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Evidence of Application Mistakes and Sophisticated Behaviour under a Priority Point Mechanism in Finnish College Admissions

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This thesis studies what kind of strategic incentives a mechanism applied in Finnish college admissions in the fields of Business Administration and Economics (BAE) during 2015–2017 offers as well as how applicants respond to these incentives. A special type of a strategy that a student can only be hurt by and therefore strategically sophisticated students should try to avoid under the mechanism – referred to as the Priority Point Mechanism (PPM) – is characterised. Given this strategy, the thesis investigates whether the applicants' behaviour is in line with some students responding to the incentives of the mechanism, and whether some students fail in responding to them.

Using data on BAE applicants' full Rank Order Lists (ROLs) and applying a First Differences approach, hypotheses associated with studying strategic behaviour are tested. The results are in line with some students strategizing under PPM: the removal of the priority points increases the probability of ranking the most prestigious programme first by 5.2 percentage points ($p < 0.001$), and for the most prestigious programmes pairs, it increases the probability of ranking programmes with small expected cut-off differences by 5.5– 12.7 percentage points ($p < 0.01$). However, out of three programme pairs studied, for one pair the estimated effect is 2.1 and insignificant ($p \approx 0.11$). There is no evidence in favour of these behavioural changes translating into longer ROLs: the estimate is 0.069 more study programmes ranked when priority points are removed, and it is insignificant ($p \approx 0.34$).

Students who fail in responding to the strategic incentives offered by PPM exist. During 2016 and 2017, 7–9 % of students submitted an ROL by which they could only be hurt, and in 2017, 2.8 % of students submitted an ROL which clearly demonstrates lack of strategic sophistication. Motivated by the result that students who make such mistakes exist, students who made a mistake are compared to those who didn't. The results suggest that having more experience and lack of informational disadvantages don't protect students from playing a strategy by which they can only be hurt, while these aspects seem to be negatively correlated with making a mistake that demonstrates lack of strategic sophistication. For both mistake types, making a mistake is associated with lower academic aptitudes.

The finding that students' behaviour is in line with some applicants strategically behaving under PPM has implications on whether true preferences should be inferred from stated preferences if stated under a manipulable mechanism. Furthermore, some students strategically behaving and some students failing in responding to the incentives can result in unfair allocations where some students justifiably envy others. In addition, factors such as luck, risk taking attitudes, confidence, and difficulties in predicting entry-thresholds may contribute to who ends up being selected. Therefore, given the importance of college admissions on young students' future prospects, how applicants respond to the incentives of the mechanism applied and how that in turn impacts the fairness of the resulting allocation of students to colleges remain questions which deserve more research.

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Abbreviations used

BAE	Business Administration and Economics
BM	Boston Mechanism
DA	Deferred Acceptance algorithm, i.e., Gale–Shapley algorithm
IB	International Business
PPM	Priority Point Mechanism
ROL	Rank Order List
TM	Taiwan Mechanism

Expressions used interchangeably

- applicant, student
- college, programme, study programme
- lack of strategic sophistication, naiveness
- sophisticated behaviour, strategic behaviour
- two-year student, multiple-year student

1. Introduction[*]

Not the least for the well-known effects of higher education on expected lifetime income, college admissions can be considered a major determinant of a young Finnish person's future (Koerselman & Uusitalo, 2014). For that reason, taking applicants' wishes into consideration when allocating students to colleges is arguably a matter of importance. Indeed, consideration of applicants' wishes is a common practice in college admissions: typically, applicants rank colleges in their order of preference, after which students are allocated to colleges based on some criteria and rules posed by the colleges. What remains unconsidered in many real-life applications, however, is that these preference orderings do not necessarily correspond to applicants' true preferences but may be manipulated because of the incentives the rules that constitute the college admissions mechanism applied offers (Budish & Cantillon, 2012).

College admissions mechanisms that are typical drivers to mis-presentation of preferences often aim to match applicants to their most preferred colleges by giving higher chances of admittance for the higher ranked options. However, students who understand the properties of these so-called priority mechanisms tend to apply to safe options rather than their true favourites (Calsamiglia et al., 2010), as truthful reporting of preferences may end up being a strategy by which an applicant can only be hurt (Abdulkadiroğlu et al., 2006). Given the complicated, risk-involving game students are involved in under these mechanisms, behavioural responses and lack of them may not only fail in pairing students with their true favourites but also lead into other unintended outcomes: who gets a seat at a college isn't necessarily determined by who deserves it but who likes a college back – or succeeds in acting as if. Therefore, these mechanisms can give an advantage undoubtedly unfair to more strategically sophisticated students, for whom it isn't guaranteed that they benefit equally either as factors such as luck, level of risk aversion, and confidence can all contribute to who ends up successfully strategizing (Wu & Zhong, 2020).

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[*] I would like to thank Tuomas Pekkarinen for his valuable comments.

A large and growing branch of economic literature studies the properties of school choice and college admission mechanisms. Especially, properties of two mechanisms, the *Deferred Acceptance algorithm* (DA) – also known as the Gale–Shapley algorithm, introduced by David Gale and Lloyd Shapley (1962) – and the *Boston Mechanism* (BM) have risen broad attention since the Boston Public School switched from the latter to the former as a result of Abdulkadiroğlu and Sönmez (2003) discussing the incentive problem of BM.

BM can be considered an extreme case of a priority mechanism, and for students who like more than one popular school, it is rarely optimal to state one's preferences truthfully under the mechanism (Abdulkadiroğlu & Sönmez, 2003). In contrast, under DA, applicants can do no better than to state their preferences truthfully. The lack of strategic incentives offered by DA as well as the mechanism's other properties have been widely acknowledged desirable, leading to a Nobel Memorial Prize in Economic Sciences 2012 (Nobel Prize, 2012). As opposed, in England, for instance, school choice mechanisms that give higher chances of admittance for higher ranked schools were ruled illegal in 2007, indicating the severeness of the problems related to and priority mechanisms in general (Pathak & Sönmez, 2013).

In this thesis, I empirically evaluate a novel college admissions mechanism applied in the fields of Business Administration and Economics (BAE) in Finland from 2015 until 2017. Under the mechanism, which I refer to as the *Priority Point Mechanism* (PPM), programmes gave extra points to an applicant based on the position in which she ranked the programme such that listing a programme as one's first, second, or third choice gave three, two, and one extra points, respectively. PPM is a priority mechanism and belongs to the family of so-called *Taiwan Mechanisms* (TMs), which can be considered hybrids of DA and BM, as I demonstrate in the thesis.

This thesis has two main goals. First, my goal is to characterize what kind of strategic incentives PPM offers. Second, I aim to find out whether there is heterogeneity in terms of how well students respond to these incentives. That is, given the type of behaviour I characterise as a mistake under PPM, that is, a strategy that an applicant can only be hurt by under PPM, my thesis answers to the following three questions:

1. Is the applicants' behaviour in line with some applicants strategizing in the presence of the priority points?
2. If they do, how do they strategize?
3. Are there students who make application mistakes?

These questions are of importance as heterogeneity in terms of strategic sophistication as well as strategic behaviour itself can translate into unfair and inefficient allocations under priority mechanisms (Ha et al., 2020; Kapor et al., 2020; Wu & Zhong, 2020). When the number of applicants exceeds the capacity of colleges, not all applicants can be guaranteed a seat, and therefore applicants' welfare and the allocation's fairness should clearly become important factors to be considered when decision on who gets a seat are made. This is the case especially in the case of BAE as it is among the most competitive fields in Finland with only around 15% of the applicants obtaining a seat each year. Furthermore, information on strategic behaviour is valuable as such as it gives an idea whether information of true preferences can be inferred from stated preferences. If not, then, for example, a student ranking a college first or a student receiving her top choice can be considered poor measures of motivation and student satisfaction, respectively.

The family of TMs is a novel family of mechanisms whose properties have yet not been empirically evaluated. In addition, empirical real-world studies on college admissions mechanisms remain rare in general due to data limitations and lack of suitable set-ups (Wu & Zhong, 2020). Instead, empirical reseach rely largely on laboratory experiments which have challenges of mimicking large-scale high-stakes environments such as college admissions that students undoubtedly take seriously in real life (Ha et al., 2020).

In this thesis, I have the advantage of being able to combine rich register data from multiple resources and, in particular, the advantage of having access to information on all BAE applicants' full applications between 2016 and 2018. What is more, given the nature of Finnish college admissions where it is typical for applicants to apply multiple years arow, I am able to follow the same individuals over time and thus, observe the behaviour of the same individual in the presence and absence of the priority points.

Although unique, PPM is not the only priority mechanism applied in Finnish college admissions or school choice. Priority points have been given in college admissions in fields other than BAE as well, including medicine where a version of PPM was applied until 2021 (Lääketieteelliset). Still in 2022, priority points are given to students applying to vocational upper secondary education (Opintopolku). What is more, until 2020, most colleges required applicants to take study programme or field specific entrance exams (OKM 2017). The system that highlights entrance exam performance shares similar properties with priority mechanisms: as scattering effort by preparing for multiple programmes' entrance exams is unlikely to yield admission to any programme, the system encourages to put efforts to a single programme or field, as if the student got extra points from the first ranked alternative. As my work is among the few to study strategic behaviour under Finnish college admissions and school choice, it may shed light on the other priority mechanisms applied in school choice and college admissions in Finland, and consequently, work as a pioneer to future work.

The remainder of the thesis is constructed as follows. In Chapter 2, I describe the institutional background, the BAE admissions procedure and its main changes from 2016 until 2018. In Chapter 3, I introduce theoretical and empirical literature related to college admissions. I introduce PPM and characterize what is considered a mistake under the mechanism. Then, I construct hypotheses to be tested to answer the research questions. In Chapter 4, I describe the data used and in Chapter 5 the empirical approach applied to test the hypotheses. In Chapter 6, I then report and discuss the results of the empirical analysis. Finally, Chapter 7 concludes.

2. Institutional Background

Since 2015, students have applied to Finnish universities and polytechnics through a common electronic platform, *Opintopolku*. The main round through which applicants can apply to study programmes offering education in Finnish or Swedish runs each year from the end of March until the beginning of April. The study programmes are college and discipline specific, and the number of programmes applicants can rank is limited to six. Students are allocated to colleges during mid-July, using DA (OKM 2016; Opintopolku). Despite the common application platform, colleges apply admission criteria that are specific to individual study programmes or, in some cases, to all programmes within a certain field, such as in the field of BAE.

The BAE study programmes studied in this thesis as well as their entry thresholds are reported in Table 1. All eleven study programmes offer education in Finnish and apply common admission criteria. In addition to the programmes offering education in Finnish, two universities offering education in Swedish, Åbo Akademi and Hanken Svenska Handelshögskolan, participated in the common admission procedure in 2018. The programme Turku International Business (IB) that took part in the common application procedure in 2016–2018 also offers education in Finnish, but the programme's admission procedure differs from the others and includes an interview.

To select students to BAE study programmes, applicants' matriculation examination and entrance exam performance were considered during 2016–2018. The Finnish Matriculation Examination[1] (*ylioppilastutkinto*, abbreviated as *yo*) is a national examination that consists of exams on different subjects which are mostly taken during the last spring term simultaneously with the college application period. Students must take an exam in at least four different subjects. A test in student's mother tongue is

[1] International Baccalaureate and European Baccalaureate examinations are also acceptable in BAE admissions, as well as Reifeprüfung and Deutsches Internationales Abitur examinations in case completed in Finland. Students with an international matriculation examination constitute a small minority of students and thus, only the Finnish Matriculation Examination is considered.

Table 1. Study Programmes' Entry Thresholds by Year and Criterium.

Year	2016		2017			2018	
Criterium	Joint	Exam	Joint	Exam	Yo	Exam	Yo
Programme							
Aalto	60.25	32.25	60.5	33.5	36	29.5	32
Joensuu	45	24.25	44.5	27	30	24	24
Kuopio	49	26.25	46.5	28.5	30	25	24
Jyväskylä, E	47.75	25.25	48.25	29	32	25.5	25
Jyväskylä, BE	51	28.5	50.5	30	30	25.5	24
Lappeenranta	50	26	50	30.25	30	26	26
Oulu	47	25.25	46.25	28.75	32	24.5	24
Tampere	56	30.25	56.25	32.5	34	28	29.33
Turku	56.75	31.5	57.5	33.25	33	28.5	30
Pori	45	23.75	46	28	30	24.5	24
Vaasa	48.25	26.25	47.5	29.75	30	24.5	24
Mean	*50.78*	*27.33*	*50.63*	*30.08*	*31.7*	*26.1*	*26.23*
Standard Deviation	*5.24*	*3.08*	*5.55*	*2.28*	*2.11*	*1.90*	*3.05*

Note: The table reports BAE study programmes' entry thresholds by year and criterium for all programmes offering education in Finnish during 2015–2018, except for the programme Turku International Business. The thresholds are calculated from scores that include the priority points. Criterium "exam" refers to the entrance exam, "yo" to the matriculation examination, and "joint" to the composite score determined by the entrance exam and matriculation examination scores. Jyväskylä, E and Jyväskylä, BE refer to study programmes Jyväskylä Economics and Jyväskylä Business Economics, respectively.

obligatory, and out of tests in four categories – second national language, foreign language, mathematics, and humanities or natural sciences – at least three must be taken. At least one of the three tests must be of advanced syllabus level; advanced syllabus level tests are offered in second national language, foreign language, and mathematics tests.

The tests scores are standardized at national level. The grades are determined by the distribution of scores as depicted in Figure 1. There are seven grades, out of which the top 5 % receives the highest and the bottom 5 % the lowest, which is fail. In the BAE admissions procedure, the grades are translated into points.

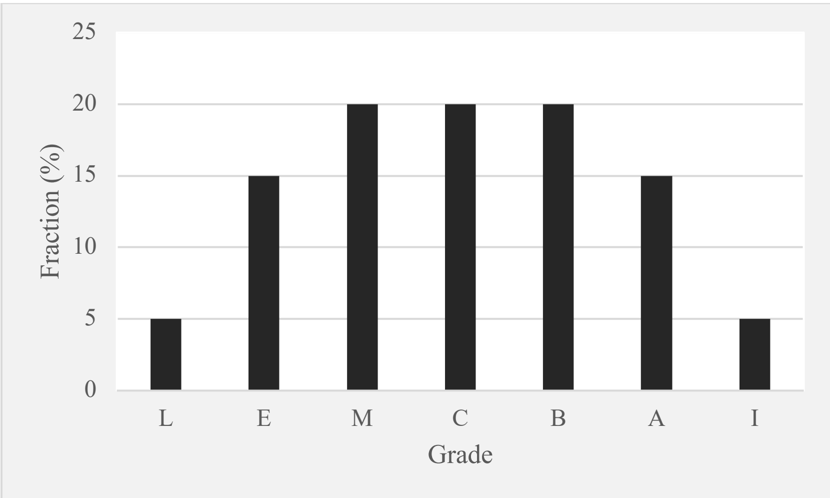

Figure 1. Matriculation Examination Grading Distribution.

Note: The figure presents the fractions of students obtaining different grades in the Finnish Matriculation Examination tests, the grades being reported from the highest to the lowest. "L" stands for *Laudatur*, "E" for *Eximia cum laude approbatur*, "M" for *Magna cum laude approbatur*, "C" for *Cum laude approbatur*, "B" for *Lubenter approbatur*, "A" for *Approbatur*, and "I" for *Improbatur*.

High school students graduating in the spring term don't learn their final grades until the end of May. Yet, they may have some idea of their matriculation examination grades at the time of submitting their applications to Opintopolku as, first, they know their grades from exams taken before the last spring and, second, the exams taken in the last spring are often tentatively graded by high school teachers before admissions. The entrance exam, on the other hand, is held after the application period is over. Therefore, applicants don't know their entrance exam scores when applying to colleges.

During 2016–2018, the roles of entrance exam and matriculation examination differ in the admission process across years within BAE. Before 2017, students were chosen based either on a composite score determined by a combination of matriculation examination and entrance exam scores or solely on their performance in the entrance exam. In 2017, a matriculation examination-based admission criterium was introduced in addition to the existing two, covering 20 % of seats. However, an applicant could be accepted based on her matriculation examination performance only by the programme she reported first. In 2018, the fraction of students chosen based on their matriculation examination performance increased to 60 %, and a student could be accepted by any programme regardless of the ranking. The remaining 40 % were chosen based on their performance in the entrance exam and the composite score was no longer applied. What is more, the entrance exam changed in 2018 so that it based on the content of compulsory high-school courses and not to separate materials, as before.

The way students without an existing academic degree were treated in the admissions procedure also varied during 2016–2018. Since 2016, Finnish colleges have been obliged to reserve seats for so-called first-timers, namely, applicants who don't have an existing academic degree and haven't accepted any offer from a college in 2014 or later (OKM 2016). Within BAE, the fraction of seats that were reserved for first-timers was 50 % in 2016 and 2017, and in 2018 the corresponding number was 70 %. The first-timer quota was also criterium specific (see Figure 2), but if the total number would already be filled before the criterium-specific quota was, then less first-timers could be accepted with respect to a certain admission type.

A change specific to the field of BAE during 2016–2018 was the removal of the priority points in the admissions procedure. From 2015 until 2017, BAE applied a priority point system in which applicants received three, two, and one extra points for their first, second, and third listed study programmes, respectively. These points were gained regardless of whether a student applied for other fields as well; only the order in which study programmes among the BAE ones were ranked mattered. Since 2018, no such points have been given.

Figure 2 summarizes the main changes from 2016 until 2018 in the BAE admission criteria. Notice that the information reported in Figure 2 is based on the information applicants received in their year of application, and the actualised outcomes might be different. Especially, the changes in seats reserved for first-timers do not correspond to the actualised changes. In real terms only around 15 % of all applicants and even a smaller number of accepted students were not considered first-timers between 2016 and 2018, partly because an applicant who has accepted an offer before 2014 but hasn't completed their degree is too considered a first-timer.

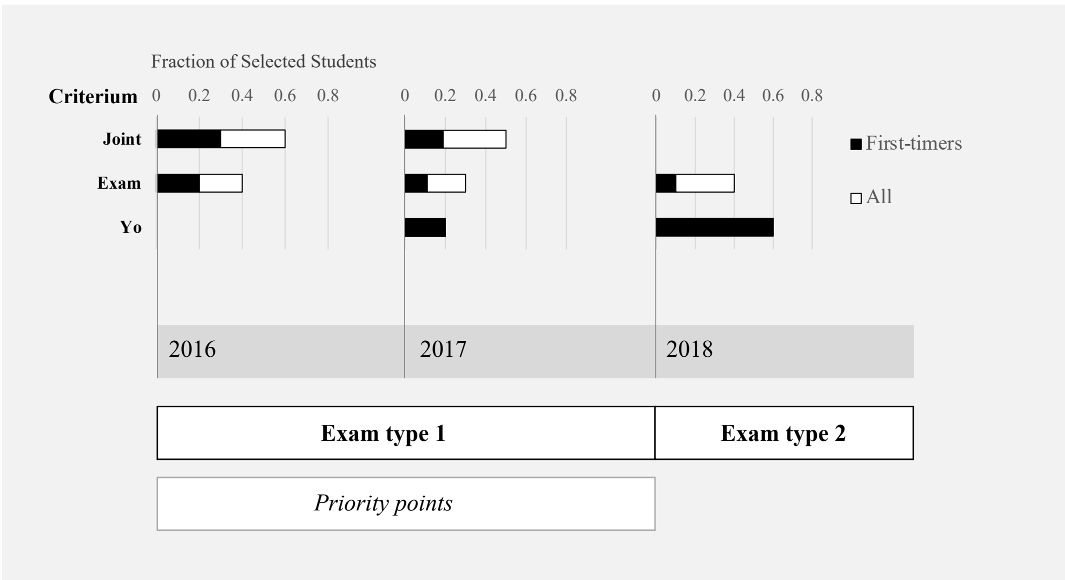

Figure 2. Main Changes in the BAE Admissions Procedure during 2016–2018.

Note: The figure reports the main changes taken place in the fields of BAE during 2016–2018 based on information given to the applicants in the year of application. Criterium "exam" refers to the entrance exam, "yo" to the matriculation examination, and "joint" to the composite score determined by the entrance exam and matriculation examination scores. A student is a first-timer if she doesn't have an existing academic degree and haven't accepted any offer from a college in 2014 or later. In 2017, an applicant could only be accepted based on her matriculation examination performance by the programme she listed first among the BAE programmes. "Exam type 1" refers to the exam whose content bases on separate materials, and "Exam type 2" to the one whose content bases on compulsory high school courses.

3. Related Literature

In this chapter, I introduce theoretical and empirical literature related to the research topic. In Section 3.1, I first present the so-called college admissions problem – the problem of matching applicants and colleges – and give relevant definitions. In Section 3.2, I then introduce college admissions mechanisms central for the purposes of the thesis and discuss their theoretical properties. I first introduce DA and BM followed by TMs, defined as hybrids of the two. Then, I characterise PPM as a member of the family of TMs. Finally, motivated by the theoretical results of the preceding sections as well as the empirical evidence introduced in the same section, the chapter concludes with Section 3.3 by formulating the hypotheses to be tested to answer the research questions.

3.1 Theoretical Background

The characterisation of a college admissions problem follows Gale and Shapley (1962).

