort that they exert to the admission tests. All individuals, skilled and unskilled, matter. The approach I follow is very similar to the one presented in the previous section when I considered the university problem. Let λ_S^* be the solution to the government problem. Similar to what I concluded before, I have that:

Theorem 2. *If $a > 1 - \alpha_L$, the solution of social planner's problem is $\lambda_S^* > 0$.*

Proof. The proof is similar to the one of theorem 1 and it is available in appendix A1.4. □

The university and the social planner agree on using the second test as a screening device. However, that does not mean that they would necessarily agree on the weight for λ.[18] I set that result in the theorem below.

Theorem 3. *The optimal λ_U^* of university is greater or equal than the optimal λ_S^* of the government, $\lambda_S^* \leq \lambda_U^*$.*

Proof. Available in appendix A1.5. □

The welfare properties I have described in the model set-up ensure that the government internalizes the cost of effort exerted by all students, including the ones that are not admitted to HE. The university only takes into consideration the students that they admit. That is key to understand why the university and the government do not always agree about λ. Nevertheless, both the university and the government agree that the weight on T_2 should be positive.

4 Admission Policies in Portugal

My theoretical model can be applied to any HE system where different admission conditions are combined, such as field-specific tests and additional requirements. This combination is common across countries, and Portugal is one such case. In Portugal, universities use national central exams and the high school score as mandatory requirements. As explained before, I aim to test whether the inclusion of a general skill test as admission

[18] See example in appendix A1.6.

criteria generates a better pool of students. However, before presenting my research question and estimation strategy in detail, it is crucial to clarify the admission procedure to HE in Portugal.

4.1 Centralized allocation of candidates: the role of the government

The process of admission to the public HE system in Portugal is centralized. Each year, the government sets the number of vacancies for each institution and degree, the *Numerus Clausus*. There are approximately 50 thousand vacancies each year, over 170 public HE institutions, offering a total of 1,180 programmes.

Table 1 provides further information. The Portuguese HE system is binary and composed of Polytechnics and Universities, which can be either public or private. I focus on the public HE system. An institution offering a degree can be a department/faculty within a polytechnic or university or can be the university or polytechnic itself, depending on its organizational structure. I only consider first degree cycles in my analysis. Throughout the text I will refer to the pair institution-degree as an *HE programme* or simply a *programme*.[19]

Table 1: First Cycle Degrees in Public HEIs, 2018

	Total Number
Institutions	170
At University	75
At Polytechnic	95
Degrees	529
Bachelors	485
Integrated Masters	38
Prep Bachelors/Master	6
Institutions x Degrees	1,180
Bachelors	1,066
Integrated Masters	112
Prep Bachelors/Masters	2
Vacancies	50,852

Source: DGES (2019a)

The government also sets boundaries on admission requirements that universities must respect. The weight to attach to the high school score (which is an average of all courses

[19]For more details on the distinction between choosing a combination of a college/major instead of only a college see Bordon and Fu (2015). The authors develop a sorting equilibrium model where they exploit variation in the college-major-specific admissions regime.

taken by the student at high school) must be between 50% and 65%. The remaining weight is allocated to the standardized test(s), chosen by the university out of the national exams (see section 4.2 on the role of each institution).

Finally, the government manages the allocation of candidates via a deferred acceptance mechanism (Gale and Shapley, 1962)[20]. Having set the number of vacancies at each programme, it then ranks all the candidates to that programme based on the admission criteria set by the university. Note that the admission score of each student is specific to each programme, as different exams and different weights are enforced across programmes. Therefore, the government computes each year approximately one thousand rankings. Each candidate will be listed in as many rankings as the number of programmes she applied to. She will be offered admission into her highest feasible stated preference, given the number of vacancies and the quality of the pool of competing applicants. Each student is allocated to a single programme, and she cannot change the result of the allocation. (section 4.3 describes the student problem in detail).

4.2 The university problem in practice

Each HEI defines, for each programme, the number and nature of national exams required as its admission criteria, as well as their weights. The institution has a set of 19 entrance exams available to choose from (see Table 2).

All students at high school must take the core field-specific exam at the end of the 12th grade, defined according to the academic track they have followed: Arts, Science and Technology, Socio-Economics or Languages and Humanities. They must additionally have taken at the end of grade 11 two other field-specific exams, chosen out of a set of three to eight possible exams (see Table 2). Independently of the track chosen, all students must take a general exam of Portuguese at the end of 12th grade. Since 2011, they can as well swap one field-specific optional exam with a general exam in Philosophy at the end of grade 11.

The university must respect one single constraint when defining the number of exams required, their nature and weights. Altogether those exams must weight between 35% and 50% of the overall admission score. The number of exams required is either one or two,

[20]For a review see, e.g., Roth and Sotomayor (1992) and Kara and Sönmez (1997).

Table 2: National Exams at High School (according to the academic track)

	Field-Specific Exams		General Exams	
Track	Core Exam (12th grade)	Additional exams (11th grade) (choice of two)	(12th grade)	(11th grade)
Arts	Drawing	Descriptive Geometry Mathematics History of Culture and Arts	Portuguese	Philosophy $^{(a)}$
Science and Technology	Mathematics	Biology and Geology Physics and Chemistry Descriptive Geometry	Portuguese	Philosophy $^{(a)}$
Socio Economics	Mathematics	Economics Geography History B	Portuguese	Philosophy $^{(a)}$
Languages and Humanities	History A	Geography Latin German French English Spanish Portuguese Literature Applied Mathematics	Portuguese	Philosophy $^{(a)}$

Source: DGE (2019). Notes: This table includes only the general tracks and not vocational or professional tracks at high school; (a) Since 2011 students are allowed to swap one of the two additional field-specific exams with the Philosophy exam.

but there may be different exam combinations considered by the university.[21] If requiring one exam, the institution can specify it or allow candidates a choice among a defined set. In either case, the university is free to require a field-specific exam or a general one (see Table 2). If requiring a second exam, the same procedure applies. If considering two exams, they must have equal weight. Whether the institution allows for different access options to a programme (exam combinations), and the student fulfils different access options (given the exams she took), the combination that is considered for ranking her among the candidates to that programme is the one that yields her the highest admission score. As a result, within the same programme, I can observe students being admitted with different exam combinations.

[21] Except for the Medicine degree, which requires three exams.

4.3 The student problem in practice

The process of application to HE requires students to rank their preferred programmes. After the announcement of the admission criteria rules, and after observing her own scores in the national exams, each student can order up to six programmes to which she applies.

As explained before, the government solves the matching problem under the procedure described above, similar to what is known in the literature as a deferred acceptance mechanism (DA). A DA mechanism is an algorithm that finds a stable matching between agents on both sides of the problem, taking into account their preferences. In this case, the government considers the capacity constraint for each programme and matches the students with explicitly stated preferences to the institutions; the institutions, in turn, have stated their preferences through the choice of admission criteria. This is an efficient and fair mechanism, which ensures that students with the same preferences and admission scores have the same opportunity of being admitted to a programme (equal treatment of equals property, ETE).[22]

Students have an incentive to report a set of six preferences that they judge feasible. Since they observe their scores and they know past programme thresholds of admission, they will try to exclude options of programmes that are beyond reasonable choice. They will not waste preference slots with scenarios that are way out of their possibilities. Hence, the student has an incentive to report her truthful rank of preferences. She knows that she will be allocated to her highest feasible stated preference, given the number of vacancies and the admission score of competing applicants.

5 Datasets

In my study I link three primary data sets: i) Applications to public HEIs (DGES, 2019b); ii) Students' Performance and iii) Graduation at HE (DGEEC, 2019).[23]

The application dataset provides information on the population of applicants to the HE system. For each student, I have demographic characteristics, socio-economic back-

[22]This system generates valuable data for research. When vacancies are binding, the assignment procedure described above generates quasi-experimental variation in institution assignment. For a review see Abdulkadiroğlu et al. (2017).

[23]The performance and graduation dataset are supplied linked by DEGADI (*Divisão de Estudos e Gestão do Acesso a Dados para Investigação)* from DGEEC and the link between the application and performance dataset was made by the author at the premises of the Ministry of Science, Technology and Higher Education in Portugal.

ground, previous academic achievement, the application process, including all programme preferences stated, and the placement. I have microdata for eleven years, from 2008/2009 to 2018/2019.

The students' performance and graduation at HE datasets are comprehensive data sources that cover all the HE institutions in Portugal and have information on all the students enrolled. They report the student's performance each year she has been enrolled and her graduation, whenever applicable. The performance dataset also reports information regarding the mobility status, such as the placement at an exchange programme. Tables 3 to 5 present descriptive statistics on the variables of interest for the full datasets; the description of all variables is presented in Tables A3 to A5 of the appendix.[24]

Over the period 2008-2018, I observe approximately 800 thousand students' applications to the first year of a HE programme under the General Access Regime (GAR) (the centralized process of application to public HEIs). The average age at the application stage is nineteen years old, and 57% of the candidates are female. On average, each candidate lists 4.5 preferences. Sixty-four per cent of the applicants are offered placement in a bachelor degree, 12% in a bachelor-master joint programme, whereas approximately 1/4 are not successful in their application to public HEIs.[25] From those that are admitted to public HEIs, half was allocated to their first preference, while 20% was allocated to the second one. On average, candidates are admitted with 1.3 admission exams, and 22% of them are admitted with a Portuguese exam.[26]

I track enrolled students over the five years of 2013 to 2018 (see Table 4). This panel comprises 1,5 million observations on individual-year on 760 thousand individuals. In this paper, I define an individual as a student enrolled in a specific programme. If a student is enrolled at two distinct programmes at the same time, according to this definition, that will count as two individuals. However, the reader should bear in mind that, as described in section 4.3, a student can only be admitted to one programme in each contest. Thus, for the student to be enrolled at two programmes in public HEIs at the same time is because she applied in different years or rounds to those programmes and, consequently,

[24]A detailed list of the diploma types included in each degree (Bachelor, Integrated Master, Master, PhD and Other) is provided in Table A7 of the appendix.

[25]This can be either because they were not allocated to any of their stated preferences or because the application was not validated.

[26]Note that students of "Other - 1st cycle" programmes will be observed in the performance dataset, even though the majority is not observed in the centralized application dataset, as they applied directly to the institution.

there are very few students for which this happens. From now on, I will drop the notion of students and refer only to individuals.

Table 3: Descriptive Statistics, Full Population at Public HEIs, **Application Dataset**[(1)]

	Mean	Std. Dev.
A. Data Structure		
Initial year	2008/2009	
Final year	2018/2019	
Nb. years	11	
Nb. individuals	790,723	
B. Applicants		
Age	18.74	2.46
Female (share)	.57	
High school GPA (0-200)	147.64	19.41
Nb. of stated preferences per applicant	4.47	
C. Placement		
Degree of placement (nb. individuals)		
Not placed	186,558	
Bachelor	504,474	
Integrated master	97,960	
Other - 1st cycle[(2)]	1,701	
Preferences of placement (share)		
1st	.51	
2nd	.21	
3rd	.12	
4th	.07	
5th	.05	
6th	.03	
Application score	144.22	19.53
Nb. of admission exams	1.31	.52
Portuguese admission exam (share)	.22	

Source: (DGES, 2019b). Notes: (1) Applications under the General Access Regime (GAR); (2) The majority of applications to "Other - 1st cycle" programmes are not centralized and, instead, made directly to the institution.

Table 4 presents the descriptive statistics for individuals enrolled at public HEIs. First of all, it is important to clarify that in my analysis I will only consider individuals that were admitted, for the first time, into a Bachelor or Integrated Master programme in a public university through the GAR (in order to match those to the application dataset). The majority of the individuals studied at a public high school, and 57% are female. One-third of the individuals are non-local students, which means that those students live in a

geographical area different from their household.[27] Moreover, only 30% of the individuals have a mother/father with a HE degree. Although one third applied for financial support, only half of those were conceded a maintenance grant.

Table 4: Descriptive Statistics, Full Population at Public HEIs, **Performance Dataset**

	Mean	Std. Dev.
A. Data Structure		
Initial year	2013/2014	
Final year	2017/2018	
Nb. years	5	
Nb. obs. individual-year	1,545,059	
Nb. individuals(1)	756,435	
Bachelor	404,394	
Integrated master	104,613	
Academic year one	360,748	
1st time enrolment	291,042	
Entry through GAR(2)	214,165	
Entry through other regime(3)	59,957	
Entry regime not specified(4)	16,920	
Repeaters	69,706	
Other programmes(5)	251,428	
B. Individuals (Academic year one, through GAR)		
Nb. Individuals	214,165	
Age	18.49	2.11
Female (share)	.57	
Application score (0-200)	144.49	20.24
Public high school (share)	.84	
Non Local Student (share)	.30	
Mother has HE (share)	.33	
Father has HE (share)	.26	
Applied to maintenance grant (share)	.31	
Received a maintenance grant (share)	.17	

Source: (DGEEC, 2019). Notes: (1) Def. individual: unique person ID per programme; (2) GAR regards the national contest of application (General Access Regime); (3) Application through special regime: transference, diplomat son, immigrant status, among other examples; (4) Application through local access contest for instance; (5) Other programmes include Master, PhD, Other - 1st cycle and 2nd cycle programmes.

Table 5 reports the descriptive statistics of the graduation dataset. I observe approximately 330 thousand individuals graduating over the period 2012 to 2017, irrespectively of their application year and years of enrolment.[28]

[27] This variable is self-reported. However, I also have information regarding the council of residence for each individual.

[28] These students may have obtained more than one diploma over this period, for instance, a bachelor and master degrees.

Table 5: Descriptive Statistics, Full Population at Public HEIs, **Graduation Dataset**

	Mean	Std. Dev.
A. Data Structure		
Initial year	2012/2013	
Final year	2016/2017	
Nb. years	5	
Nb. individuals	327,221	
Bachelor	159,283	
Bachelor (part 1 of the integrated master)	32,719	
Other programmes(1)	135,219	
B. Graduates		
Age		
Bachelor	26.03	6.50
Bachelor (part 1 of the integrated master)	24.27	3.69
Female (share)		
Bachelor	0.60	
Bachelor (part 1 of the integrated master)	0.50	
Final GPA (0-200)		
Bachelor	136.39	14.78
Bachelor (part 1 of the integrated master)	135.30	14.96
Nb. years enrolled in the programme		
Bachelor	3.87	1.37
Bachelor (part 1 of the integrated master)	4.09	1.79

Source: (DGEEC, 2019). Notes: (1) Other programmes include Master, PhD, Other - 1st cycle and 2nd cycle programmes.

In general, students on longer programmes tend to be observed for longer, and so, the age of graduation varies according to the degree. In particular, on average, it is 26 years for a bachelor degree and 24 for the bachelor part of an integrated master. The age at graduation at bachelors is higher given that the distribution is rightward biased (with a median of 24 years comparing to the mean of 26.03 years). Even if I consider the number of years that a student has been enrolled, I conclude that average age at graduation would be 22 years for a bachelor and 20 for a bachelor who is part of an integrated master. The characteristics' population can justify this difference that I am looking at. Given that the dataset includes all graduates, in the bachelor degree, I have individuals that were admitted not only through GAR but also adult students (sub 23), transferred students, among others, while the majority of individuals enrolled at integrated masters were admitted through GAR.

Finally, I link the three datasets (application, performance and graduation) restricting

the link to those individuals that applied to public HEIs through the centralized national system, who were offered a place and who enrolled. From the 214,165 individuals observed in the performance dataset, I was able to match 96% to the application dataset. Table A8 of the appendix presents descriptive statistics for the linked individuals. Once I define the outcomes of interest, the variables of interest, and the methodology to be used, I will impose further constraints that should be applied to the linked dataset in order to determine the analysis population.

6 Empirical Set-up: Admission Tests and Performance

6.1 Outcomes

In this study I consider three measures of student performance at university (y_i), for an individual i: i) the number of credits obtained through the *European Credit Transfer System* (ECTS) by the end of the first academic year; ii) whether the individual completed their HE programme on time[29] (Completion on Time); and, iii) Final GPA. These outcomes are different in their nature. They measure student performance at different stages of the degree. For each measure, the sub-population of analysis is different. In Table 6, I report descriptive statistics for each subset that will be considered in my analysis (for descriptive statistics of the total sample population see Table A8).