A college admissions problem is a set of components that are needed to assign students to colleges. Namely, a college admissions problem consists of

- a set of applicants $A = \{a_1, \dots, a_N\}$,
- a set of colleges $C = \{C_1, \dots, C_M\}$,
- a vector of capacities $q = (q_1, \dots, q_M)$,
- applicants' preferences over colleges r_n, and
- colleges' preferences over applicants R_m.

The elements of the capacity vector q, quotas q_m, indicate the maximum number of applicants each college C_m can possibly accept. Agents' preferences are given by *rank order lists* (ROLs). For each applicant a_n, an ROL r_n lists colleges such that if C_m is listed in a higher rank compared to $C_{m'}$, then applicant a_n strictly prefers college C_m to $C_{m'}$; if college C_m isn't listed at all, then applicant a_n never wants to be paired with college C_m in which case we say that college C_m is *unacceptable* to applicant a_n. Similarly, each college C_m has an ROL R_m that lists applicants in descending order of preference up to the point where the remainder of applicants are all unacceptable to the college.[2] Hence, a *college admissions problem* or, henceforth, just a *problem* can be denoted by a collection $\{A, C, q, r, R\}$, where $r = \{r_1, \ldots, r_N\}$ and $R = \{R_1, \ldots, R_M\}$. Notice that here the term college is understood broadly and, for example, in the context of Finnish college admissions, where students apply to individual study programmes, C_m could as well refer to study programme m.

The way students are assigned to colleges is determined by a *matching*. A matching assigns at most q_m applicants to college C_m such that each applicant a_n is assigned to at most one college (Roth & Sotomayor, 1989). A matching is *stable* if it isn't blocked by a pair of agents nor by an individual. We say a matching is *blocked by a pair of agents* if some applicant a_n who prefers C_m to $C_{m'}$ is assigned to $C_{m'}$ or is isn't assigned to any college while C_m that prefers a_n to $a_{n'}$ is assigned $a_{n'}$ but not a_n or is assigned fewer applicants than q_m. A matching is *blocked by an individual* if an applicant is assigned to a college she finds unacceptable, or a college is assigned an applicant unacceptable to the college. In the presence of a blocking pair (individual), there would be agents who could together (individually) act to obtain a more desirable outcome, and stability can therefore be interpreted as a feasibility requirement for a matching (Pathak & Sönmez, 2013).

Alternatively, stability can be interpreted as a minimum criterium for the fairness of the allocation of students to colleges (Abdulkadiroğlu & Sönmez, 2003). This is partly through stability eliminating *justified envy.* In the presence of justified envy, an applicant desires and deserves to be matched to a college she isn't matched to: "desires" in the sense that she would prefer studying at a college other than she is assigned to, if any; "deserves" in the sense that an applicant ranked lower in that college's ROL is accepted. For example, in the case of BAE, an applicant a_n scoring higher than some applicant $a_{n'}$ would

[2] The strict preference assumption also implies that, for all applicants and colleges, any acceptable option is strictly preferred to any unacceptable one.

justifiably envy $a_{n'}$ if $a_{n'}$ obtained a seat at, say, Tampere but a_n didn't while Tampere was the most preferred option to a_n.

We say a matching is efficient if it isn't Pareto dominated by any other matching, and if a stable matching isn't dominated by any other stable matching, the matching is called *student-optimal stable* (Abdulkadiroğlu et al., 2009). We understand Pareto dominance such that it only considers the welfare of students; that is, matching μ is Pareto dominated by μ' if and only if there is a student who strictly prefers her match under μ' to her match under μ, while there are no such student for whom the opposite would be true.

To produce a matching, a mechanism that determines the rules upon which students are allocated to colleges is needed. As a mechanism produces a matching based on agents' stated preferences, mechanisms differ in terms of how they incentivise truthful reporting of preferences. We say that a mechanism σ is *vulnerable to manipulation* or *manipulable* in problem $\{A, C, q, r, R\}$, if there is at least one student a_n who could receive an allocation she would strictly prefer by not reporting the preferences given by r_n when σ is applied (Pathak & Sönmez, 2013). Furthermore, if it holds that

(i) given any problem $\{A, C, q, r, R\}$, if mechanism σ' is vulnerable to manipulation, then mechanism σ is vulnerable to manipulation, and
(ii) there exists some problem $\{A, C, q, r, R\}$ such that mechanism σ is manipulable but mechanism σ' is not

then, we say that mechanism σ is *more vulnerable to manipulation* or *more manipulable* than mechanism σ'. If a mechanism isn't manipulable in any problem $\{A, C, q, r, R\}$, then we say the mechanism is *strategy-proof*. Under a strategy-proof mechanism it is always a weakly dominant strategy for applicants to state one's preferences truthfully: that is, regardless of how other students report their preferences, no student can individually benefit from mis-reporting her preferences.

3.2 College Admissions Mechanisms and Their Properties

In this subsection, I present three college admissions mechanisms: DA, BM, and PPM, a hybrid of the first two. In section 3.2.1, I first introduce DA and BM and discuss their theoretical properties. I describe a special type of a strategy that is never profitable under BM and can be therefore considered a mistake. Then, in section 3.2.2, I generalize DA and BM into the family of TMs and show that PPM belongs to this family. I demonstrate that PPM is not strategy-proof and that it is more manipulable than DA and specify the analogy of a mistake given for BM to the case of PPM.

3.2.1 The Deferred Acceptance Algorithm and the Boston Mechanism

The description of DA follows Gale and Shapley (1962).

DA proceeds as follows:

Round 1: Each student a_n applies to the college highest in her ROL. Each college C_m **tentatively** accepts applicants in its order of preference up to the point the college has accepted q_m students or there are no acceptable applicants left and rejects the rest.

⋮

Round k: Each applicant who was rejected in round $k-1$ but hasn't yet been rejected by all her acceptable colleges, applies to her most preferred college among the colleges that haven't yet rejected her. Each college considers all applicants who they tentatively accepted in round $k-1$ as well as those who applied in round k, and tentatively accepts applicants in its order of preference up to the point the college has accepted q_m students or until there are no acceptable applicants left and rejects the rest.

The algorithm ends when no applicant is any longer applying.[3]

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[3] When not otherwise specified, DA is understood as the *student-proposing* DA. In the *college-proposing* DA, colleges make offers to students.

The description of BM follows Abdulkadiroğlu and Sönmez (2003).

BM proceeds as follows:

Round 1: Each applicant a_n applies to the college highest in her ROL. Each college C_m **permanently** accepts applicants in its order of preference up to the point the college has accepted q_m students or there are no acceptable applicants left and rejects the rest.

⋮

Round k: Each applicant who was rejected in round $k-1$ and has at least k acceptable colleges, applies to her k^{th} preferred college. Each college considers only students applying in round k and permanently accepts applicants in their order of preference up to the point the college has accepted as many students as there are unfilled seats after the preceding $k-1$ rounds or until there are no acceptable applicants left and rejects the rest.

The algorithm ends when no applicant is any longer applying.

DA produces the unique student-optimal stable matching (Gale & Shapley, 1962) and it is strategy-proof (Dubins & Freedman, 1981) while BM is not strategy-proof and the matching it produces does not need to be stable (Abdulkadiroğlu & Sönmez, 2003). The key difference between the two mechanism and which makes one of them strategy-proof and one of them manipulable, is that DA makes tentative decisions in each round whereas in the case of BM, all decisions made are final: Under DA, as the colleges keep updating the group of applicants tentatively accepted in each round, an applicant cannot be hurt by being rejected by some of the colleges nor can she benefit from dropping some of the colleges from the ROL corresponding to her true preferences, given the stated preferences of colleges and other applicants. In contrast, under BM, the colleges and the order in which an applicant lists them is not irrelevant in the same manner.

Especially, under BM, an applicant can be hurt by without caution listing colleges that are *over-demanded*. Abdulkadiroğlu et al. (2006) specify that, in the context of school choice, a school is over-demanded if the number of applicants ranking the school as their first choice is at least as large as the capacity of the school. For the purposes of the thesis, where I consider that it is possible that some applicants are unacceptable to a specific study programme, I further require that for a college to be over-demanded, there needs to be at least as many applicants acceptable to the college ranking it as their first option as the college could accept at maximum. Given the definition, Proposition 1 specifies a special type of a strategy that an applicant can only be hurt by and can be therefore considered a mistake under BM.

Proposition 1. Under BM, an applicant listing an over-demanded college as her second choice can never be accepted by the second listed option but listing an over-demanded college as her second choice only reduces the probability of her being accepted by any lower ranked option (Abdulkadiroğlu et al., 2006).

Definition 1. Application Mistake under BM. If applicant a_n submits an ROL r_n such that the second ranked college is over-demanded, then applicant a_n makes an *application mistake under BM.*

3.2.2 The Priority Point Mechanism as a Taiwan Mechanism

So-called Taiwan Mechanisms are hybrids of DA and BM under which applicants' chances of obtaining a seat at a college are dependent on the rank-ordering of the college. The description of TMs follows Dur et al. (2022).

TMs work as follows. Consider college C_m ranking applicant a_n based on her score π_{ma_n} such that if $\pi_{ma_n} > \pi_{ma_{n'}}$, then college C_m strictly prefers a_n to $a_{n'}$. Based on a *deduction rule* $\lambda = (\lambda_1, \dots, \lambda_M)$, λ_j points are deducted from the j^{th} choice of applicants' scores. That is, if $r_n = \left(C_{n_1}, \dots, C_{n_{J_n}}\right)$, where college $C_{n_j} \in C$ is given rank $j = 1, \dots, J_n \leq M$ by applicant a_n, then $\pi^{\lambda}_{ma_n} = \pi_{ma_n} - \sum_{j=1}^{J_n} \lambda_j \mathbf{1}\{n_j = m\}$. Then, the Taiwan Mechanism with an associated deduction rule λ, TM(λ), applies the same procedure as DA as if the preference of each college C_m over applicant a_n was determined by $\pi_{ma_n}^{\lambda}$.[4] Again, I want to take into account the possibility that a student can be unacceptable to a college, and therefore further specify that if $\pi_{ma_n} < \bar{\pi}_m$ for some threshold $\bar{\pi}_m$ then applicant a_n is unacceptable to college C_m.

With given notation, TM(λ) is equivalent to DA when $\lambda = \lambda_{DA} \coloneqq (0, \dots, 0)$ and equivalent to BM when $\lambda = \lambda_{BM} \coloneqq (0, \pi_{max}, 2\pi_{max}, \dots, M\pi_{max})$, where π_{max} is the maximum score that can be potentially obtained by an applicant from any college. In case of DA, the relationship is clear as no changes to the preferences are made and then the procedure of DA applied. When it comes to BM, the first round runs similarly under the DA and the BM in the sense that colleges have only the applicants ranking them first to be considered. Then, in the second round, given the deduction rule λ_{BM} in combination with DA, those who apply to their second choice are artificially made worse compared to those who were accepted in the first round by deducing the maximum score from their initial scores, making sure that no student accepted in the first round can be replaced by a student applying in the second round, as in BM. Continuing this way, in each round k the deduction rule applied makes sure those who applied in round $k-1$ are made preferable to those applying in round k, following the logic of BM.

Now consider PPM applied in the field of BAE. For simplicity, I for now ignore the fact that study programmes within BAE consider applicants in terms of multiple dimensions rather than just one and that the maximum length of ROLs is restricted to six. Although formally applicants receive extra points from their top-listed options, rewarding applicants with three, two, and one extra points from their first, second, and third alternative is equivalent to adding three points to all acceptable applicants' scores and then reducing zero, one, and two points from the first, second, and third alternative and

[4] Although it was assumed that colleges have strict preferences over applicants, the assumption doesn't ensure that two applicants couldn't end up with the same score after the deduction rule has been applied. Therefore, we need to further require that the preferences given by $\pi_{ma_n}^{\lambda}$ are also strict, in which case there is no need for tie-breaking.

three from the rest. Furthermore, because the admission procedure follows DA after the priority points have been given, PPM belongs to the family of TMs. In specific, TM(λ_{BAE}) gives us PPM when $\lambda_{BAE} \coloneqq (0,1,2,3,\ldots,3)$.

The results of Dur et al. (2022) imply that PPM is not strategy-proof. I next illustrate why this is the case through Example 1.

Example 1. Suppose we have a set of applicants $A = \{a_1, a_2, a_3, a_4\}$ and a set of colleges $C = \{C_1, C_2, C_3\}$, and that all colleges have a quota of one. Further assume that colleges have homogenous preferences over applicants so that $\pi_{ma_n} = \pi_{a_n}$ $\forall m \in \{1, 2, 3\}$ and $\forall n \in \{1, 2, 3, 4\}$, and that $\bar{\pi}_m = 0$ $\forall m \in \{1, 2, 3\}$. Suppose applicants' preferences and scores are given by

- $r_1 = (C_1, C_3)$ and $\pi_{a_1} = 32.5$,
- $r_2 = (C_2, C_3)$ and $\pi_{a_2} = 31.5$,
- $r_3 = (C_3)$ and $\pi_{a_3} = 31$, as well as
- $r_4 = (C_1, C_2, C_3)$ and $\pi_{a_4} = 32$.

Thus, the colleges' preferences over students with and without the priority points are:

Deduction rule	λ_{DA}			λ_{BAE}		
College	C_1	C_2	C_3	C_1	C_2	C_3
Priority						
1	a_1	a_1	a_1	a_1	a_2	a_1
2	a_4	a_4	a_4	a_4	a_4	a_3
3	a_2	a_2	a_2	a_2	a_1	a_2
4	a_3	a_3	a_3	a_3	a_3	a_4

College C_1's preferences remain unaltered after the deduction rule has been applied. For college C_2, however, applicants a_1 and a_2 switch rankings and for college C_3, applicants a_3 and a_4 do.

Now, consider the allocation when all students truthfully report and PPM is applied, that is, when DA is applied and colleges' preferences over applicants are given by the preferences associated with the deduction rule λ_{BAE}:

Round 1.

- Applicants a_1 and a_4 apply to C_1. College C_1 tentatively accepts a_1 and rejects a_4.
- Applicant a_2 applies to C_2. College C_2 tentatively accepts a_2.
- Applicant a_3 applies to C_3. College C_3 tentatively accepts a_3.

Round 2.

- Applicant a_4 applies to C_2. College C_2 considers applicants a_2 and a_4, and tentatively accepts a_2 and rejects a_4.

Round 3.

- Applicant a_4 applies to C_3. College C_3 considers applicants a_3 and a_4, and tentatively accepts a_3 and rejects a_4.

The algorithm ends.

The final allocations and thresholds are as follows:

College	C_1	C_2	C_3
Student Assigned	a_1	a_2	a_3
Threshold	35.5	34.25	34

When all applicants truthfully report, PPM leaves applicant a_4 unassigned: after the priority points, colleges C_1, C_2, and C_3 give her scores 35, 34, and 33, respectively, while the respective entry thresholds are 35.5, 34.25, and 34. This matching isn't stable because, for instance, applicant a_4 justifiably envies applicant a_3: a_4 scores higher than a_3 and programme C_3 prefers a_4 to a_3, but a_3 is still matched to C_3 while a_4 is not.

Consider an alternative scenario where applicants a_1, a_2, and a_3 truthfully report but applicant a_4 skips her first two alternatives and reports:

- $r_4' = (C_3)$.

This ensures that after the deduction rule λ_{BAE} has been applied, programme C_3 ranks a_4 first. Then DA only runs one round, after which applicant a_1 is assigned to programme C_1, a_2 to C_2, and a_4 to C_3 while applicant a_3 is the one remaining unassigned. Thus, applicant a_4 could benefit from mis-reporting her preferences if others tell the truth.

End of Example.

As Example 1 demonstrates, there exists a problem $\{A, C, q, r, R\}$ such that reporting preferences according to r is not a weakly dominant strategy for all applicants under PPM. Therefore, PPM is not strategy-proof.

Notice that when no priority points are given, then $\lambda = (\mathbf{0})$ and the mechanism turns into DA.[5] Thus, to compare how the mechanisms with and without the priority points incentivise strategic behaviour, consider TM(λ_{BAE}) and DA and recall conditions (i) and (ii), p. 12. Because DA is strategy-proof and therefore never manipulable given any problem, it directly follows that, given any problem, if DA is vulnerable to manipulation,

[5] The fact that three points are added to all acceptable applicants' scores is irrelevant since it doesn't impact the colleges' preference orderings and affects only acceptable students so that no unacceptable student can become acceptable after the extra points are given.

then TM(λ_{BAE}) is manipulable as well. Therefore condition (i) holds. In addition, there is a problem under which TM(λ_{BAE}) is manipulable, namely, the one of Example 1. Therefore condition (ii) holds as well. Thus, we can conclude that PPM is more vulnerable compared to the mechanism's counterpart that gives no priority points.[6]

Following the analogy of BM and formalizing the idea of the given example, I next specify what is considered a mistake in the case of PPM.

Proposition 2. Under PPM, if an applicant lists colleges in an order such that

I) the first (second) college she lists has a cut-off of c,
II) the second (third) has a cut-off larger or equal to $c - 1$, and
III) the third (fourth) or any lower ranked college has a cut-off strictly smaller than $c - 1$,

there is no possibility that an applicant submitting such an ROL would be accepted by the second (third) option but submitting such an ROL only reduces the probability of her obtaining a seat in a college with a cut-off smaller than $c - 1$.

Definition 2. Application Mistake under PPM. If applicant a_n submits an ROL r_n such that conditions I), II), and III) of Proposition 2 hold, then applicant a_n makes an *application mistake under PPM.*

I require that not only do subsequent programmes have to have a cut-off smaller than one point for an ROL to be considered a mistake, but, as a distinction to school choice, those two programmes must be followed by a programme to which dropping the second (third) option would give a possibility of being accepted. This is because I consider that in the context of BAE, non-admission could be a preferable option to being matched to any programme, which is not typically the case in the context of school choice.

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[6] Dur et al. (2022) show more generally that when schools have homogenous preferences over students, TM(λ) is more vulnerable than TM(λ') when $\lambda > \lambda'$. It holds that $\lambda > \lambda'$ if all elements of λ are weakly greater than the corresponding elements of λ' and if the inequality is strict for at least one element.

3.3 Empirical Evidence and Hypothesis Formulation

Given the theoretical result of PPM being more manipulable than DA as well as the characterisation of an application mistake, I now construct the hypotheses to be tested to answer the research questions. The examples of school choice in Boston as well as college admissions in Germany and China shed light on how the theoretical predictions are supported in practice.

Because the reason why a strategy that is a mistake under PPM is considered erroneous is that it gives no chances of being admitted to the second (third) choice but only reduces the chances of obtaining a seat at a lower ranked choice, we would expect students having incentives to skip the erroneous second (third) choice from their ROLs under PPM. Example 2 illustrates why this could be the case, taking into account that students don't know their scores at the time of submitting their ROLs, as opposed to Example 1.

Example 2. Continuing with the set-up of Example 1, we have four applicants and three colleges with quotas of one and homogenous preferences over applicants. Recall the preferences and scores of applicants a_1, a_2, and a_3:

- $r_1 = (C_1, C_3)$ and $\pi_{a_1} = 32.5$,
- $r_2 = (C_2, C_3)$ and $\pi_{a_2} = 31.5$, and
- $r_3 = (C_3)$ and $\pi_{a_3} = 31$.

Suppose applicant a_4 also has the same preferences over programmes as in Example 1 so that $r_4 = (C_1, C_2, C_3)$, but now suppose she doesn't know her score; instead, she knows the distribution of the score. Suppose the distribution is such that applicant a_4 believes she scores strictly above 32.5 with probability $\frac{1}{2}$, and between 32 and 32.5 with probability $\frac{1}{2}$.

Then denote the utility applicant a_n gets from being matched to programme C_m with $u_n(C_m)$. Suppose others truthfully report. If applicant a_4 truthfully reports as well and scores above 32.5, she is assigned to C_1. If she truthfully reports but scores below 32.5 then she is not assigned to any programme.[7] Therefore, her expected utility when truthfully reporting is $\frac{1}{2}u_4(C_1)$, setting the utility from non-assignment to zero.

Now consider applicant a_4 dropping C_2 from her ROL and reporting

- $r_4' = (C_1, C_3)$

while others report truthfully. Then, again, if applicant a_4 scores above 32.5, she is assigned to C_1. If she scores below 32.5, she is assigned to programme C_3. Therefore, her expected utility from submitting r_4' is $\frac{1}{2}u_4(C_1) + \frac{1}{2}u_4(C_3)$.

Therefore, we get

$$\frac{1}{2}u_4(C_1) + \frac{1}{2}u_4(C_3) > \frac{1}{2}u_4(C_1).$$ [8]

That is, for a_4, the expected utility from submitting r_4' is strictly larger than the expected utility from truthfully reporting.

End of example.

[7] Suppose the score is continuously distributed so that the probability of a_1 and a_4 ending up with the same score is zero.

[8] Because we set the utility from non-assignment to zero and because we assume that applicants have strict preferences over colleges, an applicant's utility obtained from being matched to an acceptable college must be strictly positive. Therefore $u_4(C_3) > 0$ which implies $\frac{1}{2}u_4(C_1) + \frac{1}{2}u_4(C_3) > \frac{1}{2}u_4(C_1)$.