I only observe the number of ECTS for students that completed the first academic year of their degree. I do not have information on the ECTS for the 2017/2018 entry cohort and individuals that dropped out during their first year (on average, dropouts represent 17% of enrolments per year). Overall, there are no differences between the sub-sample of individuals with ECTS credits (see Table 6) and the total sample (see Table A8).

I define "Completion on Time" as a dummy variable equal one if a student graduated on time and zero otherwise. I only consider students enrolled either in a three-year bachelor programme or in an integrated master (that awards a bachelor certificate after successfully completing the first three academic years). I exclude from the analysis the cohorts 2015/2016 to 2017/2018 and those individuals enrolled in four or six-year bachelor programmes on the 2013/2014 and 2014/2015 cohorts. By comparison to the number of ECTS, in this sub-sample of analysis students have, on average, a lower admission score,

[29] In order to finish the degree each student needs to complete a minimum of 180 ECTS.

but better performance at high school. Additionally, I observe a slightly higher share of students admitted with the Portuguese exam (28%).

Finally, the Final GPA[30] is only available for students that have finished their degree during the period of analysis, and it is an average score of all courses taken at university (including those taken in the first year). For that reason is this subset I only consider students enrolled in a three-year or four-year programmes for the 2013/2014 cohort and those enrolled in three-year programmes of the 2014/2015 cohort (the ones that could potentially have graduated). In this sub-sample of analysis, I observe a higher share of female graduates and graduates have, on average, a higher high school score.

Comparing the three different sub-samples of analysis, the majority of the descriptive statistics remain the same. The major difference is associated with the gender and the high school score variables. In particular, both the share of females and the average high school score tend to increase when I look at those that graduate. It is important to control for both characteristics in the empirical analysis. Although the descriptive statistics are similar, I believe that it is relevant to look at the three different outcomes.

The number of ECTS and Final GPA can vary across programmes. Namely, some programmes might be more restrictive in their marking standards compared to others. Thus, those outcomes can be very different across programmes. For that reason, I consider deviations to the mean instead of total scores in my analysis. I standardize the number of ECTS and Final GPA within the programme by subtracting the mean and dividing by the standard deviation. I consider for each student the deviation to the mean outcome for the programme that she is enrolled in.

[30]For a review on the determinants of Final GPA see, e.g., (Betts and Morell, 1999).

Table 6: Descriptive Statistics, Analysis Population according to the **Outcomes**

Outcomes	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	ECTS accumulated by the end of the first year		Completion on Time (for three-year degrees)		Final GPA	
			A. Data Structure			
Initial cohort		2013/2014		2013/2014		2013/2014
Final cohort		2016/2017		2014/2015		2015/2016
Nb. year		4		2		2
Nb. Individuals		134,143		52,966		29,263
			B. Individuals			
Age	18.40	1.67	18.63	1.99	18.39	1.73
Female (share)	.58		.56		.67	
High school score (0-200)	134,14	19.91	144.69	17.32	149.06	17.19
Public high school (share)	.85		.86		.87	
Non-local student (share)	.31		.29		.31	
Mother has HE (share)	.32		.28		.26	
Father has HE (share)	.26		.21		.19	
Applied to a maintenance grant (share)	.32		.32		.36	
Received a maintenance grant (share)	.24		.26		.28	
			C. Placement			
Degree of placement (nb. individuals)						
Bachelor		108,373		52,966		29,257
Integrated Master		25,770		-		6
Preferences of placement (share)						
1st	0.59		0.58		0.64	
2nd	0.21		0.21		0.20	
3rd	0.10		0.10		0.09	
4th	0.05		0.05		0.04	
5th	0.03		0.03		0.02	
6th	0.02		0.01		0.01	
Application score (0-200)	144.96	20.05	138.95	17.41	143.01	17.48
Nb. of admission exams	1.37	0.56	1.15	0.36	1.19	0.39
Portuguese admission exam (share)	.22		.28		.29	
Portuguese exam score (0-200)	121.78	28.36	117.00	27.08	120.99	26.94

6.2 T_2 in practice: the Portuguese exam

From my model, there are two relevant attributes of the admission requirements that should be considered: the number of exams and their nature (generic or field-specific). In fact, the existence of a second exam always adds more information to the selection process (e.g., Holmström, 1999). The addition of a general exam diversifies the nature of the information gathered by the institution. Furthermore, allowing the inclusion of a general exam favours candidates who are relatively better at general skills than at field-specific skills. However, the general exam is only taken into account when it improves the student's admission score.

The goal is to understand whether including the general exam in entry requirements increases the average student performance at university. In other words, will students admitted with a general admission exam perform better: during university (ECTS by the end of first year); and at graduation (completion on time and final GPA)? In my empirical analysis, the Portuguese exam is considered to be a general exam for the majority of HE programmes. To finish high school, all students must have taken the Portuguese exam irrespective of the high school track they have chosen (see section 4.2).

I now explain why the student and the university may care about the general exam (Portuguese). Consider the following example in Table 7, where two students (Pedro and Alexandre) apply to the same degree at universities A and B. Both students prefer university A over B. However, university A only considers a field-specific exam (T_1) as an admission criterion, while university B allows students to apply with a general exam (T_2) combined with T_1. Both Pedro and Alexandre have taken T_1 and T_2 at high school. However, when applying to university B, T_2 is only considered in Alexandre's case. Only in his case, the score on T_2 increases the application score. On the other hand, in Pedro's case, only the score on T_1 is considered given that he performed better in T_1 relatively to T_2. That means, holding constant preferences, Pedro will be allocated to university A and Alexandre to B.

In this example, I observe that Pedro performed much better on T_1 relatively to T_2. Instead, Alexandre had a similar score on T_1 compared to Pedro but performed even better on T_2. Pedro represents a student profile strong on field-specific skills (specialist). Alexandre represents students that performed sufficiently well across disciplines, both field-specific and general skills (all-rounder profile). University A places a higher value on

Table 7: Example with Two Students, Two Universities

	Exams		Admission Score		
Student	Exam	Score	Required	University A	University B
Pedro	T_1	170	T_1	**170**	170
	T_2	110	$T_1 + T_2$	n.a.	140
Alexandre	T_1	160	T_1	160	160
	T_2	200	$T_1 + T_2$	n.a.	**180**

Note: Assume that each university has capacity for just one student. University A allows the students to apply with the T_1 and university B allows students to apply either with T_1 only or T_1 and T_2 combined. Scores are in a scale between 0 and 200.

specialists students while university B allows all-rounders to compete with specialists for the same place. Thus, university B captures a different pool of students compared to A.

Note that if both universities had given the students the option to add the exam T_2, Alexandre would have displaced Pedro at university A. Indeed, for the student, the option of inclusion of a general exam favours a student profile relatively more robust on general skills, all else equal. I aim to understand whether allowing all-rounders to compete with specialists would have increased student performance at university. The empirical specification should thus control for other attributes of the candidates.

The example also illustrates another implication for the university. If both universities had considered T_1 as the single admission criteria, the allocation of students would have remained unchanged. However, the admission threshold of university B would have decreased from 180 to 160 (the admission score of the last admitted student). Therefore, one might imagine that the introduction of T_2 can be seen as an incentive that universities use to boost the admission threshold score and signal themselves as more selective universities.

Alternative Entry Requirements

The university defines for each degree the entry requirements subject to the boundaries imposed by the Ministry (see section 4.1). For each programme, there may be different alternative entry requirements (exam combinations). On average, each programme allows for three alternative entry exam combinations. Some combinations include the Portuguese exam, and others do not. Within and across programmes, it is up to the discretion of each institution, whether to include the Portuguese exam in one or more of the exam combinations allowed.

Table 8 presents the total number of exam combinations within programmes. In total,

Table 8: No. of exam combinations by programme-year

	No. of exam combinations with Portuguese								
No. of exam combinations	0	1	2	3	4	5	6	8	Total
1	2,112	204							2,316
2	1,305	322	25						1,652
3	3,535	3,657	24	35					7,251
4	63	351	2	0	23				439
5	2	117	2	0	0	15			136
6	9	117	2	2	0	0	19		149
7	0	0	7	0	0	0	0		7
8	0	0	0	0	0	0	0	1	1
Total	7,026	4,768	62	37	23	15	19	1	11,951

Source: Author's calculations based on the application dataset. Notes: This table includes all the different programme/year for the 11 years, from 2008 until 2018.

there are 11,951 programmes over the eleven years of analysis. I refer to each programme per year as programme-year. For instance, there are 2,316 programme-year that allows for a single entry exam combination, of which only 204 included the Portuguese exam. Moreover, there are 136 programme-years that select students based on their best result among five different exam combinations. Among those 136, only two programmes did not allow for the Portuguese Exam while 117 programmes allowed for it in one out of the five exam combinations. Additionally, 15 programmes allowed for five different exam combinations where all of them included Portuguese. In my analysis, I only consider programmes that include Portuguese as an alternative requirement (and not mandatory). That is, Portuguese is included in at least one of the allowed exam combinations, but not in all.

Student admission score for each programme

For each of the individual's stated preferences (up to six), her application score is computed as the highest score out of the exam combinations set by the programme.[31] For each student, the dataset reports the full set of applications ranked by order of preference. For each programme ranked, it reports the exam combination considered, the student's score on each of those exams, as well as the overall application score itself. Out of this information I derive a sequence of variables: i) **Actual application score** (τ): the

[31]The computation is conditional on the result of the national exams the student takes at high school. For instance, imagine that Pedro only took the Mathematics and the Portuguese exams and he is applying to digital marketing at a particular university, as one of his stated preferences. The digital marketing programme specifies that students can apply with the Mathematics exam or the combination of the IT and the Portuguese exams. As Pedro did not take the IT exam, his application score is determined by the Mathematics exam only.

application score in the programme in which the student was admitted; ii) the **individual exam scores** used in the application process to all programmes that the student applies for; iii) the entry requirements based on the observed **exam combinations allowed**; and, iv) the **actual placement threshold** (τ^*).

Let me return to Pedro and Alexandre's example. Imagine that now both universities A and B allow the students to apply with the Mathematics exam only or with the combination of Mathematics and Economics exams. Also, university B adds a third alternative option: the Economics and Portuguese exams combined. The exams scores of Pedro and Alexandre are reported in Table 9. In this example, Pedro is admitted to university A and Alexandre to university B as in the original example.

Table 9: Exam and application scores

	Exams' scores			Actual application score	
	Mathematics	Economics	Portuguese	University A	University B
Pedro	170	150	110	**170**	170
Alexandre	160	170	200	165	**185**

Note: Assume that each university has capacity for only one student. Consider there is only one degree and two universities. Both students prefer university A over B. However university A allows the students to apply with the Mathematics exam only or with the combination of Mathematics and Economics exams. University B allows for the same two combinations adding a third alternative: the Economics and Portuguese exams combined.

Instead of considering only two students, I can extend the example to a larger pool of students. Assume that there is some heterogeneity associated with the pool of students admitted to university B. I would observe some individuals being admitted at university B with an exam combination that includes Portuguese, and some without. This is an example of a variation on the exam combination within programmes. Returning to the initial objective, I would like to estimate the effect of being admitted with an exam combination that includes Portuguese. To do this, I compare the student performance of those that were admitted with a Portuguese exam with students that were admitted without it.

6.3 Selection into Treatment

The treatment is the inclusion of the Portuguese exam as an admission criterion at the individual level. I define $y(1)$ as the observed outcome of student performance in case of treatment and $y(0)$ otherwise. The problem I must tackle is that selection into treat-

ment might not be random. However, I can accommodate selection in my model by understanding how individuals are assigned to treatment.

In my analysis, I define four different groups of students (see Figure 3). Some were admitted without the Portuguese exam (Groups A and B). Their field-specific skills are better than their general skills ($T_1 > T_2$ and $T_1 > \tau^*$). Those that were admitted with Portuguese, but could have been admitted even without it (Group C). Students that are relatively better at general skills but whose field-specific skills would have been enough to get them admitted ($T_2 > T_1 > \tau^*$). Finally, I observe students that were only admitted because their score in the Portuguese exam was sufficiently high (Group D). These are students whose fields specific skills are relatively weak compared to their peers, who would not have been admitted without the Portuguese exam. ($\frac{T_1+T_2}{2} > \tau^* > T_1$).

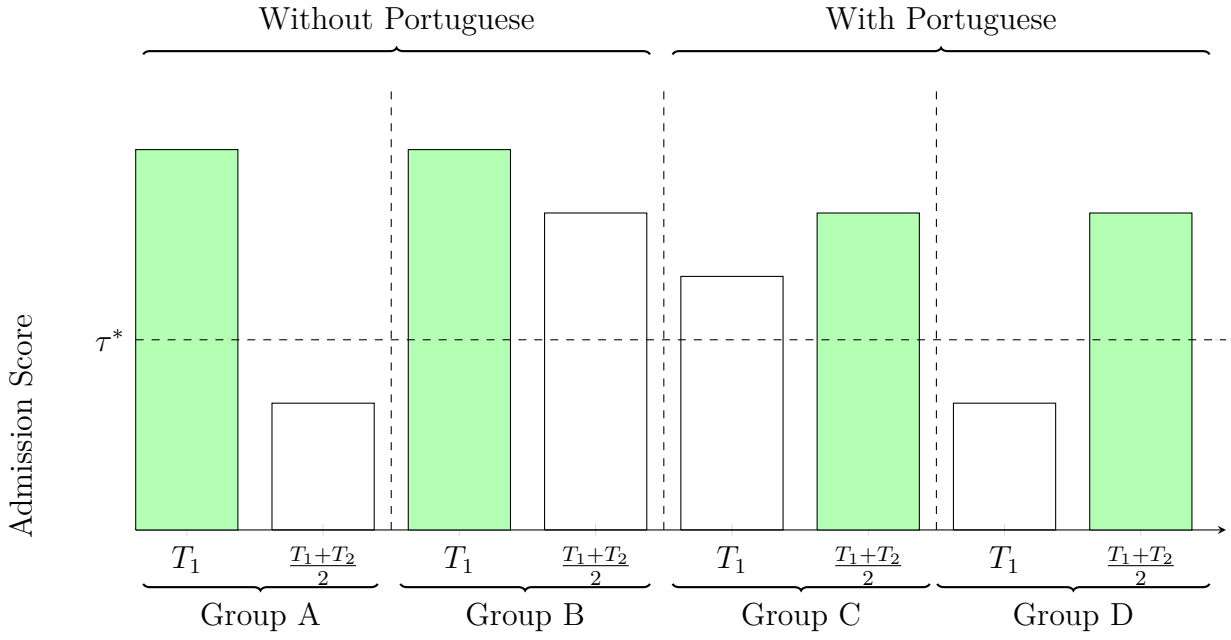


Figure 3: Different groups of students within the same programme

In fact I can classify these groups into three categories: i) the *specialists* (Group A); ii) the *generalists* (Group D); and, iii) the *all-rounders* (Groups B and C). There is a potential trade-off in allowing for generalists to compete with specialists. The university can increase the average quality of the pool of students by admitting all-rounders (Group C, for instance). At the same time, the university might get pure generalists in their pool (Group D). In the exam example, all students gained entry to the programme. A consequence of including Portuguese as an alternative requirement (T_2) is that generalists

may take places that would have been otherwise allocated to specialists.

I consider two different ways of framing my research question: i) Do students with slightly better general skills outperform students with slightly better field-specific skills? ii) Does the *generalists* perform better at university relatively to their peers?

In order to answer the first question, I consider relative performance at T_2. I divide individuals according to whether their performance in T_2 increased their average admission score, i.e. whether their general skills were better than their field-specific skills. I compare students of similar ability from Groups C and D that performed slightly better in the general exam with students from Groups A and B that performed slightly worse in the general exam.

To answer the second question I look at performance in T_1 and T_2. For individuals that were admitted with Portuguese, I dichotomize them according to whether their performance in T_1 was sufficient by itself to meet the entry requirement (τ^*).[32] For individuals that were admitted without Portuguese, I look at performance in T_2. In my estimation strategy Group A will be the comparison group. I hypothesise that the effect of allowing the inclusion of the Portuguese exam on individual performance will be different across groups. Namely, I expect students in Group D to perform worst at university in comparison to their peers, given that students in Group D are weaker in terms of field-specific skills.