Empirical evidence of applicants avoiding making mistakes by dropping the erroneous second option under BM is found, for instance, in the context of school choice in Boston as well as in the context of college admissions in Germany. BM was named after the mechanism that was used to allocate students to elementary, middle, and high schools in Boston from 1999 until 2005 when it was replaced by DA (Abdulkadiroğlu et al., 2006). By looking at discontinuities in students' rankings of over-demanded schools, Abdulkadiroğlu et al. (2006), find that some students' parents avoid listing an over-demanded school as second option. For example, the most popular school had almost 200 students ranking it first, but only just over 30 ranked it second. In general, a one-unit increase in the ratio between the number of applicants ranking a school first and the school's capacity, calculated using the previous year's numbers, was associated with twenty more students ranking the school first than second.

Braun, Dwenger, and Kübler (2010) study second-choice behaviour under BM in the context of college admissions in the field of medicine in Germany in 2006 and find similar results as Abdulkadiroğlu et al. (2006). The fraction of students ranking an over-demanded college as first was around seven percentage points larger than the fraction ranking such college second. The regression results of Braun, Dwenger, and Kübler indicate that there is a clear difference between ranking an over-demanded college first or second. They additionally show that no such differences are found for other rankings, indicating that a discontinuity indeed lies between the first and the second option.

Given Example 2 and the real-life evidence from Boston and Germany, we have a reason to suspect that, under PPM, applicants would avoid making application mistakes by avoiding listing an erroneous second or third choice – that is, listing a study programme with an entry threshold larger or very close to the first (second) ranked option second (third). The following recommendation from the University of Jyväskylä application guide to BAE (2017) even strengthens the perception that applicants should indeed be aware of and even informed about this property: "…For this reason, you should carefully consider how to rank the programmes. If you apply to Jyväskylä as your first choice, you probably shouldn't rank Aalto second as it has considerably higher cut-off scores."[9]

Thus, recalling the result that PPM is more manipulable than DA, we are ready to construct the first hypothesis to be tested:

Hypothesis 1a. Students avoid ranking programmes with small expected cut-off differences among the first four alternatives more under PPM compared to DA.

There is a difference in how serious an application mistake is depending on how high chances of admittance the applicant has to her top ranked option. Abdulkadiroğlu et al. (2006) say that the strategy defined as an application mistake under BM is always a weakly suboptimal response but a strictly suboptimal one in case chances of obtaining the top choice are low. This applies to PPM as well, as demonstrated in Example 3.

Example 3. Again, continue with the set-up of Example 2, but this time let the beliefs of applicant a_4 be such that she believes she scores above 32.5 with probability $\varepsilon \in [0, 1]$ and between 32 and 32.5 with probability $1 - \varepsilon$.

Now truthful reporting gives her expected utility of $u_4(C_1)\varepsilon$, whereas if she reported

- $r_4' = (C_2, C_3)$

she would be assigned to C_2 with probability one and therefore her expected utility would be $u_4(C_2)$, conditional on others truthfully reporting.

Now when $\varepsilon \longrightarrow 1$, the mistake the applicant makes when she truthfully reports and doesn't skip C_2 from her ROL is irrelevant in the sense that she'll be matched to her top choice no matter what and that she can ensure utility level that approaches $u_4(C_1)$.

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9 Author's translation.

However, if applicant a_4 only has a random priority to C_1, that is, if $\varepsilon \longrightarrow 0$, submitting r_4' always gives a strictly higher utility than truthful reporting as $u_4(C_1)\varepsilon$ approaches zero. Thus, if applicant a_4 expects low chances of admittance to her favourite programme, she is strictly better off by dropping that option from her ROL.

End of example.

The skipping of popular school's from ROLs was a widely known strategy in Boston, where students were even directly recommended by the Boston Public School to list a less popular school first as opposed to one's true favourite (Abdulkadiroğlu et al., 2006). Empirical evidence of such behaviour is found in the context of Chinese college admissions. Since 2001, Chinese provinces have gradually moved from BM to a so-called Parallel mechanism (Chen & Kesten, 2019) which belongs to the family of TMs and is a less manipulable mechanism compared to BM (Dur et al., 2022). Using data on the province of Sichuan where PA was introduced in 2009, Chen, Jian, and Kesten (2020) find support to the theoretical predictions (2017) and experimental findings (2019) of Chen and Kesten of students avoiding ranking prestigious colleges as their first choice. They measure prestigiousness by students' average scores and by national rankings of colleges.

When it comes to PPM, by listing a study programme with a high entry threshold a student risks "wasting" the three extra points for a programme she has no chances being admitted to – or even if she has, it is a risky alternative to do so. Because of this pressure to apply to safer options and because not all students can expect to score higher than the cut-off of the most-difficult-to-get-in programmes, we can formulate the second hypothesis to be tested as follows:

Hypothesis 1b. Students avoid ranking programmes with high expected cut-off scores as their first choice more under PPM compared to DA.

If students avoid applying to programmes with small cut-off differences among their first four alternatives as well as applying to prestigious programmes under priority mechanisms, that alone should translate into applicants submitting shorter ROLs under BM and PPM compared to DA. However, shorter ROLs under priority mechanism could also be expected because of something called *irrelevance at the bottom*; if a student expects zero admission probabilities for the lower ranked options, she may drop those programmes as well because it will end up being a pay-off irrelevant change in her ROL (Fack et al., 2019). Because the nature of priority mechanisms is to give higher chances of admittance to the higher ranked programmes, skipping programmes because of irrelevance at the bottom is exactly what could be expected under BM and PPM.

The phenomenon that programmes that are ranked low may be irrelevant can be seen from Example 1. When PPM is applied and all students truthfully report, all accepted students are matched to the programme they reported first; it is irrelevant whether any of the applicants report other programmes after their favourites or not. Notice that if DA was applied, then students a_1, a_2, and a_4 would be accepted by their first (a_1) and second (a_2 and a_4) reported options.

Chen, Jian, and Kesten (2020) find that students do indeed submit shorter ROLs under BM compared to PA: under PA, students list almost one college more than under BM. The preceding discussion motivates the third hypothesis to be tested:

Hypothesis 1c. Students submit shorter ROLs under PPM compared to DA.

Theory doesn’t tell us anything about whether some students fail in responding to the strategic incentives the mechanism offers and end up making application mistakes. However, although there is evidence of students avoiding making mistakes under BM in Boston and in Germany, some students still ranked an over-demanded school or college as their second choice. In Boston, about one fifth of the students listed two over-demanded school as their first and second choice (Abdulkadiroğlu et al., 2006). In contrast, in Germany, the number of students ranking an over-demanded college as a second option was larger, almost one half (Braun et al., 2010).

It is unclear how these results generalize to the context of PPM and the field of BAE in specific, and therefore, we want to test the following and our final hypothesis:

Hypothesis 2. Applicants who make application mistakes under PPM exist.

In this chapter, I gave a brief theoretical background and introduced two mechanisms, DA and BM, which I generalised into the family of TMs. I then showed that PPM belongs to this family. I demonstrated that PPM is not strategy-proof and that it is more manipulable than DA. By formulating a strategy that an applicant can only be hurt, I characterised what is considered an application mistake under PPM. Then, given these theoretical results as well as examples and empirical evidence introduced, I constructed hypotheses to be tested to answer the research questions. The hypotheses are summarized in Table 2.

Table 2. Research Questions and Associated Hypotheses.

Research Question	No.	Hypothesis
1. Is the applicants' behaviour in line with some applicants strategizing in the presence of the priority points? and 2. If they do, how do they strategize?	1a	Students avoid ranking programmes with small expected cut-off differences among the first four alternatives more under PPM compared to DA.
	1b	Students avoid ranking programmes with high expected cut-off scores as their first choice more under PPM compared to DA.
	1c	Students submit shorter ROLs under PPM compared to DA.
3. Are there students who make application mistakes?	2	Applicants who make application mistakes under PPM exist.

4. Data and Summary Statistics

To study the research questions, I combine register data from multiple resources. For information on applicants' full ROLs as well as admittance- and first-timer status, I use the student admission register from Finnish National Agency for Education (OPH). The register covers all applications to Finnish universities and polytechnics for the period 2016–2018. In addition, information on number of times applied is obtained from the same register. To link applicants to their background characteristics, I use the FOLK personal data modules from Statistics Finland, which include information on applicants' gender, year of birth, native language, and whether they live in an urban or rural area. Data on which of the applicants are high school graduates as well as their year of graduation, exams taken, and grades from the exams is offered by the Matriculation Examination Board (YTL). Both, the FOLK modules and the YTL data cover the years 2016–2018. Data on BAE study programmes' thresholds is public (Kauppatieteet).

To study whether the applicants' behaviour is in line with students being strategic as well as potential application strategies under PPM, I use information on applicants applying two years arow when there was no change in the mechanism (applied 2016 and 2017) and when there was (applied 2017 and 2018). I call these students two- or multiple-year students, interchangeably. To study whether there exist students who make application mistakes, I use information on all BAE applicants applying in 2016 or 2017. In this thesis, I only use information on those applicants who have a Finnish Personal Identity Code.

Table 3 reports summary statistics for BAE applicants applying in 2016 and 2017 for three categories: all students (columns 1 and 2), accepted students (columns 3 and 4), and students who applied the following year as well (columns 5 and 6). Applicants are similar across groups and years: over one half of the applicants are males, they are on average 21 to 22 years old, the vast majority are native Finnish speakers, first-timers, and high school graduates and live in urban areas. Some differences persist, but they are small: Accepted and multiple-year students are on average just over 21 years old, all applicants around 22.

Table 3. Summary Statistics by Applicant Group and Year.

Applicants		All		Accepted		2-year	
Year		2016	2017	2016	2017	2016	2017
Variable		(1)	(2)	(3)	(4)	(5)	(6)
Male (= 1)		0.58	0.56	0.59	0.56	0.59	0.59
Age		22.07	21.99	21.25	21.17	21.21	21.11
Native Finnish Speaker (= 1)		0.96	0.95	0.98	0.98	0.96	0.95
Lives in Urban Area (= 1)		0.90	0.88	0.97	0.95	0.89	0.88
First-timer (= 1)		0.85	0.85	0.86	0.87	0.92	0.92
Yo-graduate (= 1)		0.92	0.92	0.97	0.97	0.94	0.95
Times applied before	0	0.61	0.60	0.41	0.43	0.60	0.61
	1	0.25	0.25	0.38	0.35	0.27	0.25
	2	0.09	0.10	0.16	0.17	0.08	0.09
	≥ 3	0.05	0.05	0.05	0.05	0.05	0.05
Observations		*9,773*	*9,930*	*1,471*	*1,476*	*3,322*	*3,220*

Note: The table reports means for student characteristics as well as the distribution for times applied before by applicant group and year. A student is a 2-year applicant if she applied the following year as well. A student is a first-timer if she doesn't have an existing academic degree and haven't accepted any offer from a college in 2014 or later. A student is a yo-graduate in case she has a Finnish Matriculation Examination degree. "Times applied before" refers to number of times applied before since 2009.

The fraction of accepted students who come from urban areas is around 95 % whereas the corresponding number for the other two groups is approximately seven percentage points lower. The group of accepted students has slightly larger number of students who have completed the Finnish Matriculation Examination, and first-timers are slightly more represented in the group of two-year students.

As seen from Table 3, applying multiple times is frequent among BAE applicants. The number of two-year applicants is over 3 000 in both years, and they constitute around one third of all applicants applying the same year. For all students and multiple-year applicants, each year around two fifths had applied at least one time before. When it comes to students who were accepted, for almost 60 %, more than one attempt was required before admittance.

Table 4 reports information on BAE applicants' matriculation examination performance for all, accepted, and two-year students for years 2016 and 2017. The distribution of grades in the mother tongue exam and the fraction taking the test in long math differs across categories but not considerably within categories across years. Subtle differences occur for accepted students; recall that the matriculation examination-based admission was introduced in 2017.

Unsurprisingly, the distribution of grades in the mother tongue test are more skewed to the left for accepted students compared to the other two categories. The distribution for multiple-year students seems to have slightly less mass in the top 20 % and slightly more in the middle 60 % when compared to all applicants, potentially explained by the fact that accepted students are included in the set of all applicants but not for multiple-year students.[10] The pattern is similar for the fraction taking the test in long math: the fraction is highest for accepted students and slightly higher for all compared to two-year students.

[10] In 2016 and 2017, around 1 % of accepted students applied again the following year.

Table 4. Matriculation Examination Performance by Applicant Group and Year.

Applicants		All		Accepted		2-year	
Year		2016	2017	2016	2017	2016	2017
Variable		(1)	(2)	(3)	(4)	(5)	(6)
Mother Tongue	Top 20 %	0.19	0.20	0.34	0.37	0.15	0.17
	Middle 60 %	0.73	0.72	0.63	0.59	0.76	0.75
	Bottom 20 %	0.08	0.08	0.03	0.04	0.09	0.08
Advanced Math	(= 1)	0.41	0.41	0.52	0.54	0.39	0.39
Observations		*8,979*	*9,139*	*1,421*	*1,437*	*3,133*	*3,056*

Note: The table reports the fractions of students who received grades L or E (top 20 %), M, C, or B (middle 60 %), and A or I (bottom 20 %) in the mother tongue test as well as the fraction of students taking the test in mathematics, advanced syllabus level, in the Finnish Matriculation Examinations by applicant group and year.

The data on applicants' entrance exam scores is incomplete, and therefore, no information on exam scores is used. Following the principles of good research ethics, all data used is anonymised, and no individual can be identified from any statistics or results reported in the thesis. In addition, the empirical methods presented next are pre-determined and not affected by any results found.

5. Empirical Approach

In this chapter, I introduce the empirical approach applied to study the research questions and to test the hypotheses constructed. In Section 5.1, I first define the outcome variables associated with each hypothesis to be tested and in Section 5.2, I introduce the empirical method applied to investigate sophisticated behaviour.

5.1 Outcome Variables

In subsection 5.1.1, I specify the outcome variables associated with investigating sophisticated behaviour – that is, Hypotheses 1a, 1b, and 1c – and in subsection 5.1.2, the outcome variables associated with application mistakes, Hypothesis 2. For each of the hypotheses, the unit of observation I use is applicant i in year t.

5.1.1 Sophisticated Behaviour

To construct the outcome variables associated, recall Hypothesis 1a:

Hypothesis 1a. Students avoid ranking programmes with small expected cut-off differences among the first four alternatives more under PPM compared to DA.

To test Hypothesis 1a, I specify three outcome variables for which $Y_{it} = 1$ if applicant i applies to two programmes with small expected cut-off differences as subsequent choices among the first four alternatives in year t, and for which $Y_{it} = 0$ otherwise. I do this by looking at programme pairs that have had small cut-off differences with respect to the entrance exam score during 2015–2017. The relative cut-offs are reported in Table 5. Then, conditional on applicant i applying to one of the two as one of her top three choices in year t, I consider that the applicant does not avoid ranking programmes with small cut-off differences if the programme is followed by the other one of the two. Namely, I specify the following three outcomes:

Table 5. Study Programmes' Relative Entry Thresholds and Division into Groups.

Criterium	Exam			Joint			**Group**
Year	2015	2016	2017	2015	2016	2017	
Programme							
Aalto	0	0	0	0	0	0	1
Tampere	-1.75	-2	-1	-6.5	-4.25	-4.25	2
Turku	-2.5	-.75	-.25	-5	-3.5	-3	2
Vaasa	-6.5	-6	-3.75	-12.75	-12	-13	3
Lappeenranta	-6.75	-6.25	-3.25	-13.5	-10.25	-10.5	3
Pori	-7.5	-8.5	-5.5	-13.75	-15.25	-14.5	4
Jyväskylä, BE	-8	-3.75	-3.5	-11.75	-9.25	-10	3
Oulu	-8.25	-7	-4.75	-15.25	-13.25	-14.25	4
Kuopio	-8.5	-6	-5	-14.25	-11.25	-14	4
Joensuu	-9	-8	-6.5	-17.25	-15.25	-16	4
Jyväskylä, E	-10	-7	-4.5	-16.25	-12.5	-12.25	4

Note: The table reports study programmes' entry thresholds by criterium and year, relative to Aalto's thresholds: value $-x$ indicates that a study programme's threshold was x points lower than Aalto's. Jyväskylä BE and Jyväskylä E refer to programmes Jyväskylä Business Economics and Jyväskylä Economics, respectively.

Outcome I, Hypothesis 1a. Small-Point Difference Behaviour: Aalto and Turku.

$Y_{it}|$(Student i ranks Aalto 1st in year t)$=$ $\mathbf{1}${Student i ranks Turku 2nd in year t}.

Outcomes II and III, Hypothesis 1a. Small-Point Difference Behaviour: Tampere and Turku (II), Lappeenranta and Vaasa (III).

$Y_{it} | (\text{Student } i \text{ ranks } C_m \text{ or } C_{m'} \text{ in year } t\ n^{\text{th}})$
$= \mathbf{1}\{\text{Student } i \text{ ranks } C_m \text{ or } C_{m'} \text{ in year } t\ (n+1)^{\text{th}}\}$, where

I. $(C_m, C_{m'}) = (\text{Turku, Tampere})$ and $n \leq 2$ and
II. $(C_m, C_{m'}) = (\text{Lappeenranta, Vaasa})$ and $n \leq 3$.[11]

Then, recall Hypotheses 1b and 1c:

Hypothesis 1b. Students avoid ranking programmes with high expected cut-off scores as their first choice more under PPM compared to DA.

Hypothesis 1c. Students submit shorter ROLs under PPM compared to DA.

It should be clear that Aalto is the study programme with the highest threshold. Thus, to test Hypothesis 1b, the outcome variable Y_{it} is a dummy indicating whether student i applied to Aalto as her first choice at year t:

Outcome, Hypothesis 1b. First-Choice Behaviour.

$Y_{it} = \mathbf{1}\{\text{Student } i \text{ ranks Aalto first in year } t\}$.

Finally, for Hypothesis 1c, Y_{it} is simply the length of the ROL of student i at year t:

Outcome, Hypothesis 1c. ROL length.

$Y_{it} = |ROL_{it}|$.

---

[11] No applicant can potentially rank the same programme as her n^{th} and $(n+1)^{\text{th}}$ choice.

Hypotheses 1a, 1b, and 1c, and the associated outcomes are related so that if the hypotheses were true, then positive effects of the switch from PPM to DA on outcomes should be found; small values of the outcomes related to Hypotheses 1a, 1b, and 1c are associated with avoidance of ranking programmes with small expected cut-off differences among the first alternatives, avoidance of ranking programmes with high cut-off scores first and submittance of shorter ROLs, respectively. In other words, a positive effect of the removal of the priority points on associated outcomes, conditional on the procedure of DA being applied, would give support to the Hypotheses 1a, 1b, and 1c. That in turn would support the claim that students strategize under PPM, and in ways expected.

5.1.2 Application Mistakes

To specify the outcome variables associated, recall Hypothesis 2:

Hypothesis 2. Applicants who make application mistakes under PPM exist.

To test Hypothesis 2, I specify an outcome variable such that $Y_{it} = 1$ when an applicant makes a mistake and $Y_{it} = 0$ otherwise. As mentioned, PPM applied in practice slightly differs from TM(λ_{BAE}) – namely, by students being evaluated across multiple criteria – for which reason the definition of a mistake given in Chapter 3 cannot be directly applied. Therefore, I define two outcome variables to study Hypothesis 2.

Denoting the actualised cut-off with respect to admission type a – either entrance exam or composite score – of a programme student i reports as her n^{th} option in year t by c_{itn}^{a}, I specify the first outcome variable to test Hypothesis 1 as follows.

Outcome I, Hypothesis 2. Mistake.