In the data, I attempt to determine the application score for each student in the case that she was admitted with a different exam combination. For each student I compute: i) her application score in the case the Portuguese exam was considered (τ_{PT}); ii) her application score in the case that the Portuguese exam was not considered ($\tau_{\sim PT}$). Based on four blocks of information (admitted with Portuguese, τ^*, (τ_{PT}), and ($\tau_{\sim PT}$) I can distinguish between the different comparison groups. Table 10 reports the number of students for which I can identify each one of the two types of application scores.

[32] Remember that for each programme and each student I observe the actual application score and the actual placement threshold (τ^*).

Table 10: Descriptive statistics on the Portuguese exam

	All programmes			programmes that allow for PT		
	Mean	Std. Dev.	Freq.	Mean	Std. Dev.	Freq.
Nb. Individuals			205,297			78,233
Actual application score (τ)	144.72	20.13	205,297	139.02	17.66	78,233
Admission score included PT (share)	0.22		45,154	0.51		40,016
Portuguese exam score	127.90	23.08	139,241	120.10	25.90	67,896
Application score with PT (τ_{PT})	134.55	18.05	73,034	133.71	17.79	67,896
Application score without PT ($\tau_{\sim PT}$)	146.56	20.31	172,500	141.65	18.06	46,837
($\tau_{PT} - \tau_{\sim PT}$)				-9.59	12.40	33,896

Notes: programmes for which Portuguese is a mandatory requirement were not considered in the analysis. Thus, there are 5,138 students that were admitted to programmes for which Portuguese is mandatory and, for that reason, they were excluded from the analysis. All scores are in a scale between 0 and 200.

7 Heterogeneity of Skills

7.1 Estimation Strategy: sharp RDD

In this section, I tackle the question about a slight difference in skills. For that, I start by computing the difference for each student between i) her application score in the case that Portuguese is considered (τ_{PT}); and, ii) her application score in the case that Portuguese is not considered ($\tau_{\sim PT}$).

A student admitted with an exam combination that did not include Portuguese is classified as belonging to either Group A or B. In the case that Portuguese is considered, she is included either in Group C or D. From the 78,233 enrolled students I observe that 50% were admitted with Portuguese (see Table 10). I am interested in comparing university performance of students from Groups C and D who at the margin performed slightly better in the general exam with students from Group A and B that perform slightly better in the field-specific exam. For that, consider the reduced form regression:

$$y^i = \alpha 1\{\tau^i_{PT} - \tau^i_{\sim PT} \geq 0\} + u^i \tag{10}$$

where y^i is the outcome and $1\{\tau^i_{PT} - \tau^i_{\sim PT} \geq 0\}$ is an indicator equal one if the student's application score with Portuguese is higher than her application score without Portuguese.

Therefore, I have a model of selection into activating the Portuguese exam based on

observables. The inclusion of the Portuguese exam follows deterministically from the decision rule $\{\tau^i_{PT} \geq \tau^i_{\sim PT}\}$. As a result, I am able to identify a local treatment effect for individuals around the discontinuity point. However, I can have students with totally different ability levels around this discontinuity. It is important that in my estimation, I control for individual's ability.

Additionally, I run the analysis, including cohort, preferences, and programme fixed effects, as well as individual characteristics. The equation of interest is as follows:

$$y^i = \gamma_0 + \gamma_1 1\{\tau^i_{PT} \geq \tau^i_{\sim PT}\} + \gamma_{\mathbf{i}}{}'\mathbf{X^i} + \Theta + \epsilon^i \tag{11}$$

where $\mathbf{X^i}$ is the vector of controls (gender, individual ability and home location) and Θ represents the fixed effects. γ_1 is the coefficient of interest. γ_1 tell the reader whether the student who is slightly better at general skills performed better at university. Table 11 reports the number of students that I am able to identify around the discontinuity point.[33]

Table 11: Individuals around the assignment rule

	Overall	$\lvert\tau_{PT} - \tau_{\sim PT}\rvert \leq x$		
	Sample	$x = 10$	$x = 5$	$x = 2$
Nb. Individuals	33,896	17,405	9,412	3,853
Groups C and D (share)	0.18	0.27	0.31	0.30

Source: Author's calculation.

7.2 Results

In Figure 4 and Table 12, I compare students that have slightly better general skills with the ones that are slightly better on field-specific skills.

In Figure 4, the left panels A, C and E summarize results of specifications analogous to the reduced form presented in equation (10). The x-axis describes the difference between the two application scores that I computed (τ_{PT} and $\tau_{\sim PT}$); the y-axis describes the different outcomes considered. I plot the mean of the difference $\tau_{PT} - \tau_{\sim PT}$ collapsed into cells containing individuals who are within the same distance from zero (at a maximum

[33]Table A9 of the appendix provides descriptive statistics for all variables considered in the estimations (according to all constraints imposed in the analysis population).

of 2 points distance from zero). The right-hand side of panels B, D and E plot analogous information when I control for individual and programme characteristics. The y-axis is based on residuals from a regression specified in equation (11).

Table 12 presents a summary of my different estimations.[34] Firstly, I include the reduced form proposed in equation (10) (column 1). Additionally, I control for individual characteristics such as ability, gender, and home location (column 2). In column 3, I include programme fixed effects. In all specifications, I include preferences and cohort FE. The Final GPA and number of ECTS outcomes are standardized within programmes.

Both Table 12 and Figure 4 lead to the same conclusion. For students that had performed well in both tests, having slightly better general skills is not associated with better performance at university. Even controlling for individual ability (by including the High School score), I do not observe a difference in performance at university between the two groups overall. According to column (3), there is a negative effect for those admitted with Portuguese in the first academic year. At the beginning of the programme students that are slightly better at general skills tend to perform worse. However, when I consider outcome measures more towards the end of the programme, I do not observe differences in academic performance. Students with slightly better general skills tend to perform as well as their peers with slightly better field-specific skills. However, the reader should bear in mind that I am only looking at average effects within programmes at the margin of difference on skills, not at the margin of admission.

A drawback of this approach is that I am only able to determine the difference between the two scores whether: i) the individual applies to a programme that includes Portuguese in at least one of exam combination allowed (but not in all); ii) the individual at high school performed in all exams for at least one exam combination that did not include Portuguese. Moreover, this approach does not allow me to distinguish between each one of the four groups.

From a policy perspective, it would be even more interesting to look at what happens at the margin of gaining entry in HE, namely whether better general skills can signal better students. That variation should be subject to empirical scrutiny to fully understand what occurs at the margin of entry. I might verify that a tailored policy would be more effective.

[34] Table A13 of the appendix provides a more detailed version, including different distance bands around the assignment rule.

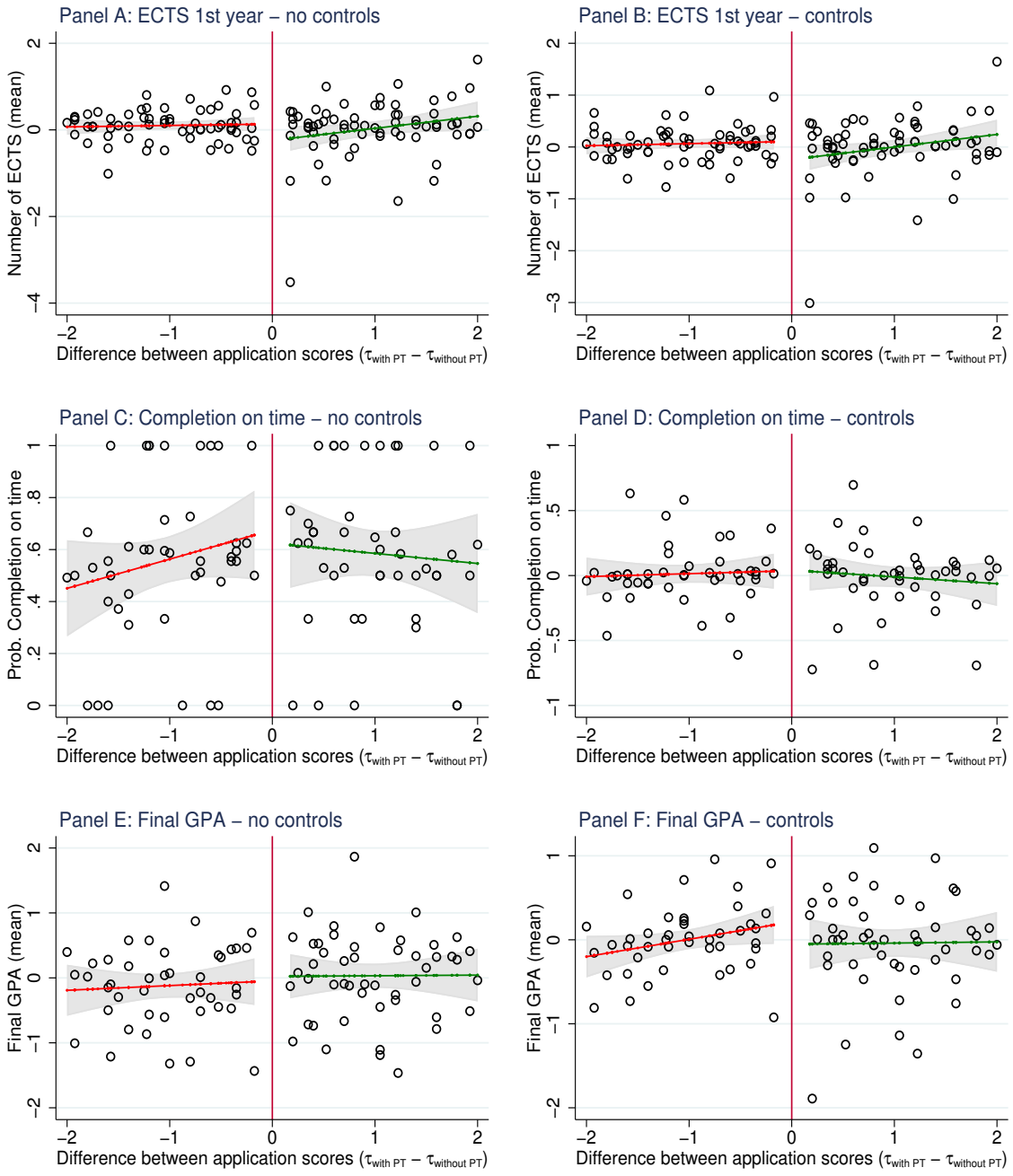


Figure 4: Difference on Skills

Note: The left-hand-side panels plot (2 points) of the difference between the two admission scores cell means of the dependent variable. The right-hand-side panels plot similar means of residuals from a regression of the dependent variable on the difference between the two admission scores. The running variable is measured in a scale between 0 and 200. In each panel, the solid lines are fitted values of regressions of the dependent variable on a linear trend in on each side of the cutoff. The dependent variable in panels A and B is the final GPA (deviation to the mean within each programme); the dependent variable in panels C and D is the number of ECTS accumulated by the end of the first academic year (deviation to the mean within each programme); For both variables, the dependent variable in panels E and F is an indicator for having concluded the degree on time. In this analysis, I include all programmes that allow for the Portuguese exam as an alternative requirement.

Table 12: Difference on Skills

	$\lvert\tau_{PT} - \tau_{\sim PT}\rvert \leq 10$		
	(1)	(2)	(3)
Panel A: No. ECTs accumulated by the end of the 1st year (Cohorts 2013/2014 to 2016/2017)			
PT Exam	-0.013	-0.038*	-0.056***
	(0.020)	(0.019)	(0.021)
Controls	No	Yes	Yes
Programme FE	No	No	Yes
R^2	0.012	0.047	0.117
N	11,072	11,072	11,072
Panel B: Completion on time (Cohorts 2013/2014 to 2014/2015) (Probit - Average Marginal Effects)			
PT Exam	0.028	0.006	-0.021
	(0.017)	(0.017)	(0.017)
Controls	No	Yes	Yes
Programme FE	No	No	Yes
Pseudo R^2	0.021	0.068	0.185
N	4,500	4,500	4,223
Panel C: Final GPA (Cohorts 2013/2014 to 2014/2015)			
PT Exam	0.103**	0.036	-0.019
	(0.041)	(0.040)	(0.046)
Controls	No	Yes	Yes
Programme FE	No	No	Yes
R^2	0.025	0.102	0.247
N	2,891	2,891	2,891

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regression include cohort and preferences FE. The number of ECTS by the end of the first year and Final GPA were standardized within programmes. All coefficients in panels A and C should be interpreted in terms of standard deviation changes in the outcome. Control variables: Female, High School Score, Non-Local Student. A more detailed version is provided in Table A13 of the appendix, where I also consider a distance of five points from the threshold.

8 Genalists vs Specialists

8.1 Estimation Strategy: Partial equilibrium analysis

In the previous section, I look at the effect of being admitted with Portuguese. However, I can classify students into a further partition. Namely, when a student was admitted

with Portuguese, I can consider her counterfactual score if Portuguese were not part of the admission criteria.[35] That enables me to distinguish between Groups C and D.

In the case that $\tau^i_{\sim PT} < \tau^*$, student i is allocated to Group D. Otherwise she is allocated to Group C. As a result, according to Table 13, I observe that eight per cent of the enrolled students are in Group C, and seven per cent in Group D. Additionally, for 38 % I cannot distinguish between C and D. This occurs because I am not able to observe their scores on the exam combination required in the case that Portuguese was not considered.

To distinguish between A and B, I need to look at performance in T_2. Individual i belongs to group A when I observe that $\tau^i_{PT} < \tau^*$. Otherwise, she is included in Group B. In fact, I observe 21 % of the enrolled students in Group A and 15 % in Group B while for 13 % I am not able to distinguish between A and B.

In both distinctions, I assume that the pool of allocated students and the threshold (τ^*) would remain the same in the case of changing the admission criteria.[36] Due to data constraints, the division between groups A and B is more accurate than the division between C and D. In the dataset I observe the Portuguese exam score for the majority of students. As a result, there is only 13% of students for which I am not able to distinguish between Group A and B while for C and D it is 39%. The unbalance on the assigning the sample into groups can potentially bias the results. I need to understand whether the non identified students are missing at random.[37]

In my analysis I consider two different ways of addressing the problem of not being able to identify the corresponding group for each student: i) I run my analysis without distinguishing between C and D. In that case, I only have 13% of missing observations;[38] and ii) I use regression analysis to predict to which group the student should be allocated. I regress the observed application score with and without Portuguese on individual and

[35] In the section before I was strict on my definition of a counterfactual score. For cases in which I only observe some of the exam scores required in the alternative exam combination, I was not able to determine the counterfactual score. However, I now relax my previous assumption in order to increase the number of observations. I consider the partial scores observed as the combination itself. For more details see the Table A10 of the appendix for an example.

[36] This is not necessarily true due to the fact that a change on admission criteria rules would change the pool of applicants, their preferences and also their performance at the high school exams for instance.

[37] In Table A11 of the appendix I analyse whether the individuals for which I do not know their group are missing at random.

[38] I also consider only individuals for which I can identify the group. There is a drawback of having 52% of missing observation.

Table 13: Comparison groups in the overall distribution and around the threshold (shares)

	Observed				Imputation			
	Overall	$0 \leq \tau - \tau^* \leq x$			Overall	$0 \leq \tau - \tau^* \leq x$		
	Sample	$x = 10$	$x = 5$	$x = 2$	Sample	$x = 10$	$x = 5$	$x = 2$
Nb. Individuals	78,233	42,350	26,358	13,592	78,233	42,350	26,358	13,592
Groups A and B								
Group A	0.21	0.29	0.31	0.33	0.28	0.37	0.41	0.43
Group B	0.15	0.07	0.04	0.02	0.21	0.11	0.07	0.04
Non identified	0.13	0.11	0.11	0.11	-	-	-	-
Groups C and D								
Group C	0.08	0.06	0.04	0.03	0.38	0.34	0.30	0.27
Group D	0.04	0.06	0.08	0.09	0.14	0.18	0.23	0.26
Non identified	0.39	0.40	0.41	0.42	-	-	-	-

Source: Author's calculations

programme characteristics.[39] I obtain the predicted application score for each group of peers, and I replace the missing values for each individual within those groups. As a result, according to Table 13, when I consider a distance of ten or five points from the threshold, I observe a higher percentage of students in group A, following by C and D and finally a small percentage of students in group B.