$Y_{it} = \mathbf{1}\{$Student i submits an ROL in year t such that a) or b) or c) holds$\}$,

where a), b), and c) are given by

a) For both admission types a and for some $n \in \{3,4,5,6\}$

   $c_{it2}^{a} \geq c_{it1}^{a} - 1$ and $c_{itn}^{a} < c_{it1}^{a} - 1$,

b) For both admission types a and for some $n \in \{4,5,6\}$

   $c_{it3}^{a} \geq c_{it2}^{a} - 1$ and $c_{itn}^{a} < c_{it2}^{a} - 1$, and

c) The 2[nd] ranked option is Turku IB, and for both admission types a and for some $n \in \{4,5,6\}$

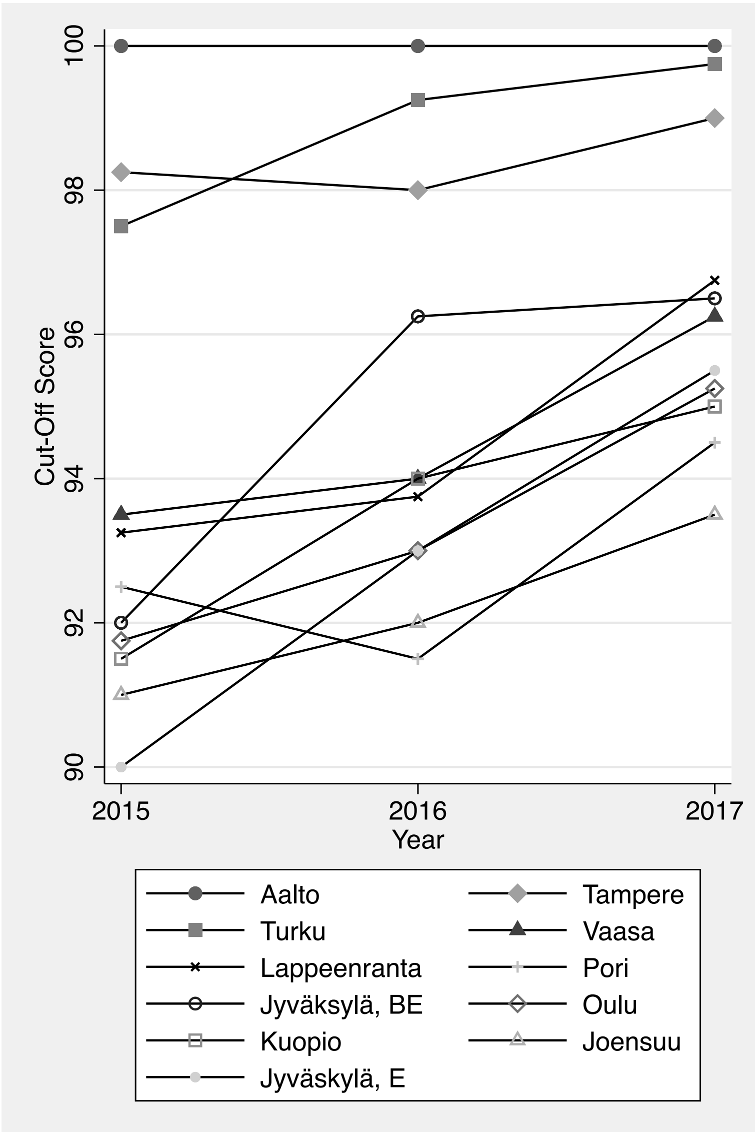
   $c_{it3}^{a} \geq c_{it1}^{a} - 2$ and $c_{itn}^{a} < c_{it1}^{a} - 2$.

Notice that even though the matriculation examination-based admission was introduced in 2017, ROLs fulfilling some of the conditions a), b), or c) would still be mistakes: because an applicant could be accepted in the matriculation examination queue only by her first ranked option in 2017, it is the relative thresholds of the other admission types that matter. Since Turku IB participated in the BAE admissions in 2016 and 2017 but it has a separate admission procedure compared to other study programmes within BAE, I take the approach that it can be listed in any position in an ROL without it being a mistake unless some of the conditions a), b), or c) holds.

An applicant ending up doing a mistake given by Outcome I, Hypothesis 2, doesn't necessarily lack understanding of the strategic incentives PPM offers but may just have inaccurate beliefs of the admission thresholds. Indeed, applicants do not have information about the thresholds of the year of application, but rather, they can use public information from previous years' thresholds which are not stable across years. Especially, for study programmes other than Aalto, Turku, and Tampere, the order of thresholds varies across years as seen in Figure 3. What is more, also the score differences between thresholds of study programmes vary year by year and within a year depending on the admission type as seen in Table 5.

To investigate whether some applicants clearly lack strategic sophistication, I therefore consider another outcome variable for making a mistake. For this approach, I assume that in 2017, a strategically sophisticated applicant reasonably ranks study programmes across groups of programmes after considering the previous years' cut-offs (2015 or 2016) or the realistic expected cut-offs (2017). Namely, based on the thresholds of 2015, 2016, and 2017, I consider a division of study programmes into four groups given by Table 5.

Panel A. Entrance Exam.



Panel B. Composite Score.

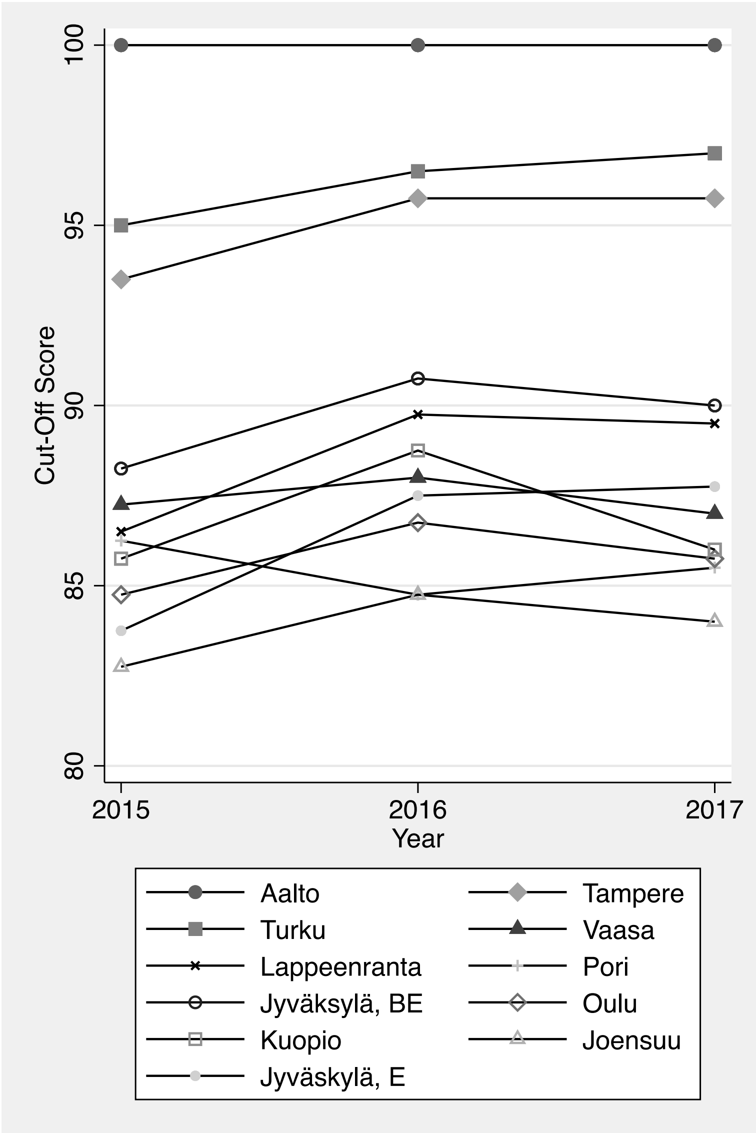


Figure 3. Study Programmes' Entry Thresholds across Years.

Note: Aalto's cut-off is set to 100. Other programme's cut-off scores are set relative to Aalto's. The composite score is determined as the sum of entrance exam and matriculation examination scores.

The division is such that if programme m is from group g and programme m' from group g' and $g > g'$, then the entry threshold of programme m is at maximum the entry threshold of programme m' plus one for all years 2015–2017 and for both criteria. The threshold differences across groups are illustrated in Table 6. This means that regardless of which year the applicant takes as a basis of her expectations, if the first (second) ranked option's group index g is larger than the second (third) ranked one's, there is no chance that the applicant would be accepted by the second (third) option.

Table 6. Maximum Threshold Differences between Programme Groups.

Group	1	2	3	4
1	.	-0.25	-3.25	-4.5
2	.	.	-1.75	-3.5
3	.	.	.	0.75
4	.	.	.	.

Note: The cells of the table are determined as $\max_{m,m',a,t} c_{mta} - c_{m'ta}$, where c_{mta} is the entry threshold of programme m in year t with respect to admission type a, and programme m belongs to the group determined by the column and programme m' to the group determined by the row.

On the other hand, for all programmes m and m' such that programme m is from group g and programme m' from group g' and $g > g'$, there is at least one year and criterium such that the entry threshold of programme m' is more than two points larger than that of programme m. The maximum point differences between all study programmes are reported in Appendix, Table 19.[12] This means that if an applicant ranks the programmes in ascending order of group index as subsequent choices among her first alternatives, then, based on the thresholds of 2015–2017, there is a realistic chance that she would be accepted by the lower ranked of the two. Because a point-difference of more than two points can be found for all study programmes from different groups, this is true even if programme Turku IB was ranked between the two programmes.

[12] For programmes Vaasa and Kuopio, this maximum difference is exactly 2 points which I consider an irrelevant shortcoming.

Therefore, with the following specification, it can be considered that if applicant i submits an ROL in year t such that $Y_{it} = 1$, then, she makes what I call an obvious mistake.

Outcome II, Hypothesis 2. Obvious Mistake.

$Y_{it} = \mathbf{1}\{$Student i submits an ROL in year t such that A) or B) holds$\}$,

where A) and B) are given by

A) The first (second) listed programme is from Group n, the second (third) from Group n' such that $n' < n$ and the third (fourth) or lower ranked from Group n'' such that $n'' > n$, and

B) The second listed programme is Turku IB, the first from Group n, the third from Group n' such that $n' < n$ and the fourth or lower ranked from Group n'' such that $n'' > n$.

When it comes to the outcomes defined, positive means of the outcomes would give support to Hypothesis 2.

Table 7 summarizes the outcome variables associated with each hypothesis and demonstrates what kind of results found for each outcome variable would be in line with the related hypothesis.

Table 7. Outcome Variables and Findings Supporting Hypotheses.

No.	Hypothesis (H)	Measure	Outcome Y_{it}	H supported if…
1a	Students avoid ranking programmes with small expected cut-off differences among the first four alternatives more under PPM compared to DA.	Small-Point Difference Behaviour	I: Aalto & Turku	Effect of the removal of the priority points on Y_{it} positive
			II: Turku & Tampere	Effect of the removal of the priority points on Y_{it} positive
			III: Lappeenranta & Vaasa	Effect of the removal of the priority points on Y_{it} positive
1b	Students avoid ranking programmes with high expected cut-off scores as their first choice more under PPM compared to DA.	First-Choice Behaviour	Ranking Aalto 1st	Effect of the removal of the priority points on Y_{it} positive
1c	Students submit shorter ROLs under PPM compared to DA.	ROL Length	ROL Length	Effect of the removal of the priority points on Y_{it} positive
2	Applicants who make application mistakes under PPM exist.	Mistake	I: Mistake	$\sum_{i=1}^{N} Y_{it}$ positive in year t
		Obvious Mistake	II: Obvious Mistake	$\sum_{i=1}^{N} Y_{it}$ positive in year t

5.2 Investigation of Sophisticated Behaviour

When it comes to investigating whether some students make application mistakes, the empirical approach applied is straightforward, as only the means of given outcomes needs to be determined. Therefore, in this subsection I introduce the empirical method applied to study strategic behaviour only, that is, to investigate Hypotheses 1a, 1b, and 1c, addressing the fact that the removal of the priority point system coincided with other changes in the admission procedure within BAE, as explained in Chapter 2. In section 5.2.1, I argue that under some reasonable conditions, if an effect associated with the removal of the priority points and the other criteria is identified, then, it should only give us a conservative estimate of the effect of the removal of the priority points alone. In section 5.2.2, I then specify the identification strategy applied.

5.2.1 Impact of Other Changes in Admission Criteria on the Treatment Effect

Recall that to test Hypotheses 1a, 1b, and 1c, we need to determine the effect of the removal of the priority points on different outcome variables. To specify what the effect we are interested in indeed is, first define the following zero-one variable that indicates when the priority points are applied and when they are not:

$PP_{it} = \mathbf{1}\{$Priority points *not* in use in year t for applicant $i\}$.

Then, define two other variables that indicate whether the matriculation examination-based admission is applied or not and whether an applicant can be accepted only by her first reported alternative or by any alternative. Namely, define YO_{it} such that $YO_{it} = 1$ if, for applicant i in year t, the matriculation examination-based admission that considers all possible rankings is applied and $YO_{it} = 0$ otherwise. Then define YO_{it}^1 such that $YO_{it}^1 = 1$ if, for applicant i in year t, the matriculation examination-based admission that considers only the first rankings is applied and $YO_{it}^1 = 0$ otherwise.

$YO_{it} = 1$ and $YO_{it}^1 = 1$ cannot hold simultaneously; when $YO_{it} = 0$ and $YO_{it}^1 = 0$, the entrance exam and combination point-based admission is applied, which I refer to as the baseline criteria. Therefore, $YO_{it} = 0$, $YO_{it}^1 = 0$ refers to the criteria similar to the ones applied in 2016, $YO_{it} = 0, YO_{it}^1 = 1$ to the ones applied in 2017, and $YO_{it} = 1, YO_{it}^1 = 0$ to those of 2018 (recall Figure 2, p. 9). Table 8 summarizes.

Table 8. Admission Criterium Variables' Interpretations.

Value of YO_{it}^1 / **Value of YO_{it}**	1	0
1	Cannot occur.	Matriculation Examination-based admission applied such that an applicant can be accepted by any option regardless of the ranking.
0	Matriculation Examination-based admission applied such that an applicant can be accepted only by her 1st reported option.	Baseline Criteria.

Further define zero-one treatment variables D_{it} and D'_{it} such that for D_{it}

$D_{it} = 0 \Leftrightarrow PP_{it} = 0, YO_{it} = 0$, and $YO_{it}^1 = 0$ and
$D_{it} = 1 \Leftrightarrow PP_{it} = 1, YO_{it} = 0$, and $YO_{it}^1 = 0$,

and for D'_{it}

$D'_{it} = 0 \Leftrightarrow PP_{it} = 0, YO_{it} = 0$, and $YO^1_{it} = 1$ and
$D'_{it} = 1 \Leftrightarrow PP_{it} = 1, YO_{it} = 1$, and $YO^1_{it} = 0$.

Then denote the *potential outcome* with respect to treatment D_{it} (D'_{it}) for applicant i in year t when untreated, that is, when $D_{it} = 0$ ($D'_{it} = 0$) with Y_{0it} (Y'_{0it}), and as treated, that is, when $D_{it} = 1$ ($D'_{it} = 1$) with Y_{1it} (Y'_{1it}).

With given notation, to test Hypotheses 1a, 1b, and 1c, what we would like to capture is the *Average Treatment Effect* (ATE) with respect to treatment D_{it},

$$\mathbb{E}[Y_{1it} - Y_{0it}],$$

the ATE with respect to PP_{it} conditional on the baseline criteria being applied.[13]

However, as $D_{it} = 1$ doesn't hold for any year t, Y_{1it} is never observed for any individual. Therefore, if we are able to identify an effect associated with a change in PP_{it} based on observed potential outcomes, the effect can be confused with $\mathbb{E}[Y'_{1it} - Y'_{0it}]$ or $\mathbb{E}[Y'_{1it} - Y_{0it}]$.[14] As shifts from $D_{it} = 0$ or $D'_{it} = 0$ to $D'_{it} = 1$ are associated with changes in other variables than just PP_{it}, we are no longer certain about whether the effect is driven by the change in priority points.

Nevertheless, as large values of the ATE with respect to D_{it} are in favour of Hypotheses 1a, 1b, and 1c (recall Table 7, p. 41), if we could make the case that $\mathbb{E}[Y_{1it}] \geq \mathbb{E}[Y'_{1it}]$ and $\mathbb{E}[Y_{0it}] \leq \mathbb{E}[Y'_{0it}]$, then, the limitation of not being able to identify ATE with respect to D_{it} would only lead into conservative estimates when confused with the other two effects, as illustrated in Figure 4: if the two inequalities (Inequalities 1 and 2, Figure 4) hold, it follows that $\mathbb{E}[Y_{1it} - Y_{0it}] \geq \mathbb{E}[Y'_{1it} - Y_{0it}] \geq \mathbb{E}[Y'_{1it} - Y'_{0it}]$ (Inequality 3, Figure 4).

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[13] To be precise, we are interested in the ATE($\boldsymbol{X}$), that is, the ATE conditional on some variables $\boldsymbol{X}$.
[14] $\mathbb{E}[Y'_{1it} - Y_{0it}]$ is the ATE with respect to d_{it} such that $d_{it} = 0 \Leftrightarrow D_{it} = 0$ and $d_{it} = 1 \Leftrightarrow D'_{it} = 1$.

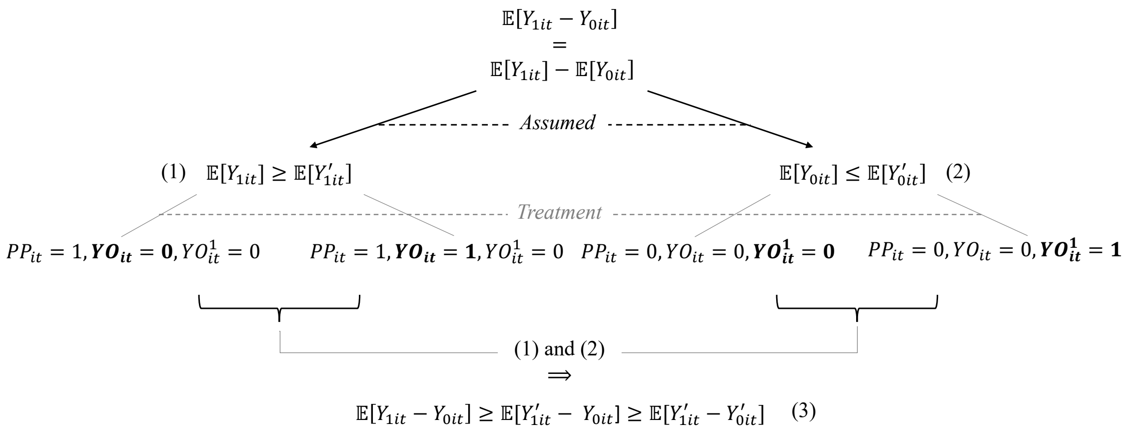


Figure 4. Illustration: Assumptions Yielding Conservative Estimates.

Note: The figure illustrates that in case Inequalities 1 and 2 hold, then, if a treatment effect that is confused with the other changes in the BAE admission criteria that took place in 2018 is identified, that should only give us conservative estimates for the switch from PPM to DA alone, conditional on the baseline criteria.

First consider $\mathbb{E}[Y_{1it}] \geq \mathbb{E}[Y'_{1it}]$, that is, Inequality 1 in Figure 4. $\mathbb{E}[Y_{1it}]$ and $\mathbb{E}[Y'_{1it}]$ differ in terms of whether the matriculation examination-based admission is applied or not but, for both, the priority points are absent. When the priority point system is not applied, students can do no better than to state the programmes in a truthful order regardless of whether the matriculation examination-based admission is applied or not. On the other hand, there should be no reason why applicants who – for one reason or another – don't understand that truthful revealing of preferences pays off in the absence of priority points would apply differently due to application of matriculation examination-based admission.

The only channel through which the matriculation examination-based admission could matter is that an applicant can be indifferent between submitting an ROL corresponding to her true preferences and an ROL that differs through programmes to which applicants expect zero admission probabilities being dropped (Fack et al., 2019). As discussed in Chapter 2, there is more uncertainty related to the entrance exam scores compared to matriculation examination scores. For that reason, irrelevance at the bottom should be more prevalent when the matriculation examination-based admission is applied. Therefore, applicants should expect non-zero admission probabilities more often when evaluated through entrance exam performance, giving support to $\mathbb{E}[Y_{1it}] \geq \mathbb{E}[Y'_{1it}]$.

For $\mathbb{E}[Y_{1it}] \geq \mathbb{E}[Y'_{1it}]$ not to hold, we should have students who expect doing so badly in the entrance exam that they wouldn't have any chances of being admitted to some programmes and deciding not to include those programmes in their ROLs – even if that wouldn't hurt them – while expecting having chances of being accepted to those programmes if the matriculation examination-based admission was applied. That is, *skipping the impossible* (Fack et al., 2019) should be a more prevalent phenomenon when the baseline criteria are applied compared to when the matriculation examination-based admission is applied. I consider that it is reasonable to assume that this is not the case.

Then consider $\mathbb{E}[Y_{0it}] \leq \mathbb{E}[Y'_{0it}]$, that is, Inequality 2 in Figure 4. The change in the rule that a student could be accepted in the matriculation examination-based criteria by her first listed option, conditional on priority points being applied, isn't necessarily without strategic incentives: if an applicant isn't accepted by her first choice in the matriculation examination queue, she loses the possibility of being accepted with respect to that admission type by any other programme.

For example, consider an applicant who would apply to Aalto first and Turku second if the baseline criteria and priority points were applied. Now, everything else constant, if the matriculation examination-based admission that only considered the first-stated option was applied instead of the baseline criteria, listing Aalto first gives zero probability of being admitted in the matriculation examination queue to Turku. This matters if the applicant believes she has high chances of admittance in the matriculation examination queue to Turku, but lower ones to Aalto with respect to any admission type. In this case, she could play safe and drop Aalto, to have a higher potential of obtaining a seat in the first place. But if this was the case, with the same logic, the applicant should drop Aalto in the alternative scenario too, that is, when $YO^1_{it} = 0$ – she should have similar incentives to play safe as her chances of obtaining a seat at Aalto based on her entrance exam or composite score were low. In contrast, $YO^1_{it} = 1$ should make applicants who expect good chances of being admitted in the matriculation examination que to add prestigious schools at the top of their ROLs, thus, giving support to the claim that $\mathbb{E}[Y_{0it}] \leq \mathbb{E}[Y'_{0it}]$ holds.

For $\mathbb{E}[Y_{0it}] \leq \mathbb{E}[Y'_{0it}]$ not to hold, in our example Aalto should be just slightly preferable to Turku from the applicant's point of view, and the applicant should believe that the relative differences between Aalto and Turku's matriculation examination thresholds would be larger compared to entrance or composite score thresholds, which I therefore assume is not the case for a significant fraction of the students. Additionally, I need to assume that applicants who decide not to take the exam when they have the option not to – and already know at the time of application that they won't – and therefore decide to apply to only one programme when $D'_{it} = 0$, although she might apply to many programmes when $D_{it} = 0$, constitute a small minority of the applicants.