Figure 5 presents the distribution of the scores for the identified observed groups (Figure A7 of the appendix reproduces the same when I consider all individuals according to the imputation method). It seems that I correctly identified the different groups. As expected, in Group D, the majority of students perform very well in Portuguese and worse in terms of field-specific skills. For Group A, the opposite occurs. In Groups B and C, the densities are similar according to the two different application scores distributions.

To address the problem of self-selection, I run my analysis precisely around the admission threshold. I am interested in comparing student performance among those whose Portuguese exam was, at the margin, the only reason why they were admitted (Group D). In this set-up, consider the reduced form regression:

$$y^i = \alpha_0 + \alpha_1 Group_D + \alpha_2 Group_C + \alpha_3 Group_B + \alpha_{\mathbf{i}}{}' \mathbf{X^i} + \Theta + u^i \tag{12}$$

where y^i is the outcome, $\mathbf{X^i}$ the vector of controls, Θ represents the fixed effects, and

[39] For details see appendix A12.

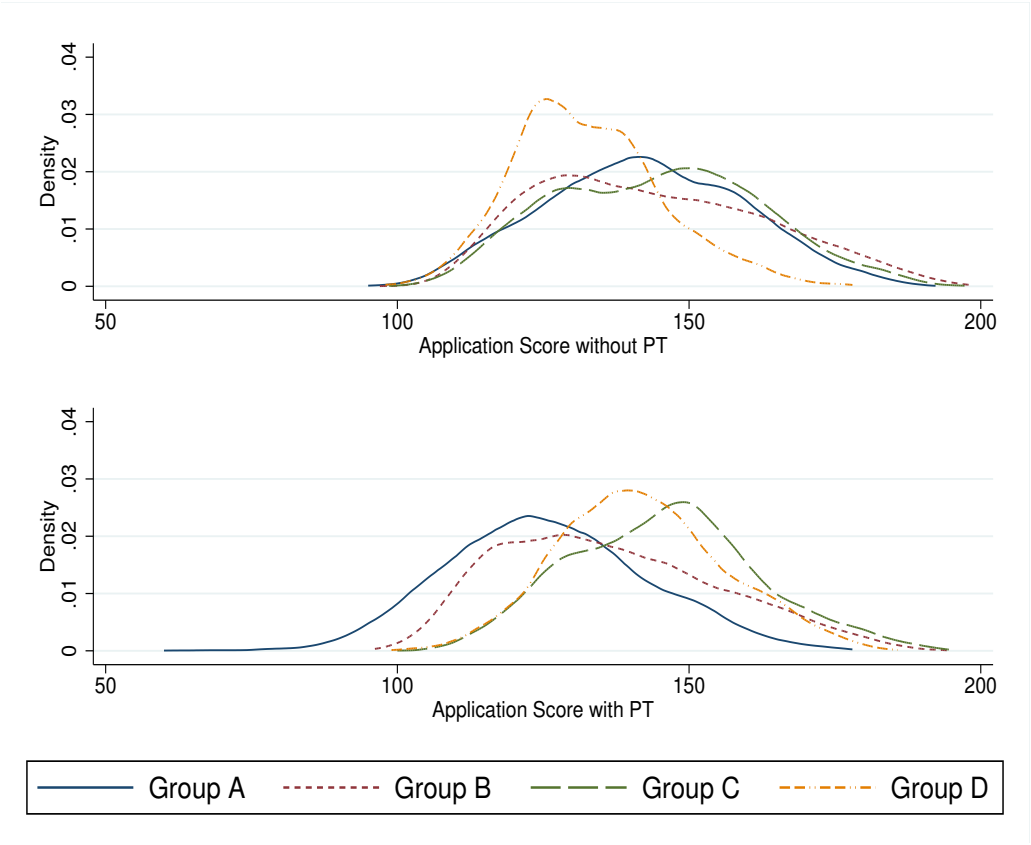


Figure 5: Distribution of application scores by groups - without imputation

$Group_D$ is an indicator equals one if the student's application score without Portuguese is smaller or equal than the threshold. The treatment toggle on whether the student needed her result on the Portuguese exam to gain entry in the HE programme. α_1 is the coefficient of interest. α_1 tell the reader whether the *generalists* (Group D) performed better at university in comparison to the *specialists* (Group A), at the margin of gaining entry in HE. α_2 and α_3 measures differences on students performance when comparing *all-rounders* with *generalists*.

The advantage of comparing students close to the threshold in the distribution of the admission score is that students were admitted to the same programme, and I can observe their outcome. I assume that individuals around the assignment rule are comparable (comparing students that at the margin were admitted only because of the Portuguese exam with the ones for which was not necessary). I run my analysis within 10, 5 and 2 points distance from the threshold.[40]

[40]Table A9 of the appendix provides descriptive statistics for all variables considered in the estimations (according to all constraints imposed in the analysis population).

8.2 Results

I perform my analysis at the margin of gaining entry in HE. All results in this section should be interpreted in that context. I consider three different approaches. Firstly, I look at groups C and D jointly. Secondly, I consider them separately. I run the analysis either considering the division of groups when I use the imputation technique described on section 8.[41]

Tables 14 presents a summary of the different estimations.[42] Similarly to the previous section, I start my analysis by considering the reduced form proposed in equation (12) (columns (1) and (4)). Additionally, in columns (2) and (4) I control for individual characteristics, and in columns (3) and (6) I include programme fixed effects as well. For that reason, the complete estimation is reported in columns (3) and (6). Coefficients in Panel A and C should be interpreted in standard deviation changes like as before.

According to Table 14, I observe differences on students performance regarding group B relatively to group A. In all outcomes and specifications considered I find evidence that *all-rounders* with better field-specific skills perform better than their *specialists* peers at university. For instance, according to column (3), a student in group B would have, on average, an increment of 0.138 standard deviations on her Final GPA when compared to a student of the same ability in group A (within the same programme).

Moreover, I find no evidence that students admitted with the Portuguese exam perform worse than the group of *specialists*. In fact, there is a positive effect of being admitted with Portuguese in terms of Final GPA. The result is pronounced even when I control for individual and programme characteristics. Within programmes, I observe that a student that was admitted with Portuguese obtains 0.077 standard deviations more on her Final GPA on average when compared to a student of the same ability in group A. Although the overall effect of groups C and D is non-significant, it is relevant to distinguish between groups C and D to fully understand whether such effect is driven by one of the two groups jointly considered.

The non-significant effect associated to groups C and D becomes significant when I distinguish between C and D.[43] Thus, the aggregation of the two groups might lead to

[41] Additionally, as a robustness analysis, I also considered the original classification with missing data (see Table A16 of the appendix).

[42] Tables A14 and A15 of the appendix provide a more detailed version, including different distance bands around the threshold.

[43] In Table A17 of the appendix I test the statistical difference between groups C and D.

misleading conclusions. Regarding the number of ECTS by the end of the first year, I observe no difference in performance between group D and group A. Instead, I observe a positive effect associated with group C that becomes non-significant when I introduce programme fixed effects. When I consider completion on time as an outcome the positive effect is driven by group D instead of group C. Finally, in terms of Final GPA seems that all groups outperform group A in all specifications considered.[44]

At the margin of the cutoff, I expect students to have a similar ability, and I would not expect many differences across groups. My results show that differences in performance across groups exist. Firstly, I find no evidence that students admitted purely based on their performance on the Portuguese exam perform worse at university than the others. I do not observe *generalists* (group D) performing any worse than the *specialists* (group A), which is a surprising result.

In turn, I observe consistent differences on performance regarding groups B and C relatively to group A. Students within group B tend to perform better at the end of the first academic year, to have a higher Final GPA (together with group C), and they have a higher probability of completion on time. In other words, I find evidence that *all-rounders* perform better than their *specialists* peers at university. This implies that students that performed sufficiently well in both admission tests perform better at university. Overall, these results suggest that general skills matter at the margin of gaining entry in HE.

[44]In Table A18 of the appendix I consider the Final GPA only for those that completed the degree on time, and in Table A19 of the appendix I consider take into account the possibility of dropout during the programme. My main results remain the same.

Table 14: At the margin of gaining entry in HE

	$0 \leq \tau - \tau^* \leq 10$					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: No. of ECTS by the end of the 1st year (Cohorts 2013/2014 to 2016/2017)						
Groups C and D	0.009	0.016	-0.026			
	(0.014)	(0.014)	(0.016)			
Group D				0.056***	-0.016	-0.009
				(0.018)	(0.018)	(0.018)
Group C				0.060***	0.060***	-0.001
				(0.015)	(0.015)	(0.017)
Group B	0.172***	0.153***	0.138***	0.137***	0.099***	0.036
	(0.024)	(0.023)	(0.024)	(0.021)	(0.021)	(0.022)
Controls	No	Yes	Yes	No	Yes	Yes
Programme FE	No	No	Yes	No	No	Yes
R^2	0.008	0.035	0.062	0.009	0.035	0.058
N	23,750	23,750	23,750	26,594	26,594	26,594
Panel B: Completion on time (Cohorts 2013/2014 to 2014/2015) (Probit - Average Marginal Effects)						
Groups C and D	0.019*	0.006	-0.011			
	(0.010)	(0.010)	(0.011)			
Group D				0.094***	0.034***	0.006
				(0.012)	(0.012)	(0.012)
Group C				0.020**	0.014	0.005
				(0.010)	(0.010)	(0.011)
Group B	0.104***	0.069***	0.067***	0.064***	0.024	0.037**
	(0.018)	(0.018)	(0.018)	(0.015)	(0.015)	(0.015)
Controls	No	Yes	Yes	No	Yes	Yes
Programme FE	No	No	Yes	No	No	Yes
Pseudo R^2	0.018	0.064	0.169	0.019	0.064	0.166
N	11,431	11,431	11,055	12,976	12,976	12,621
Panel C: Final GPA (Cohorts 2013/2014 to 2014/2015)						
Groups C and D	0.146***	0.138***	0.077**			
	(0.026)	(0.026)	(0.030)			
Group D				0.171***	0.127***	0.126***
				(0.032)	(0.032)	(0.034)
Group C				0.154***	0.152***	0.063*
				(0.027)	(0.027)	(0.034)
Group B	0.223***	0.194***	0.138***	0.192***	0.157***	0.089**
	(0.042)	(0.042)	(0.045)	(0.037)	(0.037)	(0.041)
Controls	No	Yes	Yes	No	Yes	Yes
Programme FE	No	No	Yes	No	No	Yes
R^2	0.023	0.039	0.097	0.027	0.043	0.093
N	6,174	6,174	6,174	6,837	6,837	6,837

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. Control variables: Female, High School Score, and Non Local Student. All regressions include cohort and preferences FE. A more detailed version is provided in Tables A14 and A15 of the appendix, where I also consider a distance of five points from the threshold.

8.3 Discussion and mechanisms

Universities that allow for Portuguese as an alternative requirement benefit at the margin of admission. Students that perform better in general skill exams perform no worse at university than their specialist peers. Alternatively, there is some evidence suggesting that students with a sufficiently high score in the Portuguese exam perform better at university, even when they did not need the general skills exam to gain entry in HE. As a result, the inclusion of a general skill test as an admission criterion can have a positive effect on student performance at the margin of admission.

The evidence suggests that all groups performed better relative to the *specialists* group in terms of Final GPA. However, that effect is less pronounced when I look at completion on time and at the number of ECTS by the end of the first year. Differences across groups vary according to the type of measure I consider. Namely, at the beginning of the programme differences are less pronounced rather than towards the end.[45] I interpret that result from two perspectives.

Final GPA includes all course scores while ECTS only measure the number of credits accumulated, independently of the scores. *Specialists* might have a head start, but they do not capitalize on that advantage. Students with better general skills do not substantially outperform the *specialist* group by the end of the first year. On average, both groups have the same quantity of ECTS accumulated within the same programme. Even so, *generalists* outperform *specialists* when I consider the final GPA as outcome. To a certain extent, this signals that *generalists* are able to adapt to changes. Students with different skills need time to adapt.

Additionally, I can also infer that the specialist exam may not be well designed. This result assumes particular relevance in a centralized admission system that emphases the importance of field-specific skills. Throughout the paper, I made the assumption that the field-specific exam provides a good measure of specialists skills. However, in the light of my results, I can hypothesise that the specialist exam is not very accurate at checking the field-specific skills required. In fact, by the end of the programme students within the *specialists* group obtain a worse Final GPA on average. The field-specific exam seems not to match the skills needed to obtain a good performance in the degree.

[45]Even when I consider the final GPA only for those that finished on time (see Table A18 of the appendix) I observe a positive difference on performance regarding groups D and B relatively to A.

Nevertheless, my empirical analysis only considers programmes that already allow for Portuguese as an alternative requirement. A sceptic reader might argue that such a policy has different impacts according to the goal and type of institution. For instance, in less well-regarded programmes, often the goal is to admit as many students as possible. They have an incentive to allow for as many exam combinations as possible in order to fill the number of vacancies. Opening the application process to all type of students might be perceived in different ways. Allowing for different alternative entry requirements can be perceived as a sign of being a less rewarded programme. Students that perceive themselves as high ability students might not apply to those programmes.[46]

I acknowledge that the type of institution can potentially drive my results.[47] My results might not be verified for elite institutions. Nevertheless, the reader should keep in mind that those institutions are able to select the top distribution of students, even with only one admission criterion. Regardless of the nature of the admission exams, there is always a high demand for programmes in elite institutions. I still believe that my results are relevant for the average institution, which represents the majority of the HE system.

Additionally, the reader might ask herself whether my results would depend on the field of study. Even controlling for differences across fields, my main results remain the same. The access to some fields might be more restricted than others and may affect students' choices (see, Hastings et al., 2013; Kirkeboen et al., 2016). My results might be driven by the type of field that allows more often for Portuguese as an alternative admission requirement. Therefore, the distribution of students across different fields of study is relevant to understand my results.[48] In the sub-population of analysis, I observe very few Natural Sciences programmes. My results might be misinterpreted that universities should be asking all Physics, Maths, or Engineering students to do Portuguese, while my empirical analysis does not allow me to conclude that.[49]

[46]Figure A8 of the appendix, shows which type of programmes allow for Portuguese and how students are distributed between them. Additionally, Figure A9 presents students' distribution by programme in terms of ability.

[47]An alternative approach would have been to perform a general equilibrium analysis where I contemplate the scenario of all institutions allowing for the Portuguese exam as an alternative entry requirement. However, in that scenario, students could have performed differently in the Portuguese exam. Students might have allocated more effort to the Portuguese exam if they knew that such an exam would have been a valid admission criterion for all programmes.

[48]Figure A10 of the appendix show how students are distributed according to fields.

[49]Nevertheless, my model is applicable to all fields, and the optimal choice of λ is not zero. How far λ is from zero depends on other factors, such as the precision of the field-specific exam. Thus, if one believes that for natural sciences the field-specific test is relatively more precise than in fields such as sociology or economics for instance, then my model predicts that for some fields λ is closer to zero in comparison

9 Conclusion

Intended and unintended consequences of university admission practices have been under the spotlight of the academic, political, and judicial agendas.[50] I contribute to that debate by analysing the nature of the admission requirements. I test whether the inclusion of a general admission exam generates a better pool of admitted students.

In this paper, my first contribution is theoretical. I set up a model in which the university faces a particular trade-off when deciding to combine a general admission requirement with a field-specific exam. The university gains information about the student's ability at the cost of reducing the weight allocated to the field-specific requirement. As a result, in equilibrium, the student would decrease the effort level in the productive test (the field-specific exam). Nevertheless, I find that the university benefits from including a general admission test on its requirements.

My second contribution is the provision of an empirical application of the model using Portugal as a case study. I find evidence that including a general exam as an entry requirement increases the average student performance at university, at the margin of admission to HE. This is a surprising result that has not been a consistent finding in the literature.

I find that in the first academic year the *generalists* tend to fail more when compared to the *specialists*, while towards the end of the programme they have a better performance on average. In order words, the *generalists* group outperform the *specialists*. This result has two possible interpretations.

First, universities that allow for general admission requirements should not put too much weight on first year assessment. Albeit the fact that performance in the first-year is often considered as a good proxy to evaluate who the good students are, the *generalists* group need time to adapt in order to obtain a better performance.

Secondly, my results show that the field-specific exam may not be well designed in some fields. Students admitted purely based on their field-specific skills perform worse at university. That means that the field-specific exam is not accurate at checking the specialists' skills needed to complete the degree.

to other fields.

[50] For instance, in the US there is an ongoing discussion about this topic with centre on the affirmative action exerted by some Ivy League universities (e.g., Card and Krueger, 2005; Arcidiacono et al., 2011; Calsamiglia et al., 2013; Arcidiacono and Lovenheim, 2016).

My findings have substantial implications for the determination of university selection policies. Universities should rethink their admission practices by either designing admission tests that evaluate field-specific skills more accurately or by introducing general admission requirements in order to effectively distinguish their candidates. In short, diversity in admission criteria has a positive effect on student performance at university.

My results offer an optimistic view of the possibility to affect the pool of admitted students at university. Even though I focus on the Portuguese system, this paper provides generalizable insights about the importance of the choice of admission criteria.

Finally, this paper poses some interesting questions that are worthwhile to explore in future research. I have shown that the general admission exam has an important role to play on university admission practices. However, this paper does not provide an answer to what should be the optimal weight to allocate to that exam. Additionally, there might be some unintended consequences of increasing the weight associated with the general exam. For instance, by introducing a general admission exam, the university may change the gender composition of the admitted pool of students and/or it can also change the way students rank their preferences when applying to HE. In sum, these possibilities open scope to future research.

Appendix of Chapter 2

A1 Appendix: Model Derivations

A1.1 Proof of Proposition 1

In a pure strategy Nash Equilibrium all students exert the same level of effort, which means that $\mathbf{e} = (e_1, e_2) = (e_1^*, e_2^*) = \mathbf{e}^*$. In order to derive the optimal expressions of (e_1^*, e_2^*) I divide this proof into four parts: i) derivation of $Prob(T_1 + \lambda T_2 \geq \tau^*)$; ii) define τ^* as a function of $\mathbf{e}^*$; iii) FOC; iv) SOC v) Corner Solution.

1. **Convolution of probability distributions**

   In order to solve the student maximization problem I need to derive the probability of getting into university, $\Pi = Prob(T_1 + \lambda T_2 \geq \tau^* = Prob(\epsilon_1 + \lambda\epsilon_2 \geq \tau^* - (1 + \lambda)\overline{\alpha} - e_1 - \lambda e_2)$. Let f denote the density function of $z = \epsilon_1 + \lambda\epsilon_2$. Knowing that ϵ_1 and ϵ_2 follow uniform distributions $[0, a]$ and $[0, 1]$, respectively, $f(\epsilon_1 + \lambda\epsilon_2)$ is represented as follows in Figure A1.[51] (see appendix A1.2 for the full derivation of the joint distribution of the two errors and its median point).

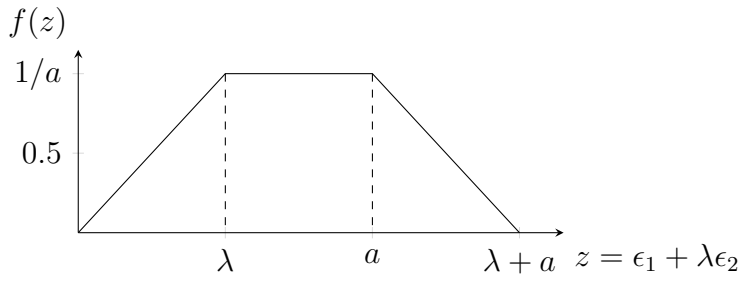


Figure A1: Density function of combined scores from two tests

2. **Threshold**

   The solution to the student's problem depends on τ^*. τ^* is the admission score of the last student being admitted to the university, and in my model is the median of the student's test scores distribution. τ^* depends on the admission test effort of the other students, $\mathbf{e}^*$, which implies that

$$\tau^*(\mathbf{e}^*) = (1 + \lambda)\overline{\alpha} + e_1^* + \lambda e_2^* + \frac{a + \lambda}{2}. \tag{A1}$$

[51] In Figure A1 I assume $\lambda > a$ but if I consider that $\lambda < a$ the density representation would be the same. λ and a would be in swapped positions on the horizontal axis

3. **FOC**

The FOC of the student's problem w.r.t (e_1, e_2) are

$$v\overline{\alpha}f(\tau^* - (1+\lambda)\overline{\alpha} - e_1 - \lambda e_2) = \frac{\partial C}{\partial e_1} - 1$$
$$\lambda v\overline{\alpha}f(\tau^* - (1+\lambda)\overline{\alpha} - e_1 - \lambda e_2) = \frac{\partial C}{\partial e_2}.$$

I can replace τ^* by the expression derived in part (2) of this proof, and in equilibrium I have that $e_1 = e_1^*$ and $e_2 = e_2^*$. Hence, the FOC simplify as follow

$$v\overline{\alpha}f(\frac{a+\lambda}{2}) = \frac{\partial C}{\partial e_1} - 1 \tag{A2}$$
$$\lambda v\overline{\alpha}f(\frac{a+\lambda}{2}) = \frac{\partial C}{\partial e_2}.$$

In order to find an explicit expression of (e_1, e_2) I need to replace the derivatives of the cost function and substitute $f(\frac{a+\lambda}{2})$ by $\frac{1}{a}$. As a result,

$$e_1 = e_1^* = \frac{v\overline{\alpha}}{a(1-\delta^2)}(1-\lambda\delta) + \frac{1}{1-\delta^2} \tag{A3}$$
$$e_2 = e_2^* = \frac{v\overline{\alpha}}{a(1-\delta^2)}(\lambda-\delta) - \frac{\delta}{1-\delta^2}.$$

4. **SOC**

By considering the Hessian matrix, $H^f_{(e_1,e_2)} = \begin{pmatrix} -\frac{\partial^2 C}{\partial e_1^2} & -\frac{\partial^2 C}{\partial e_1 \partial e_2} \\ -\frac{\partial^2 C}{\partial e_2 \partial e_1} & -\frac{\partial^2 C}{\partial e_{2j}^2} \end{pmatrix} = \begin{pmatrix} -1 & -\delta \\ -\delta & -1 \end{pmatrix}$, I conclude that $det(H_1) = -1 < 0$ and $det(H_2) = 1 - \delta^2 > 0$ which means that H is negative definite and (e_1, e_2) is a local maximum.

5. **Corner Solution**

Finally, the explicit expression of (e_1, e_2) stated on the previous point is feasible when $e_1, e_2 > 0$. Which is true for $\frac{\lambda}{\delta} > \hat{\lambda}$, with $\hat{\lambda} = 1 + \frac{a}{v\overline{\alpha}}$. For small λ, optimal $e_2^* = 0$ and optimal e_1 is found from the FOC for e_1. Thus, for $\frac{\lambda}{\delta} < \hat{\lambda}$ the solution is $\mathbf{e}^* = (\frac{v}{a}\overline{\alpha} + 1, 0)$ with $\lambda = 0$, provided that $a > 1 - \alpha_L$ (for $a < 1 - \alpha_L$ the previous reasoning does not apply).[52]

[52]When $a \to 0$ I have that $e_{1j} \to \infty$ and the student should not exert effort in the second test,$e_2 = 0$. With $a = 0$ the test becomes an all pay auction (Lazear and Rosen, 1981) and there is no equilibrium in pure strategies.

A1.2 Convolution of the errors

Consider $Z = \epsilon_1 + \lambda\epsilon_2$ where $\epsilon_1 \sim U[0,a]$, with $0 < a < 1$ and $\epsilon_2 \sim U[0,1]$. This means that the corresponding density functions are $h(\epsilon_1) = \begin{cases} 1/a, & \text{if } 0 < \epsilon_1 \leq a \\ 0, & \text{otherwise} \end{cases}$ and

$g(\lambda\epsilon_2) = \begin{cases} 1/\lambda, & \text{if } 0 < \epsilon_2 \leq \lambda \\ 0, & \text{otherwise} \end{cases}$

Given that $0 < Z < a + \lambda$ I have that $f(z) = 0$ for $z < 0$ and $z > a\ + \lambda$

Outside of the previous range of z I can take the convolution of the two random independent variables:

$$f(z) = \int_{-\infty}^{+\infty} h(z - \lambda\epsilon_2)g(\lambda\epsilon_2)d\epsilon_2 = \int_0^1 h(z - \lambda\epsilon_2)d\epsilon_2$$

I need to consider 3 cases: (i) $0 \leq z \leq \lambda$; (ii) $\lambda < z \leq a$ and (iii) $a < z \leq \lambda + a$

For $0 \leq z \leq \lambda$

$$f(z) = \int_0^z 1.\frac{1}{a\lambda}d\epsilon_2 = \frac{z}{a\lambda}$$

For $\lambda < z \leq a$

$$f(z) = \int_0^\lambda 1.\frac{1}{a\lambda}d\epsilon_2 = \frac{\lambda}{a\lambda} = \frac{1}{a}$$

For $a < z \leq \lambda + a$

$$f(z) = \int_{z-\lambda}^a 1.\frac{1}{a\lambda}d\epsilon_2 = \frac{1}{\lambda} + \frac{1}{a} - \frac{z}{a\lambda}$$

Then

(A4)
$$f(z) = \begin{cases} \frac{z}{a\lambda}, & \text{if } 0 \leq z \leq \lambda \\ 1/a, & \text{if } \lambda < z \leq a \\ \frac{1}{\lambda} + \frac{1}{a} - \frac{z}{a\lambda}, & \text{if } a < z \leq \lambda + a \end{cases}$$

Equation (A4) is represented in Figure A1. Given that $E[\epsilon_1] = a/2$ and $E[\epsilon_2] = 1/2$,

the median of the distribution is $\frac{a+\lambda}{2}$. By choosing the middle point the university is able to capture half of the student population.

A1.3 Derivation of Lemma 1

In equilibrium, I can think on each admission test as a monotonic transformation of the noise term (effort and ability levels are fixed in equilibrium).[53] To determine the measure of admitted students I focus on the uniform distribution of the error terms (ϵ_1, ϵ_2) associated to the admission tests, as presented in the figure below.

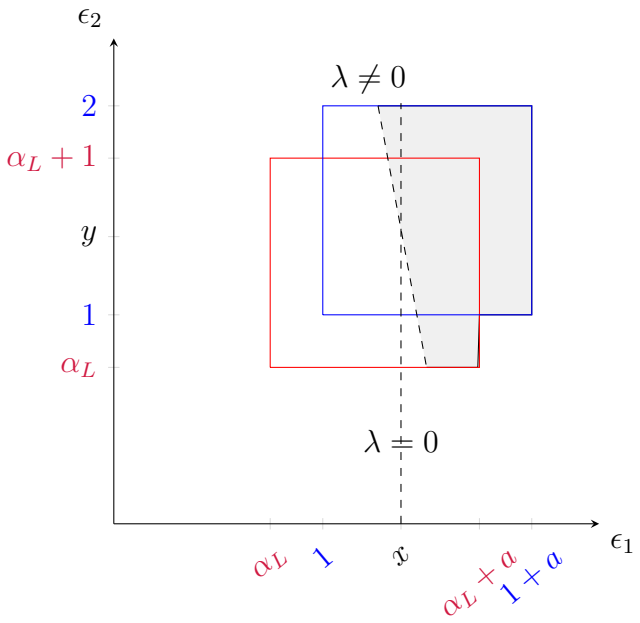


Figure A2: Error terms distribution

where the dotted line labelled $\lambda \neq 0$ is given by the following expression:

$$\epsilon_2 = k - \frac{\epsilon_1}{\lambda} \tag{A5}$$

The line represents the test scores, T_1 and T_2, such that the combined test score

[53] In Figure 2 I plotted the distribution of the two tests according to the two levels of ability. When λ increases slightly, there is a rotation of the vertical line. However, the two student's distribution rectangles also change positions. Namely, they move in the Northwest direction (for $\lambda > \delta\hat{\lambda}$)). Firstly they move to the west direction (given that $\frac{\partial e_1^*}{\partial \lambda} < 0$) and thereafter ($\lambda > \delta\hat{\lambda}$) to the north direction (given that $\frac{\partial e_2^*}{\partial \lambda} > 0$). In both cases what matters to determine the number of admitted students is the slope of the line (λ) of Figure 2 and not the movement of the rectangles.

$T_1 + \lambda T_2$ is constant. I define $M = (x, y)$ as the center through which the vertical line rotates when λ increases slightly. With $a = 1$ I have that $(x, y) = (\frac{\alpha_L}{2} + 1, \frac{\alpha_L}{2} + 1)$ (two exact squares). With $a \neq 1$ I need to impose that $(1 + a - x) \times 1 + (\alpha_L + a - x) \times 1 = a$ which implies that $(x, y) = (\frac{\alpha_L}{2} + \frac{a+1}{2}, \frac{\alpha_L}{2} + 1)$.

Graphical definition of $\tilde{\lambda}$

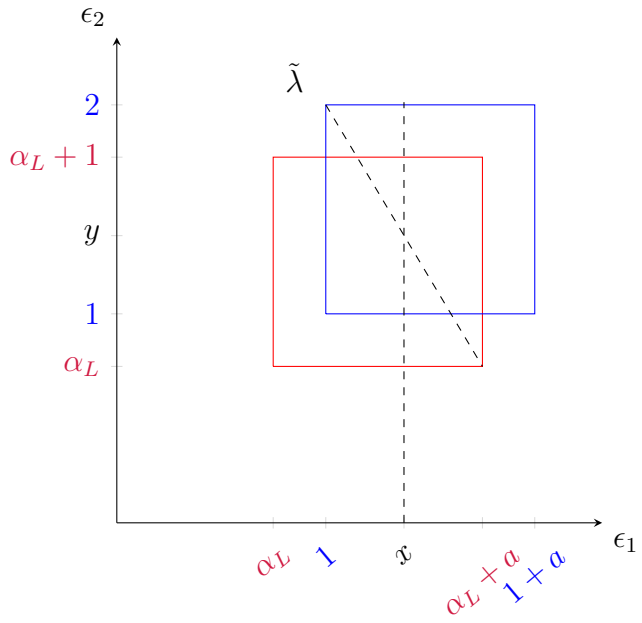


Figure A3: Definition of $\tilde{\lambda}$

where $\tilde{\lambda} = \frac{a+\alpha_L-1}{2-\alpha_L}$

For $\lambda \leq \tilde{\lambda}$

In order to find (n_H, n_L) I determine k, I impose that $\frac{\partial n_H}{\partial \lambda} = -\frac{\partial n_L}{\partial \lambda}$ and finally I replace k as a function of the parameters.

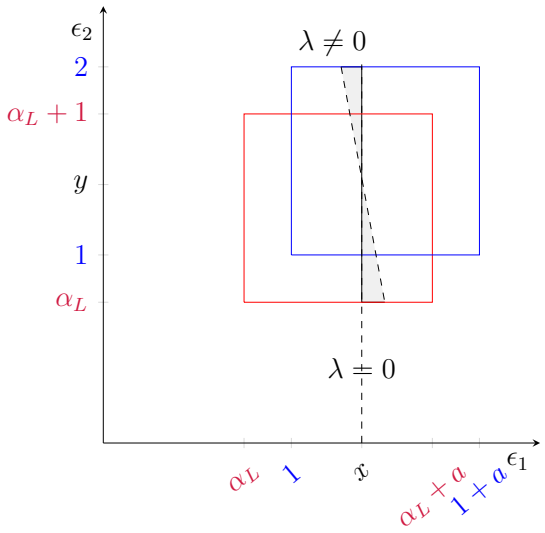


Figure A4: Variation on the number of admitted students for $0 < \lambda < \tilde{\lambda}$.

1st step: Determining k such as $n_H + n_L = a$.