To conclude, the fact that the effect of the removal of the priority points potentially partly captures other changes in the admission criteria doesn't matter, if identified: the estimate we get should only be conservative. This conclusion relies on the following assumptions:

1. Applicants who don't understand that truthful revealing of preferences pays off in the absence of priority points regardless of admission criteria applied don't behave differently when the matriculation examination-based admission that considers all rankings is applied compared to when it is not.
2. Skipping the impossible and irrelevance at the bottom are not more prevalent phenomena when the matriculation examination-based admission that considers all rankings is applied compared to when it is not.
3. The matriculation examination-based admission that only considers the first-reported option makes students who perform well in the matriculation examination add prestigious programmes on top of their ROLs more often than make them drop prestigious programmes from the top of their ROLs.
4. Students who choose already at the time of application that they won't participate in the exam if it possible for them to avoid it constitute a small minority of students.

I consider these assumptions to be reasonable given the justifications presented, yet I discuss their implications in the remainder of the thesis.

5.2.2 Identification Strategy

The main challenge relates to identifying the treatment effect as for each year t, we can only observe one counterfactual outcome for each student i: either Y_{0it}, Y'_{0it}, or Y'_{1it}. Relying on pre- and post-priority point system comparisons has its challenges as the types of applicants might be different across years – especially because of the other changes in admission criteria – and they might behave differently for reasons we cannot observe. In this subsection, I specify the identification strategy I use to tackle the potential selectivity problems and discuss the assumptions associated.

I specify that, for students who applied in 2016 and 2017, or, in 2017 and 2018, the data generating process (dgp) is given by

$$Y_{it} = \alpha + \beta PP_{it} + \gamma n_{it} + \delta n_{it}^2 + \varepsilon_{it}, \qquad (1)$$

where the error term ε_{it} consists of a time-invariant part η_i and a time-variant part υ_{it} such that $\varepsilon_{it} = \eta_i + \upsilon_{it}$, and n_{it} indicates that it is the n^{th} time applicant i is applying in year t. The term n_{it}^2 aims to capture the fact that times applied doesn't enter the dgp linearly, but, instead, an extra year of application may be associated with smaller or larger changes in the outcome depending on whether it is the first, second, or third year of application, et cetera. Throughout the analysis, I take the point of view that the changes in application behaviour are not driven by shocks in student preferences, but a linear function of t may appear in υ_{it}. Parameter β is now the ATE(n_{it}) with respect to treatment PP_{it} and thus, our parameter of interest.

Notice that now

$$Y_{it} - Y_{it-1} = (\alpha + \beta PP_{it} + \gamma n_{it} + \delta n_{it}^2 + \varepsilon_{it}) - (\alpha + \beta PP_{it-1} + \gamma n_{it-1} + \delta n_{it-1}^2 + \varepsilon_{it-1})$$

$$\Leftrightarrow$$

$$Y_{it} - Y_{it-1} = \beta(PP_{it} - PP_{t-1}) + \gamma \underbrace{(n_{it} - n_{it-1})}_{=1} + \delta(n_{it}^2 - n_{it-1}^2)$$

$$+ \underbrace{(\eta_i - \eta_i)}_{=0} + (\upsilon_{it} - \upsilon_{it-1})$$

$$\Leftrightarrow$$

$$Y_{it} - Y_{it-1} = \gamma + \beta(PP_{it} - PP_{t-1}) + \delta(n_{it}^2 - n_{it-1}^2) + (\upsilon_{it} - \upsilon_{it-1}). \qquad (2)$$

Therefore, assuming that $\mathbb{E}(\upsilon_{it} - \upsilon_{it-1} \mid n_{it}^2 - n_{it-1}^2) = 0$ holds, applying a *First Differences* (FD) estimation on (1) which is equivalent to running *Ordinary Least Squares* (OLS) on (2) gives us an unbiased estimate of the ATE(n_{it}), that is, β. Therefore, the FD method allows us to test Hypotheses 1a, 1b, and 1c. Notice that $\mathbb{E}(\eta_i \mid n_{it}) \neq 0$ is allowed for: when first differencing, all time-invariant terms cancel out. Notice that this is also why the lack of control variables in Equation 1 becomes irrelevant: the relevant controls, such as applicant's gender, should be time-invariant.

By assuming that $\mathbb{E}(\upsilon_{it} - \upsilon_{it-1} \mid n_{it}^2 - n_{it-1}^2) = 0$ holds, I make assumptions on how multiple-year students of 2016–2017 and 2017–2018 and their behaviour are allowed to differ. To see what is assumed about the comparability of two-year students across years, consider how a student becomes a multiple-year student. For an applicant to become a second-year student in year $t + 1$, she needs to first, decide to apply in year t, second, fail to be admitted in year t and third, decide to apply again in year $t + 1$. All the three phases of the process could be different for different years t. The main reason why different types of students could be selected in different phases is because of differences in admission criteria across years.

By assuming that $\mathbb{E}(\upsilon_{it} - \upsilon_{it-1} \mid n_{it}^2 - n_{it-1}^2) = 0$ holds, I make the case that if, for any reason, the groups of multiple-year students differ – conditional on the relative differences between times of application – that is only through differences in "tastes". That is, I allow unobservable factors to be correlated with their application behaviour as far as they are not correlated with how they would adjust their application behaviour between first and second year of application. Therefore, even if, for instance, those who saw more room for improvement decided to apply again, that does not matter if the phenomenon is systematic across years, keeping in mind that we are not trying to generalize the results for the full group of applicants.

What is more, as the groups of multiple-year applicants may be different because of the changes in admission criteria, so can be the groups of other applicants they expect to face. This would be a problem if that would make students who had expected admission probabilities of zero to some programmes in their first year to expect non-zero probabilities in their second year more often had they applied for the first time in 2017 and not in 2016. The intuition for why we could expect this not to be the case is that because of the wider application of the matriculation examination-based admission in 2017, if students expect to face different types of students, then they should expect a larger change in the number of students and high-scoring students applying, which should make the relative second year chances for the treatment group lower.

In this chapter, I described the empirical approach applied to test the hypotheses constructed in Chapter 3. I first specified outcome variables Y_{it} associated with each hypothesis. Second, as the effect of the removal of the priority points on different outcomes needs to be estimated to test the hypotheses associated with investigation of sophisticated behaviour, I discussed the implications of the other changes in BAE admission criteria that coincided with the removal of the priority points on the treatment effect. I argued that they should only make the estimates conservative, if identified. Lastly, I specified the identification strategy applied to capture the effect of the removal of the priority points: an FD approach for multiple-year students of 2016 and 2017, and 2017 and 2018.

6. Results and Discussion

In this chapter I report the empirical analyses' results: results for the investigation of sophisticated behaviour in Section 6.1, and for application mistakes in Section 6.2

6.1 Sophisticated Behaviour

Subsection 6.1.1 reports descriptive statistics of outcome variables associated with investigation of sophisticated behaviour, while 6.1.2 reports the related regression results.

6.1.1 Descriptive Statistics

Figures 5, 6, and 7 depict means for outcome variables associated with testing Hypotheses 1a, 1b, and 1c, respectively, given the full sample of BAE applicants during 2016–2018. In Figure 5, small-point difference behaviour for study programme pairs Aalto and Turku, Turku and Tampere, as well as Lappeenranta and Vaasa are presented. Although not evidence in favour of Hypothesis 1a, that is, that students avoid listing programmes with small threshold differences as subsequent choices among the first four alternatives, a larger increase in the outcome variables' means between 2017 and 2018 compared to 2016 and 2017 is what we could expect if Hypothesis 1a was true.

Out of those students who ranked Aalto first, in 2016 around 28 % ranked Turku second while in 2017 and 2018 the corresponding numbers were 26 % and 33 %, respectively; there is a slight dip in the number of applicants ranking Turku right after Aalto but then a seven-percentage point jump when the priority points were removed. When it comes Turku and Tampere, a similar jump is noticeable between years 2017 and 2018, and the magnitude is around 7.5 percentage points. However, there seems to be a modest upward sloping trend in the fraction of students who, conditional on applying to Turku or Tampere first or second, ranks one of the two right after the other, even before the removal of the priority points.

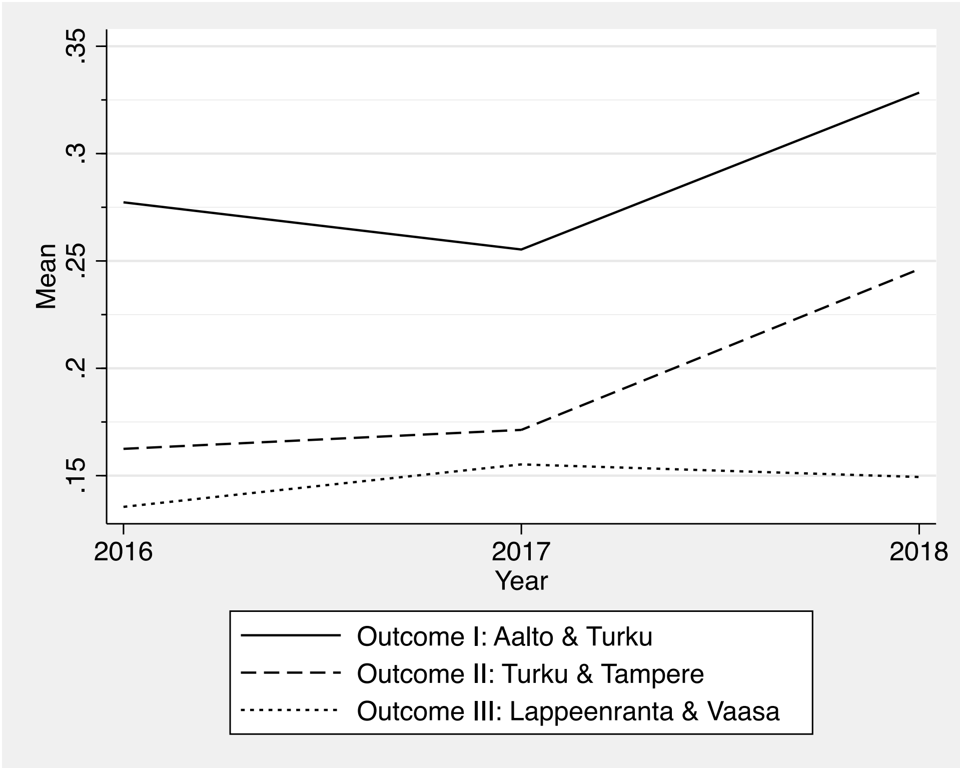


Figure 5. Small-Point Difference Behaviour during 2016–2018.

Hypothesis 1a, Outcomes I, II, and III.

Note: The figure depicts means for outcomes related to testing Hypothesis 1a. "Aalto & Turku" is a dummy that is conditioned on applying to Aalto as 1^{st} choice and that gets value 1 if a student applied to Turku as her 2^{nd} choice. "Turku & Tampere" is a dummy that is conditioned on applying to Turku or Tampere as 1^{st} or 2^{nd} and that gets value 1 if the one ranked 1^{st} or 2^{nd} is followed by the other one of the two. "Lranta & Vaasa" is a dummy that is conditioned on applying to Lappeenranta or Vaasa as 1^{st}, 2^{nd}, or 3^{rd} and that gets value 1 if the one ranked 1^{st}, 2^{nd}, or 3^{rd} is followed by the other one of the two.

For Lappeenranta and Vaasa, the pattern is opposite to the one of Aalto and Turku: the fraction of students who, conditional on applying to Lappeenranta or Vaasa among the top three programmes, applied to the other one of the two right after the other, rose from 14 % to 16 % between years 2016 and 2017, but the removal of the priority points was accompanied with a slight dip in the corresponding number. As opposed to that of Aalto and Turku, and Turku and Tampere, this pattern isn't in favour of Hypothesis 1a.

Figure 6 represents the fraction of students ranking Aalto first between 2016 and 2018. The fraction rose both in 2017 and 2018, but there seems to be a clear kink between 2017 and 2018: between 2016 and 2017, the fraction of students reporting Aalto as their top choice rose from 29.0 % to 29.7 %, but then, in 2018, it rose to 35.6 %. The pattern is what we would expect if Hypothesis 1b was true, but it could also reflect, for example, a phenomenon where more high-performing students who also like more prestigious programmes applied in 2018 when the matriculation examination-based admission was more widely in use.

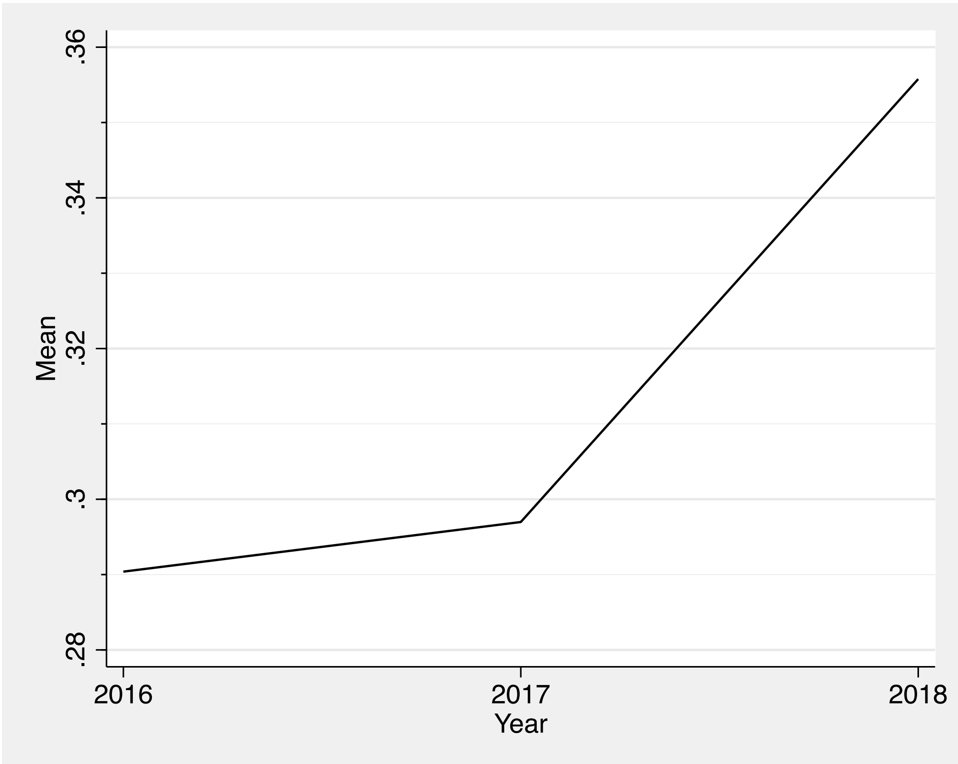


Figure 6. First-Choice Behaviour during 2016–2018.

Hypothesis 1b, Students Ranking Aalto 1st.

Lastly, Figure 7 depicts the average lengths of the ROLs submitted by BAE students. The pattern is almost perfectly linear: between 2016 and 2017, the average length rose by 0.068 and between 2017 and 2018 by 0.088. The slope between 2017 and 2018 is slightly steeper compared to that between 2016 and 2017. However, despite the trend, the yearly changes are quite modest: per every student who reported one "extra" programme, there were more than ten students who didn't.

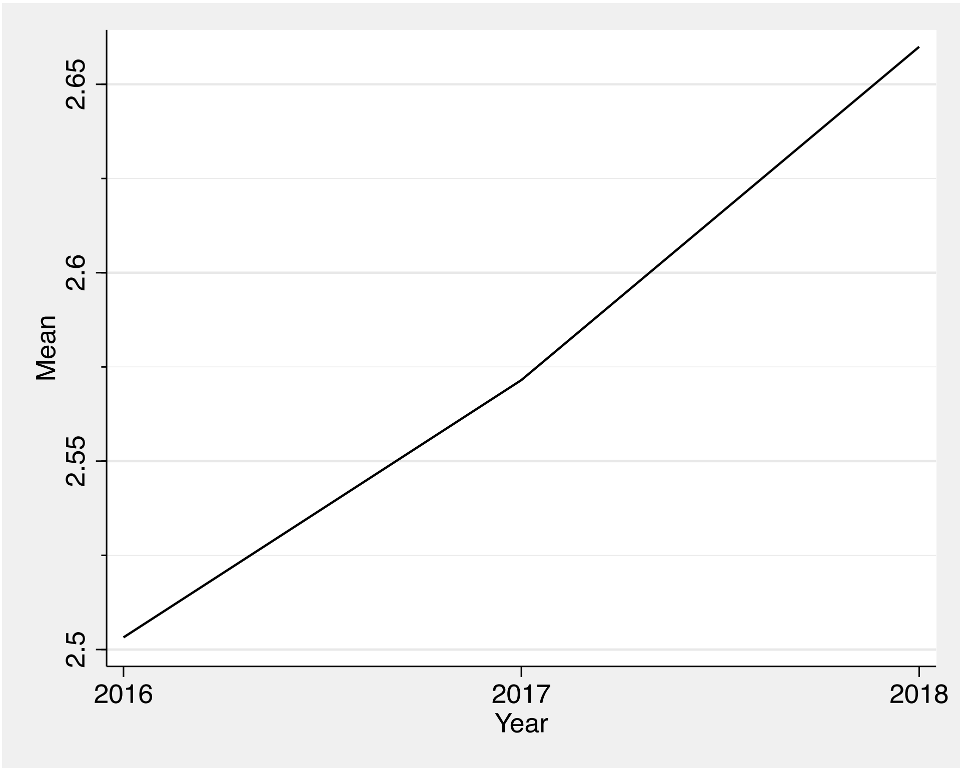


Figure 7. ROL Length during 2016–2018.

Hypothesis 1c, Students' ROL Lengths.

Recall that one of the assumptions made in Chapter 5 that ensured that the estimates – if identified – for the effect of the removal of the priority points would be conservative was that students who choose already at the time of application that they won't participate in the exam if it possible for them to avoid it, constitute a small minority of students. In other words, I assumed that such students who would only apply to one programme in

2017 when the matriculation examination-based admission that only considered applicants' first reported options was applied but to many programmes in other years don't form a substantial fraction of multiple-year students. The pattern of Figure 8 doesn't give us a reason to suspect the validity of this assumption; a dip in 2017 on the other hand would. However, the pattern isn't enough to validate the assumption either as we don't know what the trend would've been had this particular matriculation examination-based criterium not been applied; maybe the trend would have been even steeper. In addition, Figure 8 doesn't follow the same individuals over time, but the group of applicants varies across years.

6.1.2 Regression Results

Table 9 reports the FD-estimation results for the outcome variables associated with testing Hypotheses 1a, 1b, and 1c. When it comes to Hypothesis 1a, for all the three outcome variables the estimated coefficients of the removal of the priority points are positive. The magnitude of the coefficient is largest for Aalto and Turku – almost 13 percentage points – and the coefficient is statistically significant even at 0.1 % significance level. That is, the hypothesis that the removal of the priority points would have no effect on applicants ranking Turku second if they ranked Aalto first is rejected given any conventional significance level.

For programme pair Turku and Tampere, the estimated coefficient is somewhat smaller, and the estimated effect of PPM on ranking Tampere and Turku as subsequent options, conditional on ranking one of them among the top two alternatives, is 5.5 percentage points and is significant at 1% significance level. That is, if the priority points didn't have any effect on the outcome variable, there would be less than 1 % chance of obtaining results at least as extreme as the ones obtained. For Lappeenranta and Vaasa, the estimated coefficient is smaller than for the other two, only 0.021, and the associated p-value is around 0.34. Thus, there is a fair chance that the priority points don't have any effect on this outcome although we found a positive estimate for the coefficient.

Table 9. Regression Results for Sophisticated Behaviour.

Hypothesis	1a			1b	1c
Outcome / **Regressor**	Aalto & Turku	Turku & Tampere	Lranta & Vaasa	Aalto 1st	ROL length
Removal of Priority Points	0.127*** (0.029)	0.0554** (0.0201)	0.0211 (0.022)	0.0516*** (0.00992)	0.0685 (0.0427)
Times Applied Squared	-0.000237 (0.00439)	0.000815 (0.00435)	-0.00971 (0.00518)	0.00312 (0.00211)	-0.0589*** (0.00884)
Constant	-0.0419 (0.0298)	-0.0313 (0.0247)	0.0571* (0.0276)	-0.0253* (0.0117)	0.395*** (0.0495)
Observations	*1,433*	*2,673*	*1,853*	*6,542*	*6,542*
R^2	*0.015*	*0.003*	*0.002*	*0.005*	*0.005*

Note: The table reports FD estimation results, i.e., results from OLS regressions of the outcome variable's first differences on the regressor's first differences. Standard errors clustered at individual level are reported in parentheses. Lranta stands for Lappeenranta. $*\ p < 0.05,\ **\ p < 0.01,\ ***\ p < 0.001$.

The results reported in Table 9 give support to Hypothesis 1a. If we were to use the levels of the outcome variables in 2017 as a baseline (Figure 5, p. 52), the estimated effects would suggest that the switch from PPM to DA increased the probability of ranking programmes with small cut of differences by one half, one third, and one seventh for Aalto and Turku, Turku and Tampere, and Lappeenranta and Vaasa, respectively. Yet, although the results suggest that students avoid ranking programmes with small cut-off differences among the first four options more when PPM is applied compared to when DA is, the effects seem to be outcome dependent.