When λ increases slightly $n_H = 1 + a - \lambda(k-1) + \frac{\lambda}{2}$ and $n_L = \alpha_L + a - \lambda(k - \alpha_L) + \frac{\lambda}{2}$. Thus, by imposing that $n_H + n_L = a$ I obtain that $k^* = \frac{1+a+\alpha_L}{2\lambda} + 1 + \frac{\alpha_L}{2}$.

2nd step: Verifying that the two triangles of Figures A4 are equal.

Namely, $[x - \lambda(k-2)][2-y]/2 = [y - \alpha_L][\lambda(k - \alpha_L) - x]/2 \Leftrightarrow k^* = \frac{1+a+\alpha_L}{2\lambda} + 1 + \frac{\alpha_L}{2}$

3rd step: Replace k by k^* on (n_H, n_L). As a result, I obtain that $n_H = \frac{1+a-\alpha_L}{2} + \frac{\lambda}{2}(1 - \alpha_L)$ and $n_L = \frac{a+\alpha_L-1}{2} + \frac{\lambda}{2}(\alpha_L - 1)$.

For $\tilde{\lambda} < \lambda < 1$

The procedure is very similar to the previous one. The difference is that now I am dealing with trapezes instead of triangles (see Figure A5).

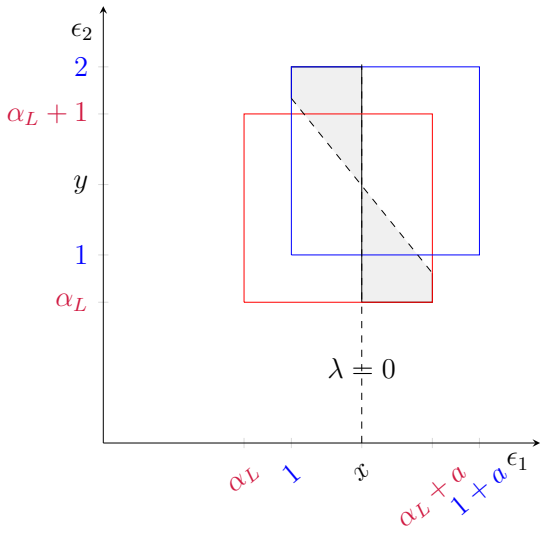


Figure A5: Variation on the admitted students for $\tilde{\lambda} < \lambda < 1$.

Again, by imposing that the two shadow areas in Figure A5 must be equal I would obtain k^*, namely,

$$(2-1-\frac{\alpha_L}{2}+2-k+\frac{1}{\lambda})\times(\frac{a+\alpha_L-1}{2})/2 = (1+\frac{\alpha_L}{2}-\alpha_L+k-\frac{\alpha_L+a}{\lambda}-\alpha_L)\times(\frac{a+\alpha_L-1}{2})/2 \Leftrightarrow$$

$$\Leftrightarrow k^* = 1 + \frac{\alpha_L}{2} + \frac{a+1+\alpha_L}{2\lambda}$$

I replace k by k^* on (n_H, n_L) and I obtain that:

$$n_H = a - \lambda\frac{\alpha_L^2}{8} - \frac{\alpha_L}{4}(a+\alpha_L-1) - \frac{(a+\alpha_L-1)^2}{8\lambda}$$

$$n_L = \lambda\frac{\alpha_L^2}{8} + \frac{\alpha_L}{4}(a+\alpha_L-1) + \frac{(a+\alpha_L-1)^2}{8\lambda}$$

Summary

Finally, I need to adjust n_H and n_L by $\frac{1}{a}$. As a result, I have that:

Table A1: Measure of admitted students

λ	$\frac{\partial n_H}{\partial \lambda}$	High Ability Students	Low Ability Students
$0 < \lambda \leq \tilde{\lambda}$	> 0	$[\frac{1+a-\alpha_L}{2} + \frac{\lambda}{2}(1-\alpha_L)]\frac{1}{2a}$	$[\frac{a+\alpha_L-1}{2} + \frac{\lambda}{2}(\alpha_L-1)]\frac{1}{2a}$
$\tilde{\lambda} < \lambda \leq 1$	$>< 0$	$[a - \lambda\frac{\alpha_L^2}{8} - \frac{\alpha_L}{4}(a+\alpha_L-1) - \frac{(a+\alpha_L-1)^2}{8\lambda}]\frac{1}{2a}$	$[\lambda\frac{\alpha_L^2}{8} + \frac{\alpha_L}{4}(a+\alpha_L-1) + \frac{(a+\alpha_L-1)^2}{8\lambda}]\frac{1}{2a}$

Notes: $\tilde{\lambda} = \frac{a+\alpha_L-1}{2-\alpha_L}$.

A1.4 Proof of Theorem 2

The social planner payoff function is a continuous function on λ, and a differentiable function on its domain except at $\delta\hat{\lambda}$ and $\tilde{\lambda}$. For that interval, the first order derivative of the social planner payoff function w.r.t. λ is:

$$\frac{\partial \pi_S}{\partial \lambda} = v(\alpha_H - \alpha_L)\frac{\partial n_H}{\partial \lambda} + \frac{\partial e_1^*}{\partial \lambda} - \frac{\partial C}{\partial e_1}\frac{\partial e_1^*}{\partial \lambda} - \frac{\partial C}{\partial e_2}\frac{\partial e_{2j}^*}{\partial \lambda} \tag{A6}$$

For $\lambda \in]0, min\{\delta\hat{\lambda}, \tilde{\lambda}\}[$ I have $\frac{\partial e_1^*}{\partial \lambda} = 0$ and $\frac{\partial n_H}{\partial \lambda} > 0$ which implies $\frac{\partial \pi_S}{\partial \lambda} > 0$.

A1.5 Proof of Theorem 3

The solutions of the university and social planner problems can be either an interior solutions(which satisfies the FOCs) or a corner solution (namely, $\delta\hat{\lambda}$ or $\tilde{\lambda}$). In this proof I do not determine the exact solution. I want to verify whether the solution of both problems exists and obtain that $\lambda_S^* \leq \lambda_U^*$.

I start the proof by computing the first derivatives of both maximization problems. Namely,

$$\frac{\partial \pi_U}{\partial \lambda} = \gamma(\alpha_H - \alpha_L)\frac{\partial n_H}{\partial \lambda} + \frac{N}{2}\frac{\partial e_1^*}{\partial \lambda} \tag{A7}$$

$$\frac{\partial \pi_S}{\partial \lambda} = v(\alpha_H - \alpha_L)\frac{\partial n_H}{\partial \lambda} + \frac{\partial e_1^*}{\partial \lambda} - \frac{\partial C}{\partial e_{1j}}\frac{\partial e_1^*}{\partial \lambda} - \frac{\partial C}{\partial e_{2j}}\frac{\partial e_2^*}{\partial \lambda} \tag{A8}$$

If $\lambda < \delta\hat{\lambda}$ I have that $\frac{\partial \pi_U}{\partial \lambda} = \gamma(\alpha_H - \alpha_L)\frac{\partial n_H}{\partial \lambda}$ and $\frac{\partial \pi_S}{\partial \lambda} = v(\alpha_H - \alpha_L)\frac{\partial n_H}{\partial \lambda}$. The solution cannot be on $]0, \delta\hat{\lambda}[$, since $\frac{\partial \pi_U}{\partial \lambda} > 0$ on this interval. The solution can only be at $\lambda_S^* = \lambda_U^*$.

Alternatively, if $\lambda > \delta\hat{\lambda}$ I have that:[54]

$$\frac{\partial \pi_S}{\partial \lambda} = \frac{\partial \pi_U}{\partial \lambda} - \underbrace{[\beta(\alpha_H - \alpha_L) + \frac{dC}{d\lambda} - \frac{1}{2}\frac{\partial e_{1j}^*}{\partial \lambda}]}_{>0} \tag{A9}$$

Consider that λ_U^* exists and satisfies the FOC $\frac{\partial \pi_U}{\partial \lambda}(\lambda_U^*) = 0$. Thus, $\frac{\partial \pi_S}{\partial \lambda}(\lambda_U^*) < 0$ which implies that $\lambda_S^* < \lambda_U^*$.

If $\lambda_U^* = \delta\hat{\lambda}$ or $\lambda_U^* = \tilde{\lambda}$, then the solution of the social planner problem would be exactly the same and $\lambda_S^* = \lambda_U^*$.

Thus, I always will have that $\lambda_S^* \leq \lambda_U^*$.

A1.6 Disagreement on λ

Consider the following example where the university would like to consider a weight for λ higher than the one desired by the government. Parameter values assumed in this example are shown in Table A2 and the corresponding payoff functions in the figures below.

Table A2: Parameter Values of Example 1

Parameter	Value
v	40
γ	40.5
a	0.85
α_L	0.5
α_H	1
δ	0.1
N	1000
Kink points of the payoff function	Value
$\delta\hat{\lambda}$	0.1028
$\tilde{\lambda}$	0.2333

[54]For $\lambda > \delta\hat{\lambda}$ I have that $\frac{dC}{d\lambda} = (e_1 + \delta e_2)\frac{\partial e_1^*}{\partial \lambda} + (e_2 + \delta e_1)\frac{\partial e_2^*}{\partial \lambda}) = \frac{v\overline{\alpha}}{a(1-\delta^2)}e_2(1-\delta^2) > 0$

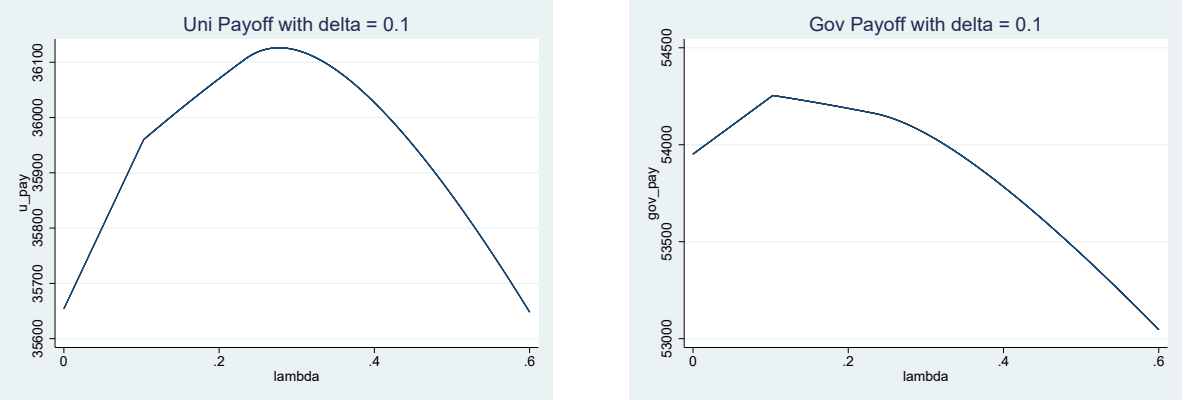


Figure A6: University and Government Payoffs

In this example, university optimal λ is approximately 0.3, and the government's optimal λ is 0.1. The social planner and the university disagree on λ.

A2 Appendix: Datasets

Table A3: Summary of original variables in the Application dataset

Unit	Variable
Programme (Degree x University)	
	Academic year
	Vacancies
	Number of allocated students
	Number of enrolled students
	Admission score threshold
	Scientific area (CNAEF)
Candidate	
Personal Characteristics	Gender
	Date of Birth
Previous Achievement	High school track
	High school course
	High school score
Application Process	Academic year
	Preferences
	Admission exams and scores (for each preference)
Placement	HEI (faculty or university)
	Institution type
	Degree
	Admission score
	Entrance exams and scores
	Preference of placement
	Geographic office of application (GAES)
	Status
	Excluded (reason)
	Type of application
	Enrolment (yes or no)
	Remained enrolled after one year (yes or no)

Source: (DGES, 2019b)

Table A4: Summary of original variables in the Performance dataset

Unit	Variables
Programme (Degree x University)	
	Academic year
	Scientific area (international, CISCED97)
	Scientific area (national, CNAEF)
	Institution type
	Geographic location
Student	
Personal Characteristics	Gender
	Age
Placement	Academic year
	Programme (Institution and degree)
	Admission score
	Preference of placement
	1st enrolment (yes or no)
	Programme transference (yes or nor)
Previous Achievement	Previous university (if applicable)
	High school track
	High school course
	High school score
Socie-conomic Background	Parents education
	Parents job occupation
	Parents job status
	Student job status
	Maintenance grant (applicants and admitted)
Mobility	Home location during high school
	Displaced student (yes or no)
	Exchange programme (type, duration, degree and country)
Performance	ECTS enrolled
	ECTS accumulated

Source: (DGEEC, 2019)

Table A5: Summary of original variables in the Graduation dataset

Unit	Variables
Programme (Degree x University)	
	Scientific area (international, CISCED97)
	Scientific area (national, CNAEF)
	Institution type
	Geographic location
Student	
Personal Characteristics	Gender
	Age
Placement	Programme (Institution and degree)
Graduation	Final GPA
	Degree type
	Diploma type
	Date of graduation

Source: (DGEEC, 2019)

Table A6: Broad Fields of Study

Code	Field	REF (UK)
1	Science: biology; chemistry; computer science; mathematics; physics	B
2	Business: administration; accounting; business studies	C
3	Social science: sociology; political science; anthropology; economics; psychology	C
4	Teaching: kindergarten teacher; school teacher	D
5	Humanities: history; philosophy; languages; media	D
6	Health: nursing; social work; physical therapy	A
7	Engineering (BSc): electrical; construction; mechanical; computer	B
8	Technology: MSc engineering; biotechnology; information technology	C
9	Law: law	A
10	Medicine: medicine; dentistry; pharmacology	A
11	Agriculture: agriculture veterinary science; forestry and fishing	A
12	Services: tourism; hotels and restaurants; sports	C
13	Unspecified	-

Note: Adapted from Kirkeboen et al. (2016). REF Categories: A) Medicine, Health and Life Sciences; B) Physical Sciences, Engineering and Maths; C) Social Sciences; D) Arts and Humanities

Table A7: Diploma types

Degree classification	(code)	Diploma type (in PT)	Translation
Bachelor	(PL)	Preparatórios de licenciatura 1.º ciclo	Bachelor preparatory programmes 1st cycle
	(PM)	Preparatórios de mestrado integrado	Integrated master preparatory programmes
	(L1)	Licenciatura 1.º ciclo	Bachelor 1st cycle
	(L)	Licenciatura	Bachelor
Integrated master	(MI)	Mestrado integrado	Integrated master
	(MT)	Mestrado integrado terminal	Terminal integrated master
Master	(M2)	Mestrado 2.º ciclo	Master 2nd cycle
	(M)	Mestrado	Master
PhD	(D3)	Doutoramento 3.º ciclo	PhD 3rd cycle
	(D)	Doutoramento	PhD
Other - 1st Cicle	(T)	Curso técnico superior profissional	Professional higher technical courses
	(CF)	Complemento de formação	Complementary course
	(C0)	Curso de especialização tecnologica	Technological specialization course
Others - 2nd Cicle	(E)	Especialização pós-licenciatura	Pos-bachelor specialization
	(GB)	Especialização pós-bacharelato	Pos-master specialization

Source: (DGEEC, 2019). Notes: Aggregation made by the author.

Table A8: Descriptive Statistics, Analysis Population, **Linked Dataset**

	Mean	Std. Dev.
A. Data Structure		
Initial year	2013/2014	
Final year	2017/2018	
Nb. year	5	
Nb. Individuals	205,297	
B. Individuals		
Age	18.42	1.71
Female (share)	.57	
High school GPA	149.46	20.05
Public high school (share)	.84	
Non-local student (share)	.30	
Mother has HE (share)	.33	
Father has HE (share)	.26	
Applied to a maintenance grant (share)	.32	
Received a maintenance grant (share)	.25	
C. Placement		
Degree of placement (nb. individuals)		
Bachelor	166,741	
Integrated Master	38,556	
Preferences of placement (share)		
1st	.56	
2nd	.21	
3rd	.11	
4th	.06	
5th	.04	
6th	.02	
Application score (0-200)	144.72	20.13
Nb. of admission exams	1.37	0.55
Portuguese admission exam (share)	.22	
Portuguese exam score (0-200)	121.66	28.21
Nb. of programmes ranked	4.79	1.58
Nb. of Institutions ranked	2.85	1.46
Nb. of broad fields ranked	2.02	0.99

Source: Author's calculations. Notes: Scores are measured in a scale between 0 and 200.

Table A9: Analysis dataset according to all contraints[(a)]

Interval Band	A. Difference on Skills $\lvert\tau_{PT} - \tau_{\sim PT}\rvert \leq 10$						B. Analysis by groups $0 \leq \tau - \tau^* \leq 10$					
Outcomes	ECTS		Completion on Time		Final GPA		ECTS		Completion on Time		Final GPA	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Nb. Individuals	11,072		4,500		2,891		26,594		12,976		6,837	
Female (share)	.69		.66		.74		.66		.62		.71	
High school score (0-200)	145.23	17.86	143.73	16.74	147.27	16.54	141.30	16.61	139.39	15.49	142.90	15.34
Non-local student (share)	.32		.31		.32		.32		.31		.32	
Preferences of placement (share)												
1st	0.52		0.49		0.55		0.50		0.49		0.53	
2nd	0.21		0.23		0.22		0.23		0.24		0.24	
3rd	0.13		0.14		0.12		0.13		0.13		0.12	
4th	0.07		0.07		0.06		0.07		0.07		0.06	
5th	0.04		0.04		0.03		0.04		0.04		0.03	
6th	0.03		0.03		0.02		0.02		0.02		0.02	
Application score (0-200)	139.93	20.05	137.79	17.41	140.65	16.58	137.37	16.31	134.26	14.99	137.12	14.76
Portuguese admission exam (share)	.29		.24		.27		0.54		0.55		0.56	
Portuguese exam score (0-200)	122.65	24.51	119.51	23.47	121.86	23.84	119.27	24.96	115.67	23.91	118.20	23.74

Notes: (a) I only consider: i) programmes that allow for PT as an optional requirement; ii) individuals for which I observe the outcome; and iii) individuals for which I was able to compute the counterfactual score (in the case of the panel regarding "Difference on Skills").

A3 Appendix: Groups Identification

A3.1 Example with observed partial scores

Consider again the Pedro and Alexandre's example. Imagine that both brothers were admitted to the same programme. The university allows the candidates to apply with the Mathematics exam score only or with the combination of the Economics and Portuguese exam scores (see Table A10).

Table A10: Observed partial scores

	Exams' scores			Actual	Application score	Application score
	Mathematics	Economics	Portuguese	admission score	without PT	with PT
Pedro	170	150	110	170		110
Alexandre	n.a.	170	200	185	n.a.	

Note: Assume Pedro and Alexandre were admitted to the same programme. The university allows the students to apply with the Mathematics exam score only or with the combination of the Economics and Portuguese exam scores. Alexandre was admitted with the Portuguese exam and Pedro without it.

In the case of Alexandre, the application score without Portuguese should be the Mathematics exam scores. Since I do not observe the Mathematics score, I consider the score of Economics as the combination itself, $\tau_{\sim PT}^{Alexandre} = 170$.

A3.2 Missing at random

Table A11: Group classification missing at random

	Total Sample		$\tau - \tau^* \leq 10$		$\tau - \tau^* \leq 5$	
	(1)	(2)	(3)	(4)	(5)	(6)
Outcome: Non Identified Group						
Probit - Average Marginal Effects						
Female	-0.002	0.002	0.006	0.007	0.012*	0.013**
	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)
Non Local Student	-0.007*	0.004	-0.002	0.006	-0.003	0.007
	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)
High School Score	-0.004***	0.001***	-0.005***	0.002***	-0.005***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother has HE degree	-0.017***	0.004	-0.016**	0.006	-0.019**	0.005
	(0.005)	(0.005)	(0.006)	(0.006)	(0.008)	(0.007)
Father has HE degree	-0.032***	0.009*	-0.026***	0.014**	-0.021**	0.017**
	(0.006)	(0.005)	(0.007)	(0.007)	(0.009)	(0.008)
Programme FE	No	Yes	No	Yes	No	Yes
Control and Preference FE	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.021	0.167	0.023	0.173	0.022	0.216
N	70,833	70,746	42,866	42,712	28,443	28,190

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. Out of the 78,233 students there are 7,400 students for which I do not have information regarding either the Mother or Father level of education. The outcome variable is a dummy equal one if I cannot allocated the student to one of the four groups (A to D) and 0 otherwise.

A3.3 Imputation of application score

Consider the following example in Table A12, where three female students were admitted, without the Portuguese exam, to the same programme whose admission threshold was 110. I have the following information for each one of the six students:

Table A12: Imputation of the counterfactual application score

Student	Admitted with the PT exam $1\{\tau_{PT} - \tau_{\sim PT}\}$	Actual admission score τ	Application score with PT τ_{PT}	Group
Ana	0	150	130	B
Joana	0	120	n.a.	n.a.
Marta	0	140	100	A

Notes: n.a. - non available. Assume that there are three female students admitted to the same programme. Three were admitted without the Portuguese exam while the other students were admitted with it.

There is one student, Joana, for which I was not able to identify the group. However, I know that she is either in group A or B. To determine the corresponding group I estimate the counterfactual application score using regression analysis. In order to determine Joana's application score with Portuguese I run the following regression:

$$\tau^i_{PT} = \beta_0 + \beta_i' \mathbf{X}^i + \Theta + \epsilon^i \quad \text{if} \quad 1\{\tau_{PT} - \tau_{\sim PT}\} = 0 \tag{A10}$$

where $\mathbf{X}^i$ represents the vector of controls (gender, individual ability and home location) and Θ the programme and year fixed effects. Thus,

$$\tau^{Joana}_{PT} = \widehat{\beta_0} + \widehat{\beta_i'} \mathbf{X}^i + \Theta \tag{A11}$$

As a result if $\tau^{Joana}_{PT} \geq 110$ then Joana is allocated to group B, otherwise she is allocated to group A. In order words, I estimate the Joana's predicted application score with Portuguese based on the information of her peers that match the same individual characteristics.

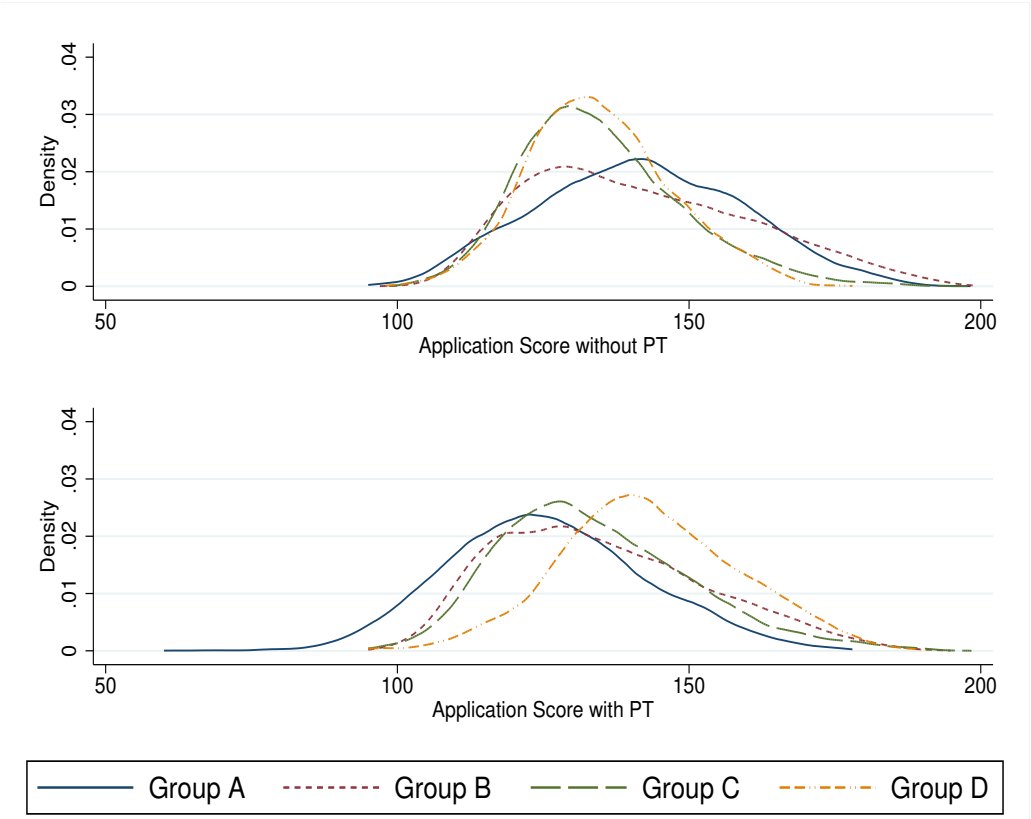


Figure A7: Distribution of application scores by groups - with imputation

A4 Appendix: Results

Table A13: Differences on Skills (detailed version)

	$\lvert\tau_{PT} - \tau_{\sim PT}\rvert \leq 10$			$\lvert\tau_{PT} - \tau_{\sim PT}\rvert \leq 5$		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: No. ECTs accumulated by the end of the 1st year - Cohorts 2013/2014 to 2016/2017						
PT Exam	-0.013	-0.038*	-0.056***	-0.005	-0.021	-0.024
	(0.020)	(0.019)	(0.021)	(0.026)	(0.026)	0.029)
Female		0.225***	0.242***		0.224***	0.255***
		(0.020)	(0.023)		(0.029)	(0.034)
Non Local Student		-0.024	-0.051**		0.003	-0.036
		(0.018)	(0.024)		(0.025)	(0.032)
High School Score		0.008***	0.018***		0.009***	0.018***
		(0.000)	(0.001)		(0.001)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
R^2	0.012	0.047	0.117	0.013	0.050	0.148
N	11,072	11,072	11,072	5,891	5,891	5,891
Panel B: Completion on time - Cohorts 2013/2014 to 2014/2015 (Probit - Average Marginal Effects)						
PT Exam	0.028	0.006	-0.021	0.020	0.011	-0.010
	(0.017)	(0.017)	(0.017)	(0.023)	(0.022)	(0.024)
Female		0.155***	0.147***		0.159***	0.171***
		(0.014)	(0.015)		(0.020)	(0.022)
Non Local Student		-0.004	-0.035*		0.002	-0.026
		(0.015)	(0.019)		(0.021)	(0.028)
High School Score		0.006***	0.007***		0.006***	0.007***
		(0.000)	(0.001)		(0.001)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
Pseudo R^2	0.021	0.068	0.185	0.018	0.063	0.178
N	4,500	4,500	4,223	2,338	2,338	2,013
Panel C: Final GPA - Cohorts 2013/2014 to 2014/2015						
PT Exam	0.103**	0.036	-0.019	0.022	-0.032	-0.091
	(0.041)	(0.040)	(0.046)	(0.055)	(0.054)	(0.067)
Female		0.147***	0.141***		0.171***	0.169**
		(0.041)	(0.046)		(0.058)	(0.070)
Non Local Student		0.054	0.084		0.121**	0.132*
		(0.038)	(0.052)		(0.052)	(0.075)
High School Score		0.016***	0.034***		0.017***	0.033***
		(0.001)	(0.002)		(0.001)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
R^2	0.025	0.102	0.247	0.028	0.105	0.297
N	2,891	2,891	2,891	1,562	1,562	1,562

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regression include cohort and preferences FE. The number of ECTS by the end of first year and Final GPA were standardized within programmes. All coefficients in panels A and C should be interpreted in terms of standard deviation changes in the outcome.

Table A14: At the margin of gaining entry in HE
(considering groups C and D jointly) - detailed version

	$\tau - \tau^* \leq 10$			$\tau - \tau^* \leq 5$		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: No. of ECTS by the end of the 1st year - Cohorts 2013/2014 to 2016/2017						
Group C and D	0.030**	0.016	-0.026	0.025	0.009	-0.029
	(0.014)	(0.014)	(0.016)	(0.018)	(0.018)	(0.020)
Group B	0.172***	0.138***	0.087***	0.162***	0.131***	0.091**
	(0.024)	(0.023)	(0.024)	(0.038)	(0.037)	(0.038)
Female		0.259***	0.290***		0.275***	0.305***
		(0.015)	(0.016)		(0.019)	(0.021)
High School Score		0.006***	0.014***		0.006***	0.013***
		(0.000)	(0.001)		(0.001)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
R^2	0.008	0.035	0.062	0.009	0.034	0.075
N	23,751	23,751	23,751	14,652	14,652	14,652
Panel B: Completion on time - Cohorts 2013/2014 to 2014/2015 (Probit - Average Marginal Effects)						
Groups C and D	0.019*	0.006	-0.011	0.022*	0.009	-0.011
	(0.010)	(0.010)	(0.011)	(0.013)	(0.013)	(0.013)
Group B	0.104***	0.069***	0.067***	0.132***	0.097***	0.115***
	(0.018)	(0.018)	(0.018)	(0.030)	(0.029)	(0.029)
Female		0.156***	0.149***		0.161***	0.163***
		(0.009)	(0.009)		(0.011)	(0.012)
High School Score		0.006***	0.004***		0.006***	0.003***
		(0.000)	(0.000)		(0.000)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
Pseudo R^2	0.021	0.067	0.169	0.016	0.069	0.176
N	11,431	11,431	11,055	6,990	6,990	6,599
Panel C: Final GPA - Cohorts 2013/2014 to 2014/2015						
Group C and D	0.146***	0.138***	0.077**	0.142***	0.139***	0.072*
	(0.026)	(0.026)	(0.030)	(0.033)	(0.033)	(0.039)
Group B	0.223***	0.194***	0.138***	0.175***	0.155**	0.124*
	(0.042)	(0.042)	(0.045)	(0.068)	(0.067)	(0.074)
Female		0.106***	0.126***		0.092***	0.098**
		(0.026)	(0.029)		(0.034)	(0.039)
High School Score		0.007***	0.015***		0.005***	0.012***
		(0.001)	(0.001)		(0.001)	(0.002)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
R^2	0.023	0.039	0.097	0.025	0.033	0.123
N	6,174	6,174	6,174	3,628	3,628	3,628

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regressions include Cohort and Preferences FE.

Table A15: At the margin of gaining entry in HE (with Inputation) - detailed version

	$0 \leq \tau - \tau^* \leq 10$			$0 \leq \tau - \tau^* \leq 5$		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: No. of ECTS by the end of the 1st year - Cohorts 2013/2014 to 2016/2017						
Group D	0.056***	-0.016	-0.009	0.056***	-0.012	-0.014
	(0.018)	(0.018)	(0.019)	(0.021)	(0.021)	(0.022)
Group C	0.060***	0.060***	-0.001	0.038*	0.043**	-0.015
	(0.015)	(0.015)	(0.017)	(0.019)	(0.019)	(0.023)
Group B	0.137***	0.099***	0.036	0.099***	0.059*	-0.003
	(0.021)	(0.021)	(0.022)	(0.033)	(0.033)	(0.035)
Female		0.265***	0.292***		0.275***	0.299***
		(0.014)	(0.015)		(0.018)	(0.020)
High School Score		0.006***	0.013***		0.006***	0.012***
		(0.000)	(0.001)		(0.000)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
R^2	0.009	0.035	0.058	0.009	0.034	0.070
N	26,594	26,594	26,594	16,397	16,397	16,397
Panel B: Completion on time - Cohorts 2013/2014 to 2014/2015 (Probit - Average Marginal Effects)						
Group D	0.094***	0.034***	0.006	0.090***	0.034**	0.001
	(0.012)	(0.012)	(0.012)	(0.015)	(0.014)	(0.015)
Group C	0.020**	0.014	0.005	0.018	0.016	0.010
	(0.010)	(0.010)	(0.011)	(0.013)	(0.013)	(0.015)
Group B	0.064***	0.024	0.037**	0.077***	0.032	0.062***
	(0.015)	(0.015)	(0.015)	(0.024)	(0.023)	(0.023)
Female		0.157***	0.148***		0.164***	0.165***
		(0.008)	(0.009)		(0.011)	(0.011)
High School Score		0.006***	0.003***		0.006***	0.003***
		(0.000)	(0.000)		(0.000)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
Pseudo R^2	0.019	0.064	0.166	0.019	0.064	0.162
N	12,976	12,976	12,621	7,923	7,923	7,523
Panel C: Final GPA - Cohorts 2013/2014 to 2014/2015						
Group D	0.171***	0.127***	0.126***	0.148***	0.121***	0.104**
	(0.032)	(0.032)	(0.034)	(0.038)	(0.038)	(0.042)
Group C	0.154***	0.152***	0.063*	0.134***	0.139***	0.044
	(0.027)	(0.027)	(0.034)	(0.035)	(0.035)	(0.045)
Group B	0.192***	0.157***	0.089**	0.131**	0.103*	0.046
	(0.037)	(0.037)	(0.041)	(0.058)	(0.058)	(0.065)
Female		0.119***	0.138***		0.105***	0.109***
		(0.025)	(0.028)		(0.032)	(0.037)
High School Score		0.007***	0.015***		0.005***	0.012***
		(0.001)	(0.001)		(0.001)	(0.002)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
R^2	0.027	0.043	0.093	0.027	0.036	0.114
N	6,837	6,837	6,837	4,019	4,019	4,019

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regressions include Cohort and Preferences FE.