Potential explanations for why such differences occur could include, for example, that ranking a safe option after a risky alternative is a common strategy that students play under PPM and would explain why the estimated effect is larger for the more prestigious study programme pairs. When it comes to less prestigious programmes, such as Lappeenranta and Vaasa, it could be that a student who applied to them was already playing safe. For example, she may want to apply to, say, Aalto, Turku, Lappeenranta, and Vaasa, but decides to skip Turku for higher chances of admittance under PPM; because the number of study programmes a student can rank is limited, a student's least preferable acceptable programme may be one that has a small cut-off difference compared to the second least preferable one. Alternatively, because the outcomes are conditioned differently, avoiding listing programmes with small expected cut-off differences may be more meaningful for the higher ranks.

When it comes to testing Hypothesis 1b, the coefficient for the removal of the priority points on the dummy indicating whether an applicant ranks Aalto first is positive and significant, even at 0.1 % level: the removal of the priority points is associated with a 5.2 percentage point increase in the probability of a student ranking Aalto as her top choice. If the probability that a student ranked Aalto was around 30 % in the absence of the priority points – as it was in 2017 – a 5.2 percentage point increase in that number would translate into a 17 % increase in the fraction of students ranking Aalto first. Thus, the finding is clearly in line with students avoiding ranking prestigious programmes on top of their ROLs more under PPM than they do under DA, supporting Hypothesis 1b.

The result that more people rank Aalto first when DA is applied compared to when PPM is – or, the possibility that it could happen – demonstrates why Outcome I for testing Hypothesis 1a is conditioned on ranking Aalto first: if we were to define a dummy that gets value one if a student applies to Aalto as her first choice and Turku as her second option, finding that the removal of the priority points has an effect on that outcome wouldn't necessarily capture a phenomenon where students rank programmes with small cut-off differences differently depending on the mechanism used, but, it could capture a phenomenon where students avoid ranking Aalto first. Also, if all the outcomes were conditioned similarly as the one for Lappeenranta and Vaasa – which would be in line with the definition of an application mistake under PPM – we could too risk capturing a phenomenon other than small point-difference behaviour.

For example, consider a case where a student applies to Aalto as her first option in 2016. As she then became a second-year student – the effect is identified only for this group – she must've failed to gain admission to Aalto. As she realises that Aalto was out of her reach, she might update her ROL in 2017 and apply to Turku instead. But then our dummy, if conditioned similarly as for Lappeenranta and Vaasa, would get value zero both years. This isn't, however, what we would like to capture since there would be no point in ranking Aalto after Turku, and the fact that we see that Turku is ranked first but isn't followed by Aalto shouldn't strengthen our belief that students don't avoid applying to programmes with small cut-off differences under PPM – or then the result would get a different interpretation. With the other two programme pairs, it is more natural to assume that a student could reasonably rank the programmes in whichever order.

Also, the conditioning is different for all outcomes as it would be unnatural to say that a student doesn't avoid applying to programmes with small cut-off differences with respect to Outcome II (Turku & Tampere) if she applied to, say, Aalto, Oulu, and Turku, in that order. Since Aalto, Turku, and Tampere are the programmes with clearly highest thresholds, if Tampere or Turku were ranked third but the other one wasn't included in the top three, then, a programme such as Oulu must've been listed higher than Turku or Tampere – but then the applicant clearly didn't avoid applying to Turku or Tampere after Oulu, regardless of the obvious threshold difference.

Lastly, notice that if we were to use a student's first and second – or second and third, or third and fourth – ranked programme's cut-off differences as an outcome, we could face two types of problems. First, even if the students ranked the exact same programmes as subsequent options, because the cut-off differences may change year by year, it could seem like students avoided or didn't avoid ranking programmes with small cut-off differences. Second, if we were to fix the cut-off differences by, say, using a certain year's thresholds, we would then miss to capture the year-by-year variation that could affect student's behaviour. Thus, the outcomes chosen aim to overcome these to problems by first, considering the same programme pairs and second, by considering such programme pairs that have had small cut-off differences each year during 2015–2018.

When it comes to Hypothesis 1c, although there seem to be clear changes in students applying to Aalto more often as well as to programmes with small cut-off differences under PPM compared to DA, we can't find strong evidence of these changes translating into students submitting longer ROLs: the coefficient for priority points is close to zero, and the associated p-value is around 0.11. One explanation for this result is the trade-off between the number of BAE programmes and other programmes a student can rank.

As a result of the wider introduction of the matriculation examination-based admission within BAE and other fields in 2018, applicants had the opportunity to seriously apply to many fields as opposed to just one. For example, an applicant who would have liked to apply to both, fields of BAE and medicine could, in practice, only apply to one of them prior to 2018 but afterwards, she would have the opportunity to apply to both. For this reason, the maximum length of ROLs being limited to only six study programmes may have become more restrictive, and an applicant may need to more carefully decide which study programmes to apply to within BAE as she might want and be able to include programmes from other fields in her ROL too.

Indeed, the average number of other programmes applicants listed declined modestly between 2016 and 2017, from 1.28 to 1.24, but increased to 1.58 in 2018. To take this potential trade-off into account, I repeat the regressions including the number of programmes other than BAE one's, that is, the ROL length of other programmes applicant i applied to in year t as a control. The results are reported in Table 10.

Table 10. Regression Results for Sophisticated Behaviour, Other Programmes' ROL Length Included.

Hypothesis	1a			1b	1c
Outcome / **Regressor**	Aalto & Turku	Turku & Tampere	Lranta & Vaasa	Aalto 1st	ROL length
Removal of Priority Points	0.140*** (0.0291)	0.0668*** (0.02)	0.0303 (0.022)	0.0559*** (0.00996)	0.221*** (0.0392)
Times Applied Squared	-0.000248 (0.0044)	0.00097 (0.00433)	(0.00884) (0.00512)	0.00323 (0.00211)	-0.0553*** (0.0081)
ROL length others	-0.0373*** (0.00937)	-0.0420*** (0.00718)	-0.0400*** (0.00759)	-0.0127*** (0.00337)	-0.451*** (0.0143)
Constant	-0.0421 (0.0298)	-0.0279 (0.0247)	0.0594* (0.0273)	-0.0248* (0.0117)	0.411*** (0.0454)
Observations	*1,433*	*2,673*	*1,853*	*6,542*	*6,542*
R^2	*0.024*	*0.015*	*0.014*	*0.007*	*0.16*

Note: The table reports FD estimation results, i.e., results from OLS regressions of the outcome variable's first differences on the regressor's first differences. Standard errors clustered at individual level are reported in parentheses. "ROL length others" is the number of programmes other than BAE ones listed. Lranta stands for Lappeenranta. $*\ p < 0.05,\ **\ p < 0.01,\ ***\ p < 0.001$.

Including the ROL length of other programmes applicant i applies to in year t as a control, larger effects for the priority points and smaller standard deviations are found. Especially, for the ROL length, the estimated coefficient is larger, suggesting that the switch from PPM to DA would lead into ROLs longer by one fifth, on average. The coefficient of the ROL length of other programmes is -0.451, suggesting that when two programmes from other fields are included in the ROL, one BAE programme is dropped, which in line with the hypothesis that a trade-off occurs. Notice that this trade-off could also give incentives in terms of the other outcome variables too since, if a student decides to limit the number of BAE programmes she applies to, she may consider listing only safer BAE programmes, or, rank one risky alternative, that is, a prestigious programme but drop some programmes and include safety options in the bottom. Both suppositions are supported based on the results of Table 10.

However, conclusions on results reported in Table 10 should be drawn with caution. As there is a trade-off between how many BAE programmes and other programmes a student can apply to, the ROL length of other programmes may in fact be considered an outcome of the priority points. At one extreme, if all students ranked the maximum number of programmes and if they maximised the number of BAE programmes included, the ROL length of other programmes would be the maximum of zero and $6 - |ROL_{it}|$. Therefore, regressions whose results are reported in Table 10 may suffer from what we call a *bad control problem*.

Ultimately, the FD approach applied is a *Difference-in-Differences* style estimation where students applying in 2016 and 2017 are used as a control group for students applying in 2017 and 2018. Now, if we control for the ROL length of other programmes, we are comparing students who, for example, shortened the ROL length of other programmes between 2017 and 2018 to those who did so too between 2016 and 2017. Then, if the ROL length of other programmes is in fact an outcome, and that increasing the length of the ROL of BAE programmes when moving from PPM to DA is expected from students who respond to the incentives of PPM, we are fundamentally comparing students who responded to the incentives of PPM to those students who increased the number of BAE programmes ranked between 2016 and 2017. Now, increasing the number of BAE programmes ranked between 2016 and 2017 could indicate that an applicant is particularly confident so that she believes that after one more year of preparation, she could have good chances of admittance to more prestigious programmes and would decide to include more programmes in her ROL in the second year of application.

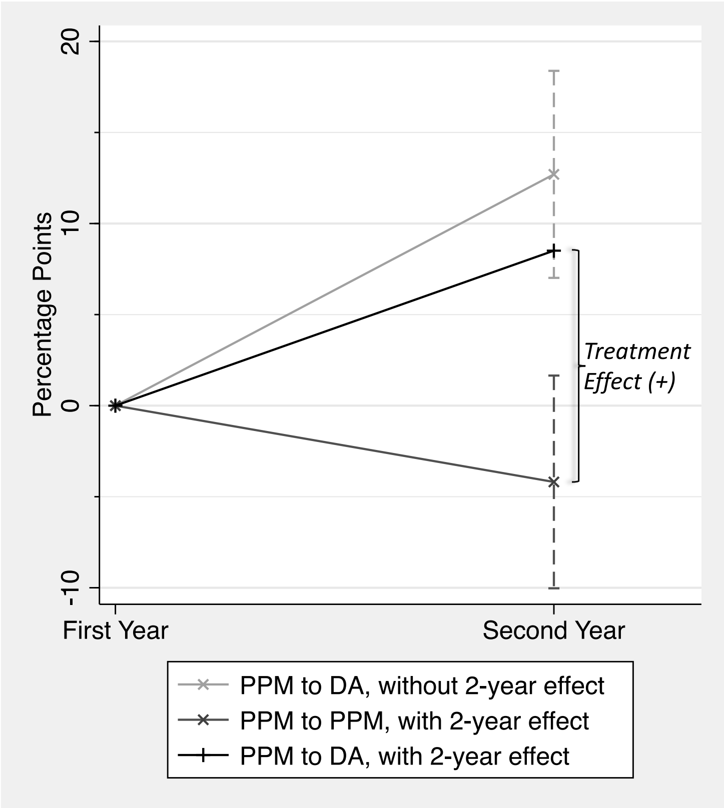
What would follow is that, in this case, it could seem like the priority points didn't have any effect – or that they had an effect smaller than in reality – as we would be comparing those who are extremely risk averse or have low confidence to those who are quite the opposite. If a trade-off occurs so that students who respond to the incentives of PPM then shorten the ROLs for other programmes, controlling for the number of other programmes a student applies to should make us compare students with opposite levels of strategic sophistication, which should lead into conservative estimates. Therefore, it isn't clear why controlling for the ROL length of other programmes would overestimate the effects in this case, but we cannot rule out that possibility that it could happen through some other channel. Thus, I consider the results of Table 9 as the main results of this thesis in the remainder of the thesis.

Another issue worth mentioning when it comes to the regression results reported in Tables 9 and 10, is the interpretation of the R^2 measure. Although larger values of R^2 are obtained when controlling for the ROL length of other programmes – indicating better fit – the larger R^2 -values shouldn't be taken as evidence in favour of the specification being more correct. A larger R^2 value is a common phenomenon when adding more controls. In addition, notice that when having discrete outcome variables, small R^2 values are expected, especially for the dummy outcome variables; most predicted values lay within the zero-one interval, while the observed outcomes reach only values zero and one, the first-differenced ones naturally -1, 0, or 1.

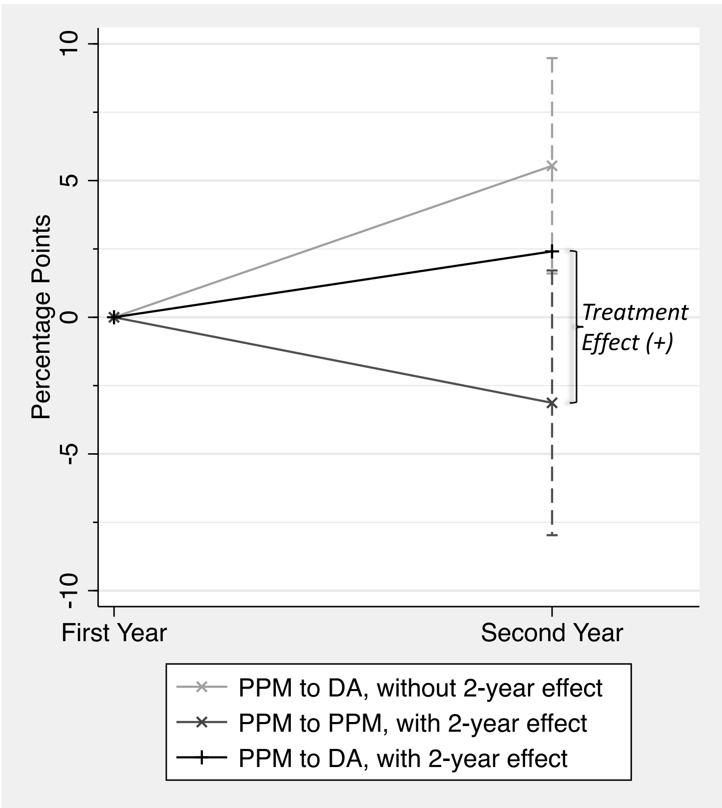
Figures 8, 9, and 10 demonstrate the regression results reported in Table 9. They visualise the FD approach by illustrating how applicants change their behaviour between the first and second year of application when PPM is applied in both years (control) compared to when a switch from PPM to DA occurs (treatment), captured by the estimated constant term and the coefficient of the removal of the priority points, keeping the relative times of application artificially constant. That is, recalling Equation 2,

$$Y_{it} - Y_{it-1} = \gamma + \beta(PP_{it} - PP_{t-1}) + \delta(n_{it}^2 - n_{it-1}^2) + (\upsilon_{it} - \upsilon_{it-1}),$$

Panel A. Outcome I, Aalto & Turku.



Panel B. Outcome II, Turku & Tampere.



Panel C. Outcome III, Lappeenranta & Vaasa.

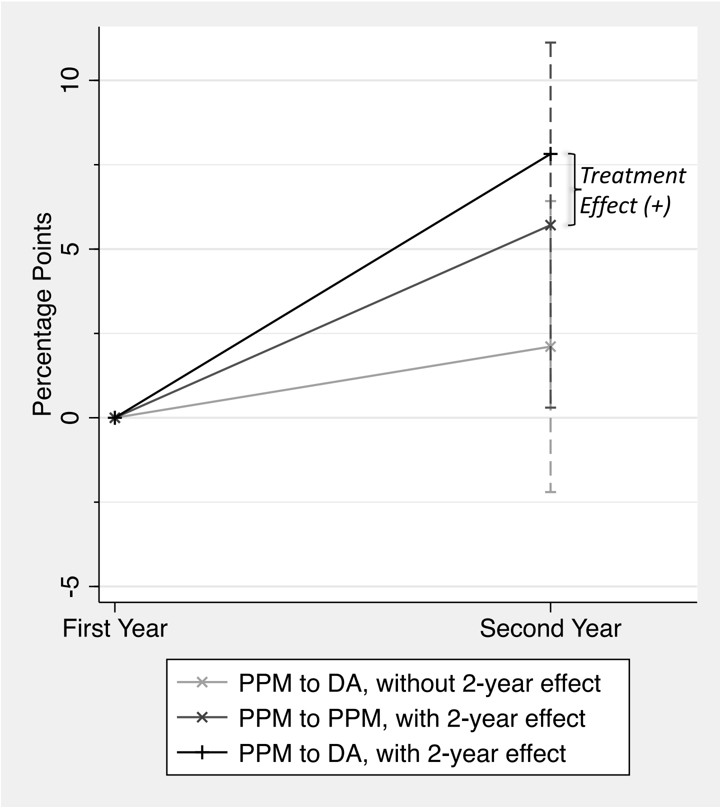


Figure 8. Small-Point Difference Behaviour, Treatment Effect Decomposed.

Hypothesis 1a.

Note: The figure demonstrates how students adjust their behaviour between first and second year of application when PPM is applied in both years (dark grey line) and when PPM is switched to DA (black line). The values in the first year are set to zero, and the values in the second year represent the estimate for the coefficient of the removal of the priority points (light grey x), the constant term (dark grey x), and the sum of the two (black plus sign) given the FD regression results. The dashed vertical lines represent the 95 % confidence intervals for the estimates of the constant term and the coefficient of the removal of the priority points. The sign inside the parentheses indicates the sign of the treatment effect.

the dark grey lines represent the estimate for γ, the light grey ones for β, and the black ones for $\gamma + \beta$. Therefore, the distance between the black line and the dark grey line is the treatment effect. The 95 % confidence intervals for the estimates of the constant term and the coefficient of the change in priority points, depicted with the dashed vertical lines, reflect the precision of the estimates.

Based on Figure 8, when no switch in mechanism occurs, students tend to apply to study programmes with small cut-off differences less often in their second year of application compared to their first, except for Lappeenranta and Vaasa. This could be explained, for example, by students who fail to gain admission in their first year of application replacing the other one of the programmes with a security option in their second year, if they still decided to apply to one of the most prestigious programmes – namely, Aalto, Turku, or Tampere. This could explain why no similar pattern is found for Lappeenranta and Vaasa, which are not among the most prestigious programmes, as discussed. The differing pattern of Vaasa and Lappeenranta could also be a result of second year students dropping prestigious programmes from the top of their ROLs, leaving more room for other options that were not included in the first year. However, the results for Vaasa and Lappeenranta are quite unprecise, as the overlapping confidence intervals indicate.

When it comes to ranking Aalto first, when the priority points are applied, we could expect there to be to forces that would draw second-year behaviour to opposite directions. First, if a student applied to Aalto as her first choice in her first year, because she became a second-year student, she failed to gain admission to Aalto and therefore learned that her score didn't suffice for Aalto. Therefore, in the second year, as students have pressure to adjust their ROLs to match their level when the priority points are applied, that should make the probability of an applicant listing Aalto first smaller in her second year compared to the first. On the other hand, as a student prepares for the same exam in her second year of application, she could expect to improve her score, which would have a positive effect on the probability of ranking Aalto first.

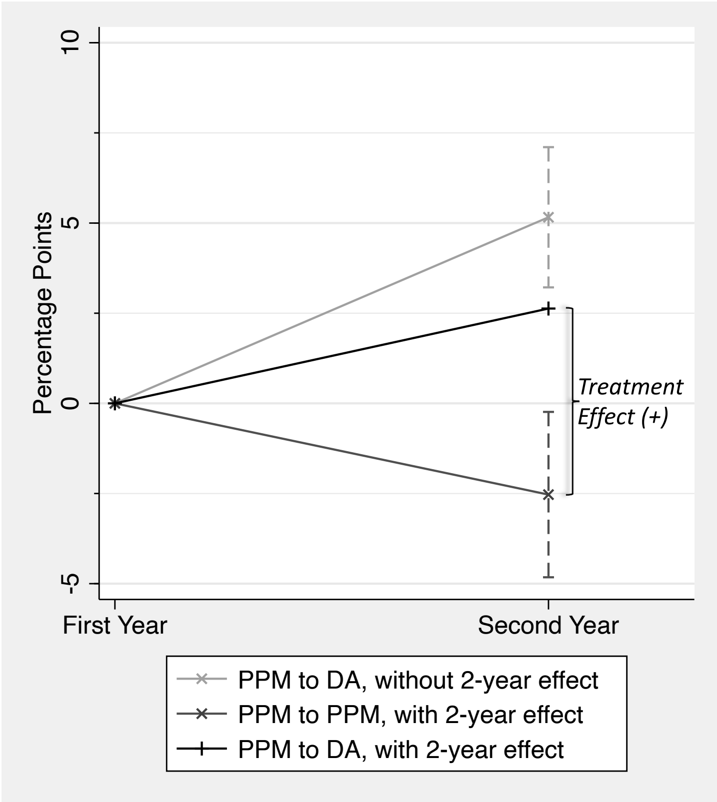


Figure 9. First-Choice Behaviour, Treatment Effect Decomposed.

Hypothesis 1b, Ranking Aalto 1st.

Note: The figure demonstrates how students adjust their behaviour between first and second year of application when PPM is applied in both years (dark grey line) and when PPM is switched to DA (black line). The values in the first year are set to zero, and the values in the second year represent the estimate for the coefficient of the removal of the priority points (light grey x), the constant term (dark grey x), and the sum of the two (black plus sign) given the FD regression results. The dashed vertical lines represent the 95 % confidence intervals for the estimates of the constant term and the coefficient of the removal of the priority points. The sign inside the parentheses indicates the sign of the treatment effect.