Table A16: At the margin of gaining entry in HE
(without Inputation) - detailed version

	$0 \leq \tau - \tau^* \leq 10$			$0 \leq \tau - \tau^* \leq 5$		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: No. of ECTS by the end of the 1st year - Cohorts 2013/2014 to 2016/2017						
Group D	0.056***	-0.016	-0.009	0.056***	-0.012	-0.014
	(0.018)	(0.018)	(0.019)	(0.021)	(0.021)	(0.022)
Group C	0.060***	0.060***	-0.001	0.038*	0.043**	-0.015
	(0.015)	(0.015)	(0.017)	(0.019)	(0.019)	(0.023)
Group B	0.137***	0.099***	0.036	0.099***	0.059*	-0.003
	(0.021)	(0.021)	(0.022)	(0.033)	(0.033)	(0.035)
Female		0.265***	0.292***		0.275***	0.299***
		(0.014)	(0.015)		(0.018)	(0.020)
High School Score		0.006***	0.005***		0.006***	0.004***
		(0.000)	(0.001)		(0.001)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
R^2	0.009	0.035	0.058	0.009	0.034	0.070
N	26,594	26,594	26,594	16,397	16,397	16,397
Panel B: Completion on time - Cohorts 2013/2014 to 2014/2015 (Probit - Average Marginal Effects)						
Group D	0.087***	0.025	0.001	0.076***	0.020	-0.008
	(0.021)	(0.021)	(0.022)	(0.025)	(0.025)	(0.026)
Group C	0.124***	0.073***	0.066**	0.119***	0.080*	0.052
	(0.027)	(0.027)	(0.029)	(0.044)	(0.044)	(0.048)
Group B	0.104***	0.069***	0.058***	0.131***	0.096***	0.118***
	(0.018)	(0.018)	(0.019)	(0.029)	(0.029)	(0.031)
Female		0.154***	0.156***		0.154***	0.160***
		(0.013)	(0.014)		(0.017)	(0.018)
High School Score		0.006***	0.005***		0.006***	0.004***
		(0.000)	(0.001)		(0.001)	(0.001)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
Pseudo R^2	0.023	0.069	0.167	0.021	0.066	0.166
N	5,266	5,266	4,925	3,186	3,186	2,875
Panel C: Final GPA - Cohorts 2013/2014 to 2014/2015						
Group D	0.169***	0.107**	-0.010	0.174***	0.126**	0.067
	(0.050)	(0.050)	(0.058)	(0.060)	(0.061)	(0.074)
Group C	0.140**	0.086	0.024	0.186**	0.170*	0.143
	(0.056)	(0.056)	(0.071)	(0.092)	(0.093)	(0.124)
Group B	0.220***	0.186***	0.064	0.174**	0.145**	0.098
	(0.042)	(0.042)	(0.049)	(0.068)	(0.068)	(0.080)
Female		0.113***	0.139***		0.126**	0.130**
		(0.037)	(0.041)		(0.049)	(0.058)
High School Score		0.008***	0.019***		0.006***	0.017***
		(0.001)	(0.002)		(0.001)	(0.003)
Programme FE	No	No	Yes	No	No	Yes
Non Local Student	No	Yes	Yes	No	Yes	Yes
R^2	0.036	0.057	0.177	0.032	0.046	0.220
N	3,077	3,077	3,077	1,762	1,762	1,762

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regressions include Cohort and Preferences FE.

Table A17: T test between groups C and D

	$0 \leq \tau - \tau^* \leq 10$		
	(1)	(2)	(3)
$H_0 : \alpha_1 - \alpha_2 = 0$			
With Imputation - Table 14			
No. of ECTS	0.07	18.19***	0.018
Final GPA	0.30	0.63	2.93*
Controls	No	Yes	Yes
Programme FE	No	No	Yes

Notes: The table reports the F statistics. Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. Control Variables: Female, High School Score and Non Local Student. All regressions include cohort and preference fixed effects.

Table A18: Final GPA for those that completed the degree on time

	$0 \leq \tau - \tau^* \leq 10$					
	(1)	(2)	(3)	(4)	(5)	(6)
Group C and D	0.141***	0.137***	0.065**			
	(0.027)	(0.027)	(0.031)			
Group D				0.160***	0.120***	0.118***
				(0.033)	(0.032)	(0.035)
Group C				0.148***	0.150***	0.046
				(0.028)	(0.028)	(0.034)
Group B	0.220***	0.192***	0.136***	0.185***	0.152***	0.079*
	(0.044)	(0.043)	(0.047)	(0.039)	(0.038)	(0.043)
Controls	No	Yes	Yes	No	Yes	Yes
Programme FE	No	No	Yes	No	No	Yes
R^2	0.025	0.041	0.093	0.027	0.043	0.092
N	5,813	5,813	5,813	6,441	6,441	6,441

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regressions include Cohort and Preferences FE. controls: Gender, Non Local Student, and High School Score.

Table A19: Heckman Selection model, by MLE (with Imputation)

	$0 \leq \tau - \tau^* \leq 10$		
	(1)	(2)	(3)
Outcome Eq. (Final GPA)			
Group D	0.170***	0.127***	0.121***
	(0.032)	(0.036)	(0.036)
Group C	0.155***	0.094***	0.047
	(0.027)	(0.031)	(0.036)
Group B	0.191***	0.163***	0.124***
	(0.037)	(0.043)	(0.044)
Female		0.322***	0.278 ***
		(0.029)	(0.031)
Non-Local Student		0.058**	-0.017
		(0.027)	(0.036)
High School Score		0.012***	0.015***
		(0.001)	(0.002)
Programme FE	No	No	Yes
Selection Eq. (Prob. of students not dropping out by the end of the first academic year)			
Group D	0.036***	0.009	0.003
	(0.010)	(0.009)	(0.009)
Group C	-0.017**	-0.018**	-0.004
	(0.008)	(0.008)	(0.008)
Group B	0.027**	0.008	0.026**
	(0.012)	(0.011)	(0.011)
Female		0.090***	0.079***
		(0.007)	(0.006)
Non-Local Student		0.033***	0.016 *
		(0.007)	(0.008)
High School Score		0.003***	0.001**
		(0.000)	(0.000)
Programme FE	No	No	Yes
Number of Obs.	12,707	12,707	12,707
Uncensored of Obs.	6,837	6,837	6,837
ρ	-0.024	-0.030	0.834
σ	0.915	0.908	1.022
λ	-0.022	-0.027	0.853
Wald test for $\rho = 0$ (Prob> χ^2)	0.536	0.315	0.000

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regressions include Cohort FE. The variable Final GPA was standardized within programmes, and all coefficients should be interpreted as standard deviation changes. For the selection equation, I report the average marginal effects.

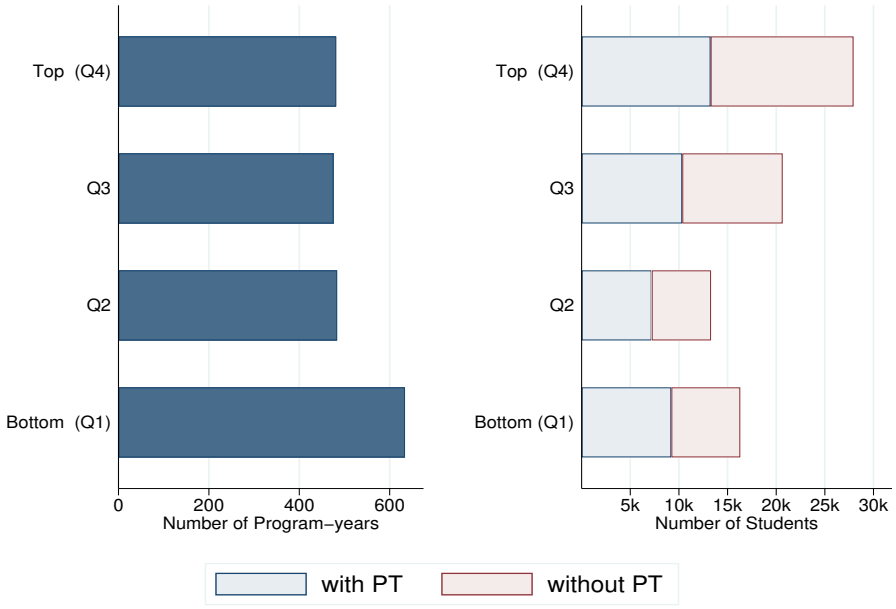


Figure A8: Programmes that allow for PT ranked by threshold in the overall distribution of programmes (quartiles)

Source: Author's calculation. I divide all programmes in the dataset into quartiles according to the admission threshold.

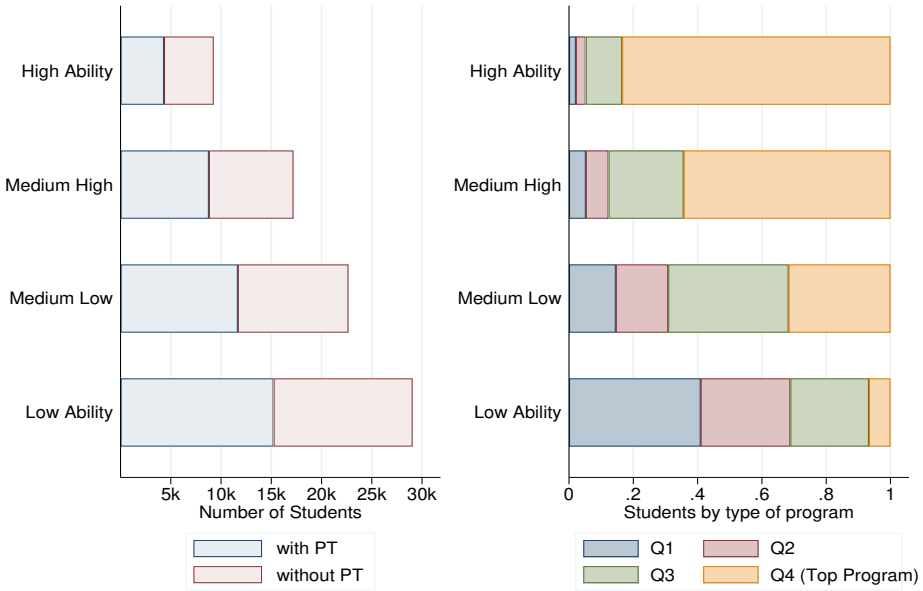


Figure A9: Enrolled students in programmes allow for PT ranked by ability in the overall distribution of student's ability (quartiles)

Source: Author's calculation. I divide all students in the dataset into quartiles according to their ability as measured by their high school score.

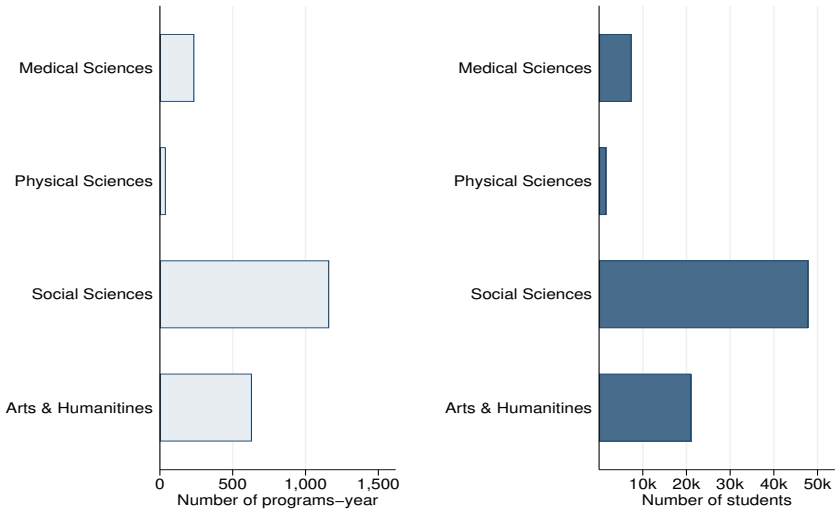


Figure A10: Number of students and programmes by field of study

Source: Author's calculation. Notes: The graphic includes all students enrolled in programmes that allow for Portuguese as an alternative requirement for the entry cohorts 2013/2014 to 2016/2017. For that reason Medical Sciences does not include the course of Medicine, where Portuguese is not allowed. A description of each field is available in Table A6 of the appendix. I group the different fields according to REF (UK) classification.

Table A20: Analysis by Field (with Imputation)

	$0 \leq \tau - \tau^* \leq 10$								
	No. of ECTS by the end of the 1st year			Completion on Time			Final GPA		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	(marginal effects)								
Group D		-0.021	-0.028		0.033***	0.031**		0.121***	0.079**
		(0.018)	(0.021)		(0.012)	(0.012)		(0.032)	(0.039)
Group C		0.059***	0.049***		0.010	0.009		0.147***	0.132***
		(0.015)	(0.018)		(0.010)	(0.010)		(0.027)	(0.034)
Group B		0.097***	0.117***		0.022	0.020		0.151***	0.094**
		(0.021)	(0.026)		(0.015)	(0.015)		(0.037)	(0.048)
Medical Sciences	0.014	-0.025	-0.011	0.182***	0.180***	0.186***	-0.004	-0.008	-0.073
	(0.022)	(0.022)	(0.044)	(0.020)	(0.020)	(0.020)	(0.040)	(0.040)	(0.074)
Physical Sciences	-0.088*	-0.090**	-0.008	-0.118**	-0.117**	-0.140***	-0.115	-0.127	-0.279**
	(0.045)	(0.046)	(0.059)	(0.053)	(0.055)	(0.054)	(0.138)	(0.138)	(0.142)
Arts & Humanitines	-0.045***	-0.049***	-0.072***	0.012	0.003	0.004	-0.070***	-0.067***	-0.116***
	(0.015)	(0.015)	(0.025)	(0.010)	(0.010)	(0.010)	(0.025)	(0.025)	(0.041)
Group D × Medical Sciences			0.018						0.175
			(0.063)						(0.119)
Group D × Physical Sciences			-0.230						-0.710***
			(0.154)						(0.147)
Group D × Arts & Humanitines			0.035						0.092
			(0.045)						(0.070)
Group C × Medical Sciences			-0.008						0.031
			(0.057)						(0.096)
Group C × Physical Sciences			-0.204						0.171
			(0.126)						(0.389)
Group C × Arts & Humanitines			0.055						0.043
			(0.035)						(0.061)
Group B × Medical Sciences			-0.094						0.131
			(0.070)						(0.122)
Group B × Physical Sciences			-0.123						0.681*
			(0.123)						(0.379)
Group B × Arts & Humanitines			-0.024						0.147*
			(0.051)						(0.085)
Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.008	0.035	0.036	0.020	0.069	0.069	0.021	0.044	0.045
N	26,524	26,524	26,524	12,927	12,927	12,927	6,829	6,829	6,829

Notes: Robust standard errors are in parentheses. * , ** and *** represents statistical significance from 10%, 5% and 1% respectively. All regressions include cohort and preferences FE.

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