Therefore, the fact that students are less likely to apply to Aalto in their second year of application compared to the first, as Figure 9 shows, could be explained by the former effect – the pressure to not to apply to too difficult programmes – dominating the latter – the benefit from preparing for the same exam. Recall that a new type of an exam was introduced in 2018, so that if we believe the explanation given, multiple-year students of 2017 and 2018 would have lost the positive effect and the estimate might be conservative.

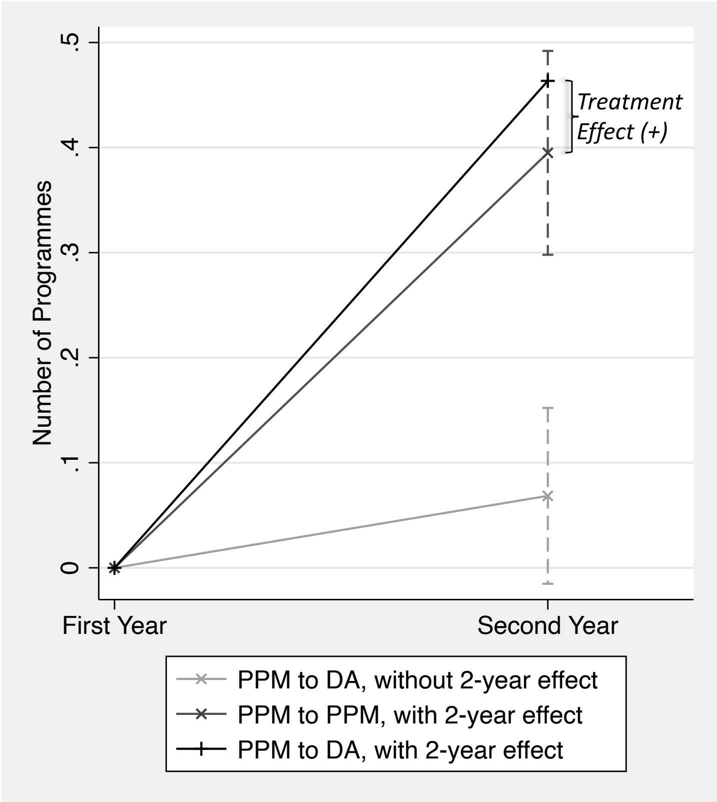


Figure 10. ROL length, Treatment Effect Decomposed.

Note: The figure demonstrates how students adjust their behaviour between first and second year of application when PPM is applied in both years (dark grey line) and when PPM is switched to DA (black line). The values in the first year are set to zero, and the values in the second year represent the estimate for the coefficient of the removal of the priority points (light grey x), the constant term (dark grey x), and the sum of the two (black plus sign) given the FD regression results. The dashed vertical lines represent the 95 % confidence intervals for the estimates of the constant term and the coefficient of the removal of the priority points. The sign inside the parentheses indicates the sign of the treatment effect.

On the other hand, students submit longer ROLs in their second year compared to the first even when PPM is applied, as seen from Figure 10. It could be that students want more insurance in their second year after failing to gain admission, or it could be that after noticing that their original target programmes were out of their reach, they decided that being accepted by some other programmes would be preferable to non-admission. For that reason, they could include more programmes to their ROLs.

Notice that although interpreted as the “2-year effect”, the constant term captures the change that is associated with all variables whose value increases by one between two years: therefore, it could capture a time trend – or a change associated with students becoming one year older, for instance.

To conclude, some of the hypotheses are supported by the results, but for some, the interpretation remains unclear. The switch from PPM to DA has a positive and significant effect on students’ small-point difference behaviour for study programme pairs Aalto and Turku as well as Turku and Tampere, and the magnitudes of the estimated effects are 12.7 and 5.5 percentage points, respectively. However, for study programme pair Lappeenranta and Vaasa, the estimated effect is only 2.1 percentage points, and the estimate is not significant given any conventional significance level. Thus, Hypothesis 1a is supported but only for some outcomes: the results suggest that students avoid ranking at least some study programmes with small expected cut-off differences subsequently among at least some of the top ranks more under PPM than DA, but not necessarily all.

The removal of the priority points has a positive and significant effect on the probability of students ranking Aalto as their top choice. Therefore, Hypothesis 1b is supported and the results suggest that students avoid ranking study programmes with high entry thresholds as their first choice more when PPM is applied compared to when DA is. Finally, the effect of the switch from PPM to DA on applicants’ ROL lengths remains unclear. The estimated effect is 0.069 programmes, and the associated p-value is 0.11. Therefore, we cannot make conclusions on Hypothesis 1c, that is, whether students submit shorter ROLs under PPM compared to DA.

Naturally, the conclusions are made assuming that the outcomes defined to test to hypothesis are valid measures, the FD approach succeeds in identifying the treatment effect, and the assumptions made in Chapter 5 hold. However, assuming they all do, the estimates we get should be conservative. As discussed, the limitation of the ROL lengths and the change in the exam between 2017 and 2018 can result in conservative estimates too. In addition, it could take time for the applicants to adjust to the new mechanism.

There is a possibility that the results are dependent on the model specification, and that the way times of application enters the regression matters. For this reason, I repeat the analyses with dummy variables indicating times of application instead of including the squared term. I repeat the analyses with and without controlling for the ROL length of other programmes. The results are reported in the Appendix, Tables 17 and 18. The results remain similar in magnitude and significance, compared to those of Tables 9 and 10.

6.2 Application Mistakes

Subsection 6.2.1. reports the results of the investigation of whether applicants who make mistakes exist, while 6.2.2, motivated by the results of 6.2.1, aims to deepen our understanding of what could make students avoid or not to avoid such behaviour.

6.2.1 Results

Table 11 reports the results for application mistakes. Each year, students who make application mistakes exist. In 2016 around 7.1 % of all applicants submit an ROL that ends up being a mistake, and in 2017, the corresponding numbers is 9.0 %. The total number of such students is thus 700–900 per year. Differences between years could be explained by, for instance, students having more chances of making mistakes in 2017 than in 2016, if their preferences are such that the programmes students tend to apply to had closer cut-offs in 2017 compared to 2016. For example, programmes Pori and Oulu had cut-off differences smaller than one with respect to both admission types in 2017, but the difference was larger than one in 2016. In 2017, around 2.6 % of all students made an obvious application mistake.

It is difficult to determine whether the number of students making mistakes is small or large. However, all p-values from the t-tests, testing the hypothesis that the fraction of students who make (obvious) mistakes is zero, are below 0.1 %, given the large sample size. Yet the fractions remain relatively small, especially for students who make obvious mistakes.

Table 11. Mistake Makers in 2016 and 2017.

Outcome	**Year**	**Mean**	***T*-test *p*-value**	*Observations*
Mistake Maker (= 1)	2016	0.071	0.000	*9,773*
	2017	0.090	0.000	*9,930*
Obvious-Mistake Maker (= 1)	2017	0.028	0.000	*9,930*

Note: The outcome variables are dummy variables that indicate whether an applicant makes a mistake or an obvious mistake. The t-test p-value is from a two-sided t-test testing the hypothesis that the sample mean is equal to zero.

One explanation for the fact that a somewhat considerable fraction of students does mistakes but not obvious ones is that students don't lack understanding of the properties of the mechanism but have difficulties in predicting expected cut-offs. Alternatively, as the cut-offs arguably capture information on applicants' preferences, the result that a reasonably small number of students make obvious mistakes could just reflect the fact that the grouping I use for the outcome is too coarse, and the number of students with such preferences that would end up being obvious mistakes – if truthfully reported – is small. In other words, given the definition of an obvious mistakes, for an applicant ending up doing an obvious mistake it could be that she should have unusual preferences. The extent of lack of strategic sophistication is difficult to quantify.

Indeed, the results are dependent on the definitions of the outcome variables. When defining the outcome variable I call a mistake (Outcome I), I required that the entry thresholds for subsequent options needs to be smaller than one for both admission criteria, entrance exam and the composite score. However, the cut-off differences are criterium-dependent, and for the composite score, the differences tend to be larger. Therefore, the chance that a student ends up doing what I call a mistake can be small, although the entrance exam threshold differences could be what is relevant for an applicant. In addition, the definition only captures one particular type of a mistake: a strategy that is a mistake because an applicant playing such a strategy couldn't potentially be accepted by one of the programmes she ranked but dropping that option from her ROL could give her chances of admittance for a lower ranked option. However, this is not the only type of a strategy that could be suboptimal under PPM.

In the spirit of Example 3 (p. 24), let say a student applied to Aalto, Tampere, and Oulu in 2016 and in that order. Such an ROL would not be a mistake, given our definition, as the cut-offs for the composite score were 60.25, 56, and 47, respectively: the cut-off difference between Tampere and Aalto is more than one point. However, ignoring the entrance exam score differences for now, if the student scores above 44 but below 46, she would be strictly better off if she dropped Aalto and Tampere from her ROL altogether; she had no chances of being admitted to Aalto nor Tampere in the first place, and by including those two programmes in her ROL, she doesn't have any chances of being admitted to Oulu either – although she would if she only listed Oulu.

Alternatively, an applicant could've applied to Oulu in the fear of not scoring high enough for having good chances of admittance to Aalto or Tampere. However, if she ended up scoring high, she would still be admitted to Oulu although she would've deserved a seat at Aalto or Tampere. In general, as discussed in Chapter 3, PPM gives a pressure to match the programmes to one's own level: if a student fails in doing so, she risks ending up with justified envy towards another student. Under DA, similar pressure doesn't exist.

Therefore, the results of Table 11 can be considered lower bounds for the number of students who submit ROLs they can only be hurt by as it doesn't capture all strategies that an applicant can be hurt by under PPM. Yet, all the ones it does, could never benefit the student but could only be hurtful.

To conclude, the results of this support Hypothesis 2: students who make application mistakes under PPM exist.

6.2.2 Who Make Application Mistakes?

Motivated by the result that applicants who make application mistakes exist, I investigate how the groups of applicants who make and who don't make application mistakes differ. The results of the comparisons with respect to students' background characteristics are reported in Table 12 for mistake makers and non-mistake makers, and in Table 13 for obvious-mistake makers and non-obvious-mistake makers. Results of the comparisons with respect to matriculation examination performance are reported in Table 14 for mistake- and non-mistake makers, and in Table 15 for obvious- and non-obvious-mistake makers. Here I call a student *mistake maker* (*obvious-mistake maker*) if, given Outcome I (II), Hypothesis 2, she made a mistake, that is, $Y_{it} = 1$, and a *non-mistake maker* (*non-obvious-mistake maker*) if $Y_{it} = 0$. That is, a non-(obvious-)mistake maker could've potentially behaved "erroneously" in some other way.

The characteristics I report describe differences between the groups as such, but also, aim to capture different dimensions. Differences in gender could be associated with differences in risk-taking attitudes; differences in age, first-timer status, and times applied before to experience; differences in fractions of students who are native Finnish speakers and from urban areas to informational differences; differences in matriculation examination related variables to academic aptitudes. Naturally, differences in these characteristics could capture different aspects as well.

The fractions of males are nearly the same for mistake makers and non-mistake makers, just over 57 %. The p-values from testing the hypothesis that the sample means are equal is as high as 0.94. Thus, if there indeed was no difference in the gender distribution between mistake- and non-mistake makers, we would have a 94 % chance of obtaining results at least as extreme as the ones obtained. Thus, the data doesn't give us any reason to believe that gender differences would occur. The same holds for the fraction of students living in urban areas: the means are very close and the p-value doesn't suggest that the parameters generating such data couldn't be equal for the two groups.

Table 12. Comparisons by Mistake Making Status, Background Characteristics.

Mistake Maker	No	Yes	***T*-test *p*-value:**
Variable			
Male (= 1)	0.572	0.573	0.944
Age	22.105	21.187	0.000
Native Finnish Speaker (= 1)	0.954	0.974	0.000
Lives in Urban Area (= 1)	0.890	0.897	0.362
First-timer (= 1)	0.848	0.885	0.000
Yo-graduate (= 1)	0.917	0.947	0.000
Times applied before	1.616	1.696	0.002
Observations	*18,109*	*1,594*	*19,703*

Note: The table reports means for background characteristics for mistake makers and non-mistake makers. A student is a first-timer if she doesn't have an existing academic degree and haven't accepted any offer from a college in 2014 or later. A student is a yo-graduate in case she has a Finnish Matriculation Examination degree. "Times applied before" refers to number of times applied before since 2009. The t-test p-value is from a two-sided t-test testing the hypothesis that the sample means are equal.

For other characteristics in Table 12, the differences are statistically significant at 1 % level or even smaller. Those who make mistakes are almost one year younger compared to those who don't. Mistake makers are two percentage points more likely to be native Finnish speakers and almost four percentage points more likely to be first-timers. They also have a larger fraction of students with Finnish Matriculation Examination degree – by three percentage points – and they have applied on average almost 0.1 more times.

The fact that mistake makers are younger and more often first-timers compared to those who don’t make mistakes could reflect a phenomenon where, over time, students learn to avoid making application mistakes. However, this hypothesis is not in line with the finding that mistake makers have had on average 0.1 more years of application. One alternative explanation is that students who make mistakes don’t learn to avoid them but, instead, make mistakes regardless of the year. Then, because making a mistake increases the chances of not being admitted, they would have attempted more times than the others. It isn’t evident why the fraction of students with Finnish Matriculation Examination degree and native Finnish speakers is larger for mistake makers than for non-mistake makers. However, although significant, these differences are quite subtle.

Table 13 reports the corresponding results but for obvious mistakes. The results are somewhat similar: no gender differences can be inferred, and obvious-mistake makers are younger and more often first-timers compared to non-obvious-mistake makers. However, the fractions of native Finnish speakers are close, 95.0 % and 95.6 %, and the associated p-value is high, 0.658. Relatively small differences and high p-values are also found for fraction for students with a Finnish Matriculation Examination degree, for differences with similar magnitudes as in Table 12, the p-values can differ just because of differences in sample sizes.

What is more, significant differences between obvious-mistake makers and non-obvious-mistake makers are found based on the fraction living in urban areas, such that obvious-mistake makers are more than five percentage points more likely to live in rural areas, given significance level 1 %. Furthermore, when it comes to number of times applied before, the finding is reversed compared to results of Table 12: those who made an obvious mistake had applied on average 0.2 fewer times compared to those who hadn’t. The difference is also significant at 1 % significance level.

The results of Table 13 support the hypothesis that students learn to avoid mistakes, and younger students with less experience, measured by first-timer status and number of times applied, may not understand as well what kind of strategies should be avoided. An alternative explanation for differences in times of application between obvious-mistake makers and non-obvious-mistake makers is that applying multiple times is a sign of being a "serious" applicant. Thus, an applicant who takes the application process seriously could put more effort into examining the admission procedure's properties as well as the previous years' cut-offs, and therefore, have higher chances of avoiding making an obvious mistake.

Table 13. Comparisons by Obvious-Mistake Making Status, Background Characteristics.

Obvious-Mistake Maker	No	Yes	***T*-test *p*-value:**
Variable			
Male (= 1)	0.565	0.560	0.877
Age	22.012	21.225	0.008
Native Finnish Speaker (= 1)	0.950	0.956	0.658
Lives in Urban Area (= 1)	0.885	0.833	0.008
First-timer (= 1)	0.850	0.887	0.088
Yo-graduate (= 1)	0.921	0.909	0.485
Times applied before	1.643	1.440	0.001
Observations	*9,655*	*275*	*9,930*

Note: The table reports means for background characteristics for obvious-mistake makers and non-obvious-mistake makers. A student is a first-timer if she doesn't have an existing academic degree and haven't accepted any offer from a college in 2014 or later. A student is a yo-graduate in case she has a Finnish Matriculation Examination degree. "Times applied before" refers to number of times applied before since 2009. The t-test p-value is from a two-sided t-test testing the hypothesis that the sample means are equal.

On the other hand, lack of strategic sophistication could be explained by informational differences, which being a native Finnish speaker and living in urban areas could capture. However, the results don't give us a reason to suspect that those who are not native Finnish speakers would suffer from informational disadvantages, yet this could be the case for students living in rural areas. It could be that optimal strategies are discussed in urban areas in larger high schools, or then living in a rural area could be correlated with something else, such as students' geographical preferences over study programmes which could again be correlated with the probability of making an obvious mistake.

Table 14. Comparisons by Mistake Making Status, Matriculation Examination Performance.

Mistake Maker		No	Yes	***T*-test *p*-value:**
Variable				
Mother tongue	Top 20 %	0.200	0.156	0.000
	Middle 60 %	0.721	0.760	0.001
	Bottom 20 %	0.079	0.083	0.519
Advanced Math	(= 1)	0.413	0.378	0.008
Observations		*16,609*	*1,509*	*18,118*

Note: The table reports the fractions of students whose mother tongue matriculation examination grade belongs to top 20 %, middle 60 %, and bottom 20 % out of all exam takers as well as the fraction of students having taken the exam in mathematics, advanced syllabus level, by mistake making status. The t-test p-value is from a two-sided t-test testing the null that the sample means are equal.

Table 14 reports results on comparisons of mistake makers and non-mistake makers by matriculation examination performance. The results suggest that there are differences in students' matriculation examination performance by mistake making status. The distribution of the scores in the mother tongue exam – the obligatory exam – has less mass in the top 20 % grades and more in the middle 60 % for mistake makers compared to non-mistake makers: the fraction of students belonging to the top fifth of all exam takers is almost five percentage points larger for those who don't make mistakes compared to those who do, and the fraction belonging to middle 60 % almost as much higher. Again, the associated p-values are small, less than 1 %.

What is more, mistake makers have a higher fraction of students not taking the exam in mathematics, advanced syllabus level, compared to non-mistake makers: around 41 % of non-mistake makers took the exam while 38 % of mistake makers did. This difference too is significant at 1 % significance level. Recall that in addition to the mother tongue test, the Finnish Matriculation Examination consists of at least three tests from four categories – second national language, foreign language, mathematics, and humanities or natural sciences – and either the test in second national language, foreign language, or mathematics must be an advanced syllabus level test. Therefore, whether a student took the test in mathematics, advanced syllabus level, could signal student's academic aptitudes, or at least mathematical preparedness.

The results for comparisons of obvious-mistake makers and non-obvious-mistake makers' matriculation examination performance, reported in Table 15, are similar in magnitude compared to those of Table 14. However, the p-values remain large. For such a small number of obvious-mistake makers, we would need larger differences to find significant results. Thus, it is difficult to conclude if the differences are a result of random variation or true differences in parameters generating the data. However, at least the data doesn't suggest that students making obvious mistakes would perform better in matriculation examination. Overall, given results of Tables 14 and 15, making an application mistake seems to be negatively correlated with students' academic aptitudes.

Table 15. Comparisons by Obvious-Mistake Making Status, Matriculation Examination Performance.

Obvious-Mistake Maker		No	Yes	***T*-test *p*-value:**
Variable				
Mother tongue	Top 20 %	0.202	0.176	0.317
	Middle 60 %	0.718	0.740	0.454
	Bottom 20 %	0.080	0.084	0.813
Advanced Math	(= 1)	0.411	0.376	0.268
Observations		*8,889*	*250*	*9,139*

Note: The table reports the fractions of students whose mother tongue matriculation examination grade belongs to top 20 %, middle 60 %, and bottom 20 % out of all exam-takers as well as the fraction of students having taken the exam in mathematics, advanced syllabus level, by obvious-mistake making status. The t-test p-value is from a two-sided t-test testing the null that the sample means are equal.

Differences in results found for comparisons of mistake- and non-mistake makers (Tables 12 and 14), and for obvious mistake- and non-obvious-mistake makers (Tables 13 and 15) could help us differentiate the sources from which application mistakes stem from, other than lack of sophisticated behaviour. For example, the fact that no differences in terms of whether students live in urban areas are found for mistake- and non-mistake makers but that differences exist between those who make obvious mistakes and those who don't, could suggest that there are reasons other than informational disadvantages that make students make mistakes. Likewise, having had multiple application attempts doesn't seem to protect students from avoiding making mistakes, which isn't the case for obvious mistakes.

These differences could reflect the difficulty in predicting the upcoming entry thresholds in the year of application. Students who make mistakes, but not obvious mistakes could potentially understand what kind of behaviour is always suboptimal under the mechanism, and thus, be strategically sophisticated yet fail in behaving accordingly with respect to the actualised cut-offs; a student may need to balance between submitting an ROL corresponding to her true preferences and playing safe if the study programmes she likes have had somewhat small cut-off differences in the past, but she doesn't know what they'll be in her year of application. This could also reflect risk taking attitudes as a less risk averse student may submit an ROL even if there is a potential that it'll end up being a mistake while a more risk averse person would avoid doing so.

Yet, if this was the case, we could expect gender differences between mistake- and non-mistake makers as typically females are more risk averse than males. On the other hand, it could be that in the absence of the fear of making an application mistake the fraction of female students making mistakes should be larger if they, for example, should realistically expect scoring higher in which case they would have higher chances of admittance for their top reported option and the second reported one, if the point difference ended up being more than one.

This would be in line with what Pekkarinen (2015) finds when investigating BAE students' answering patterns in the entrance exam in a setting where students are punished from choosing a wrong alternative in multiple choice questions: the phenomenon of omitting more answers than what would be optimal given the student's matriculation examination performance level is more prevalent for female students compared to males, but female students perform better in the matriculation examination than males. In addition, it isn't necessarily the gender that captures risk aversion attitudes, but it could be age as well. It may be more important for older students to be admitted in the first place to avoid more gap years, and it could be that they don't want to take the risky alternative and apply to one's favourite programmes at the cost of risking remaining unassigned.

To conclude, in this chapter, I reported the results for the analyses for testing the hypotheses constructed to answer the research questions. The results are summarized in Table 16. Motivated by the result that students who make application mistakes exist, I additionally compared students by their mistake making status. I found that those who make what a call a mistake, are younger, more often native Finnish speakers, first-timers, and students with a Finnish Matriculation Examination and they have had more attempts compared to those who don't. Mistake makers also perform better in terms of matriculation examination performance compared to non-mistake makers. No differences in terms of gender or fractions of students living in rural areas can be inferred.

Table 16. Summary of Results.

Research Question	**No.**	**Hypothesis**	**Supported?**
1. Is the applicants' behaviour in line with some applicants strategizing in the presence of the priority points? and 2. If they do, how do they strategize?	1a	Students avoid ranking programmes with small expected cut-off differences among the first four alternatives more under PPM compared to DA.	Yes, but programme/ ranking dependent.
	1b	Students avoid ranking programmes with high expected cut-off scores as their first choice more under PPM compared to DA.	Yes.
	1c	Students submit shorter ROLs under PPM compared to DA.	Unclear.
3. Are there students who make application mistakes?	2	Applicants who make application mistakes under PPM exist.	Yes.

Those who made what I call an obvious mistake on the other hand are younger, more often from rural areas and first-timers, and have had fewer attempts compared to who didn’t. Obvious-mistake makers have a smaller fraction of students obtaining top scores in the mother tongue matriculation examination test and a smaller fraction taking the test in mathematics, advanced syllabus level, compared to non-obvious-mistake makers. However, the changes are not large enough to yield statistically significant differences, given the small sample of obvious-mistake makers. Therefore, no conclusions on differences in terms of matriculation examination performance can be made. Likewise, evidence in favour of differences in fraction of males, native Finnish speakers, and students with a Finnish Matriculation Examination degree is not found.

7. Conclusion

In this thesis, I study a college admissions mechanism used in Finnish college admissions in the field of Business Administration and Economics (BAE) during 2015–2017. The mechanism, which I refer to as the Priority Point Mechanism (PPM), is a hybrid of the Boston Mechanism (BM) and the Deferred Acceptance algorithm (DA) and rewards students with extra points based on the position on which study programmes are ranked. The mechanism was replaced by DA in 2018.

The thesis is two-staged. First, I theoretically investigate what kind of strategic incentives PPM offers. Specifically, I define the correspondence of an application mistake under BM for PPM: a strategy by which an applicant can only be hurt under PPM. Second, given the characterisation of an application mistake under PPM, I study how students respond to the strategic incentives the mechanism offers. In particular, I investigate the following three questions:

1. Is the applicants' behaviour in line with some applicants strategizing in the presence of the priority points?
2. If they do, how do they strategize?
3. Are there students who make application mistakes?

Using information on BAE applicants' full Rank Order Lists (ROLs) and applying a First Differences (FD) approach for students participating in the BAE admissions procedure during 2016–2018, I find evidence in favour of students strategically behaving under PPM. I find that students avoid ranking study programmes with small expected threshold differences as subsequent options among their first four alternatives and listing programmes with high entry thresholds as their top choice more under PPM compared to DA, the strategy-proof mechanism. Yet, the result that students avoid applying to study programmes with small cut-off differences may not apply to all study programmes; out of three study programme pairs investigated, for the least prestigious pair the effect of the removal of priority points on the probability of ranking the programmes as subsequent options is positive, but small in magnitude and insignificant. Alternatively, avoiding listing programmes with small expected cut-off differences may be more meaningful for the higher ranks. Likewise, no strong evidence in favour of students submitting shorter ROLs under PPM compared to DA can be found. The trade-off between the number of BAE programmes and other programmes a student can list as well as the other changes that occurred in the BAE admissions procedure between 2017 and 2018 could make the estimates conservative.

Given two different measures I define for making an application mistake, I find that students who make such mistakes exist. I find that students who submit ROLs by which they can only be hurt by given the actualised entry thresholds exist. That is, students who make a *mistake* exist. In addition, students who submit ROLs that clearly demonstrate lack of strategic sophistication exist. In other words, students who make an *obvious mistake* too exist.

Motivated by the results that students who make application mistakes indeed exist, I additionally compare students who made a (obvious) mistake compared to those who didn't. I find that no gender differences occur between those who made a mistake and those who didn't, nor can differences be found in proportions of students living in urban areas. Mistake makers, however, are younger, more often native Finnish speakers, first-timers, and students with a Finnish Matriculation Examination degree, as well as have had a larger number of times of application compared to non-mistake makers. They also have worse matriculation examination grades in the obligatory mother tongue test and have a smaller fraction of students having taken the voluntary exam in mathematics, advanced syllabus level.

No gender differences could be found between those who made an obvious application mistake and those who didn't, but no differences in proportions of native Finnish speakers and students with a Finnish Matriculation Examination degree occur either. Obvious-mistake makers were also younger and more often first-timers compared to non-obvious -mistake makers, but they came more often from rural areas and had had fewer attempts.

Studying how students respond to the strategic incentives offered by the college admissions mechanism applied is important at least for two reasons. First, studying strategic behaviour under college admissions is important as such because mis-leading conclusions could be drawn if stated preferences were taken as true preferences when strategisation occurs. Especially, no conclusions can be made about motivation or student satisfaction, if measured by how high a study programme or a college was ranked and whether a student was accepted by her first reported option, respectively, if preferences are not truthfully reported. Second, strategic behaviour and the lack of it can have implications on the quality of the matching outcome: in particular, it can lead into unfair allocations where some students justifiably envy others.

However, it should be emphasised that when it comes to the investigation of strategic behaviour, the results of this study only generalize to the multiple-year BAE students of 2016–2018, and to those only under certain assumptions. Hence, the justification of the importance of studying strategic behaviour under college admissions that relies on the associated effects on the quality of the matching outcome doesn't immediately motivate the importance of the results of the thesis: it could well be that those who strategized were those who had no chances of admittance in the first place, and thus, strategic behaviour could be pay-off irrelevant.

Nonetheless, each year, one third of all students had applied at least once before during 2016–2018; for accepted students, the corresponding number is three fifths. In addition, the groups of multiple-year applicants are very similar to the groups of accepted and all applicants. Therefore, although the possibility cannot be ruled out, there is no reason to suspect that the results of students behaving strategically would be driven by students who couldn't potentially have been affected by it, and the group of multiple-year applicants may in fact be the group we are interested in as it is reasonable to think that it consists of students who take the application process seriously and have higher chances of admittance, given the large fraction of multiple-year students among accepted students. If we were to look at accepted students we couldn't, first, follow the same individuals over time. Second, we couldn't know if students who were chosen under PPM strategically behaved or whether PPM selects students who act as if they did – this could be a natural consequence of a mechanism in which the probability of being accepted depends on the ranking of the programmes, even if no strategic behaviour occurred.

As mentioned, the results of the thesis are also dependent on assumptions made. Importantly, I make the case that the other changes that occurred between 2017 and 2018 – namely, the wider application of the matriculation examination-based admission – should only make the estimates conservative if captured by the treatment effect identified. This conclusion relies on several assumptions. Although the assumptions can be considered reasonable, conservative estimates of the treatment effects are obtained only if the FD approach succeeds in identifying the treatment effect. This relies on the assumption that multiple-year students of 2016 and 2017 shouldn't change their behaviour differently compared to those of 2017 and 2018 if both faced the same change in mechanisms, controlling for relative changes in times of application. Lastly, the outcome variables should be valid measures of small-point difference behaviour, first-choice behaviour, and ROL length.

Even when all the assumptions made hold, we can only conclude that students' behaviour is consistent with students strategically behaving: there is always a chance that the effects found are driven by something else than changes in admission criteria. For example, it is always possible that students' preferences over programmes change, say, because some university towns suddenly become more attractive. Since students' true preferences are not observable, we cannot conclude with certainty that applicants were indeed strategically behaving.

Furthermore, this thesis doesn't provide any empirical evidence on improvements on the quality of students' allocation to study programmes, and it shouldn't be taken as given that manipulable mechanisms produce more unfair outcomes compared to strategy-proof ones. Again, it should be emphasised that not all types of strategic behaviour need to be harmful for the applicants. In addition to the possibility that those who strategize are the ones who don't have any chances of admittance, applicants could manipulate their preferences in a way that is irrelevant in terms of the matching outcome. In particular, if strategization was driven by students dropping study programmes to which they have zero admission probability – given the thresholds produced by the student-optimal stable matching – strategization would be pay-off irrelevant. In fact, in theory, the student-optimal stable matching can be implemented in a Nash Equilibrium of BM in the presence of complete information and all students being strategically sophisticated in the sense that they optimally respond to other students' strategies (Ergin & Sönmez, 2006).

Wu and Zhong (2014) even make the case that BM could outperform DA in terms of ex-post fairness when application takes place before an entrance exam, as in the case of BAE. They argue that under BM, students need to consider their expected admission chances based on their own level and therefore, lower ability students would give up trying their luck for prestigious colleges whereas under DA, they're not hurt by doing so and could be accepted by a more prestigious college than they would deserve if they happen to perform well in the entrance exam.

Nevertheless, the fairness trade-off rarely occurs in practice in favour of BM. First, BM producing the student-optimal stable matching relies on unrealistic assumptions of complete information and optimally responding students as well as students managing to coordinate in this complicated game, given the multiple equilibria. Second, when it comes to the claim that BM could outperform DA in terms of ex-post fairness because it forces students to apply programmes corresponding to their own level, students rarely realistically self-evaluate their admission probabilities. As a result, Pan (2019) shows that BM rewards overconfident students at the expense of underconfident ones – and overconfident students tend to be lower ability students.[15] Furthermore, if luck could contribute to a student being admitted to a more prestigious college than she would deserve, it is arguably the criteria that should be changed rather than the mechanism that should be adapted to such criteria.

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[15] Another question is whether lower ability students should be favoured: it might be that lower ability students benefit more from being matched to higher quality colleges compared to high ability students (Zhong & Zhu, 2021).

Another question worth considering is whether fairness, that is, stability should be pursued if it is done at the expense of efficiency: students being matched with their most preferred options could be a valuable goal as such, even if it resulted in justified envy. Indeed, some discussion on the potential trade-off between efficiency and fairness between DA and BM is ongoing. However, again, the theoretical results and the empirical evidence of BM outperforming DA in terms of efficiency are sensitive to assumptions on applicants having realistic ideas of their admission chances. Using survey data, Kapor et al. (2020) show that when realistic admission probabilities are assumed, a negative welfare effect is found when shifting from BM to DA, while using the actual expected admission probabilities, the sign is reversed. In addition, the discussion concerns school choice, where schools have coarse priorities over applicants, and therefore DA involves lot of tie-breaking. When schools have strict preferences over applicants, there seems to be a consensus that DA is preferrable to BM in terms of student welfare as well (Abdulkadiroğlu et al., 2009; Miralles, 2009) and focusing on stability only may guarantee efficiency too (Budish & Cantillon, 2012).

How the change in mechanism affects the quality of the matching outcome would be a difficult question to answer in the case of BAE. When it comes to the investigation of strategic behaviour under PPM, I take the approach that it is reasonable to assume that the other changes in admission criteria applied should only make the estimates of the effect of the removal of the priority points conservative, if an effect associated with all changes is identified. This assumption wouldn't arguably be reasonable if we were to investigate the associated effects on the matching outcome. Especially, if we found improvements in, say, stability, we couldn't know if the effect was driven by the change in mechanism or whether the matriculation examination-based admission succeeds in selecting students better with respect to the measure of stability used.

In this thesis, I treat the priority points as a property of the college admission mechanism. Yet, it could well be that they present a valuable part of study programmes' preferences and that the programmes do indeed prefer students who like them back: programmes may, for instance, want to capture motivation of students. Thus, it isn't evident if a student justifiably envies another in case she isn't accepted by a programme while a lower scoring student is if the lower ranking student has signalled more motivation. Nevertheless, as discussed, if applicants report programmes in an order different than their true preferences, the rank-ordering of programmes can be seen as a poor measure of motivation but may in fact reflect aspects such as confidence.

The interpretation of the results regarding students who make application mistakes isn't clear-cut either. Although the fractions of students making mistakes are significantly different from zero, the somewhat small numbers could also be interpreted as evidence in favour of students being aware of the properties of the mechanism. Yet, the measures only capture a small number of strategies that could be harmful or indicate lack of strategic sophistication, and don't give us idea of the full extent to which applicants may have been affected by their choices.

Although it would seem intuitive that students who lack strategic sophistication would always be worse off under a manipulable mechanism, this doesn't need to be the case; if strategically sophisticated students avoid applying to the most prestigious programmes, seats at prestigious programmes may be available for the less strategically sophisticated students. If strategic sophistication is positively correlated with students' academic aptitudes – as was found in the thesis – it could lead into students who understand the properties of the mechanism justifiably envying those who don't. Although the opposite result remains more widely documented, there is some evidence in favour of naïve students doing better under a manipulable mechanism (He, 2015). Yet, in this case naïve students would behave similarly as if they were overconfident, which would give them an arguably unfair advantage too. Therefore, regardless of whether the less strategically sophisticated students are harmed by or benefit from their sincerity, it can lead into non-desirable outcomes.

A student playing a strategy that ends up being an application mistake under PPM with respect to the actualised cut-offs does not need to indicate lack of strategic sophistication. On the contrary, the result that many students end up making mistakes but not obvious ones may in fact reflect difficulties in predicting the upcoming entry thresholds. Indeed, the cut-offs vary year-by-year and criterium-by-criterium, making it challenging to predict the difficulty-to-get-in order, not to mention the relative cut-off differences that are central under PPM.[16] The differences in results for comparisons of mistake makers and non-mistake makers, and obvious-mistake makers and non-obvious-mistake makers may also suggest that the reasons behind making mistakes could differ: for example, having more experience seems to protect students from making an obvious mistake but not a mistake, and informational disadvantages and lack of experience seem to translate into higher probabilities of making an obvious mistake but not a mistake. Therefore, the difficulty of playing a successful strategy even if a student understands the properties of the mechanism that arises from the difficulty in predicting the upcoming entry thresholds gives an additional dimension by which applicants could be hurt.

Under a priority mechanism, it isn't clear that students are chosen to colleges based on who would deserve it the most. In contrast, a student's strategic sophistication can play a role in whether a student is chosen. As the results of the thesis suggest, this can put students in an unequal position in terms of aspects such as informational disadvantages and experience. Furthermore, a student who is strategically sophisticated isn't always better off either: understanding the properties of the mechanism, she can rather play a strategy that is safe than what would give her the best possible allocation. What is more, because of difficulties in predicting study programmes' entry thresholds, a strategically sophisticated student can end up being hurt. As a result, level of risk aversion, luck, and confidence can contribute to who ends up being successful in the admission process. On the other hand, level of risk aversion can be correlated with applicants' gender, and confidence negatively correlated with academic aptitudes but positively with admission chances.

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[16] The phenomenon of alternating thresholds could be seen as evidence in favour of strategic behaviour as such: it doesn't seem realistic that the pattern would be driven by students' preferences alternating year-by-year. If applicants strategically apply to programmes having lower thresholds in previous year, that would change the relative orderings year-by-year if many applicants do so.

As a results of the college admissions reform of 2020, discussion on college admissions remains wide in Finland. Nevertheless, despite the importance of college admissions and despite how manipulable mechanisms can treat students unequally and reward aspects such as overconfidence, little attention has been put on priority mechanisms and how they incentivise strategic behaviour as well as the potential consequences of strategisation and students strategizing heterogeneously. In contrast, in Taiwan, after which the family of Taiwan Mechanisms was named, a similar mechanism to PPM that decreases applicants' chances of being admitted the lower a college is ranked was received with resistance.[17] However, in the case of PPM, the property of the mechanism isn't quite as clear as formally applicants are rewarded with extra points rather than punished with deduction points, although the processes are equivalent, which could explain why no such resistance was met in the context of BAE.

This thesis investigates application behaviour under the mechanism applied in the fields of BAE during 2016–2017 and is among the first ones to study strategization in the context on Finnish college admissions. Because of the importance of college admissions and because of the potential effects of strategic and non-strategic behaviour under priority mechanisms on fairness, the topic undoubtedly deserves more attention; especially the entrance-exam-heavy application process that shares similar properties with other priority mechanisms should justifiably get more attention. In addition, this thesis does not provide empirical evidence on how strategic or non-strategic behaviour translates into the quality of the matching outcome. To answer to questions about how students differently responding to a manipulable mechanism's strategic incentives affects the quality of students' allocation to colleges, more research is needed.

[17] In Taiwan, TMs with different deduction rules in different districts are applied to assign students to senior high schools. For more details, see Dur et al. (2022).

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Appendix

Table 17. Regression Results for Sophisticated Behaviour with Years of Application Dummies.

Hypothesis	1a			1b	1c
Outcome / **Regressor**	Aalto & Turku	Turku & Tampere	Lranta & Vaasa	Aalto 1st	ROL length
Removal of Priority points	0.126*** (0.029)	0.0575** (0.0202)	0.0217 (0.0219)	0.0513*** (0.00993)	0.068 (0.0427)
1 Prior attempt (= 1)	0.00721 (0.0258)	0.0428 (0.0298)	0.0701 (0.0404)	-0.00316 (0.0143)	0.349*** (0.0621)
2 Prior attempts (= 1)	-0.0406 (0.0463)	0.116* (0.0581)	0.111 (0.0796)	0.00234 (0.0275)	0.526*** (0.121)
3+ Prior attempts (= 1)	-0.0145 (0.0639)	0.233** (0.0882)	0.111 (0.12)	0.05 (0.0411)	0.575** (0.184)
Constant	-0.0373 (0.026)	-0.0828** (0.0289)	-0.0367 (0.0383)	-0.0155 (0.0139)	-0.114 (0.0601)
Observations	*1,433*	*2,673*	*1,853*	*6,542*	*6,542*
R^2	*0.017*	*0.006*	*0.003*	*0.006*	*0.006*

Note: The table reports FD estimation results, i.e., results from OLS regressions of the outcome variable's first differences on the regressor's first differences. Prior attempts refer to number of prior attempts in year $t-1$ and thus, the dummy zero prior attempts is omitted. Standard errors clustered at individual level are reported in parentheses. Lranta stands for Lappeenranta. $*\ p < 0.05,\ **\ p < 0.01,\ ***\ p < 0.001$.

Table 18. Regression Results for Sophisticated Behaviour with Years of Application Dummies, Other Programmes' ROL Length Included.

Hypothesis	1a			1b	1c
Outcome	Aalto &	Turku &	Lranta &	Aalto 1st	ROL length
Regressor	Turku	Tampere	Vaasa		
Removal of priority points	0.139*** (0.029)	0.0687*** (0.0201)	0.0308 (0.022)	0.0556*** (0.00996)	0.220*** (0.0392)
1 Prior attempt (= 1)	0.00498 (0.0259)	0.0401 (0.0296)	0.065 (0.041)	-0.00416 (0.0143)	0.314*** (0.0543)
2 Prior attempts (= 1)	-0.0441 (0.0464)	0.109 (0.0577)	0.104 (0.0808)	0.000978 (0.0275)	0.477*** (0.105)
3 + Prior attempts (= 1)	-0.0208 (0.0641)	0.223* (0.0875)	0.0994 (0.123)	0.0474 (0.0412)	0.483** (0.159)
ROL length others	-0.0371*** (0.00938)	-0.0417*** (0.00717)	-0.0400*** (0.0076)	-0.0127*** (0.00337)	-0.451*** (0.0143)
Constant	-0.0357 (0.0261)	-0.0758** (0.0288)	-0.0269 (0.0388)	-0.0138 (0.014)	-0.0548 (0.0528)
Observations	*1,433*	*2,673*	*1,853*	*6,542*	*6,542*
R^2	*0.026*	*0.018*	*0.015*	*0.008*	*0.16*

Note: The table reports FD estimation results, i.e., results from OLS regressions of the outcome variable's first differences on the regressor's first differences. "ROL Length others" is the number of programmes other than BAE ones listed. Prior attempts refer to number of prior attempts in year $t-1$ and thus, the dummy zero prior attempts is omitted. Standard errors clustered at individual level are reported in parentheses. Lranta stands for Lappeenranta. $*\ p < 0.05,\ **\ p < 0.01,\ ***\ p < 0.001$.

Table 19. Maximum Threshold Differences between Study Programmes.

Group		1	2		3			4				
	Programme	Aalto	Tampere	Turku	Vaasa	Lranta	Jkylä, BE	Pori	Oulu	Kuopio	Joensuu	Jkylä, E
1	Aalto	0	-1	-0.25	-3.75	-3.25	-3.5	-5.5	-4.75	-5	-6.5	-4.5
2	Tampere	6.5	0	1.5	-2.75	-2.25	-1.75	-4.5	-3.75	-4	-5.5	-3.5
	Turku	5	0.75	0	-3.5	-3	-3	-5	-4.5	-4.75	-6.25	-4.25
3	Vaasa	13	8.75	10	0	2.5	3	-1	-1	0.75	-2	0.75
	Lranta	13.5	7	8.5	0.75	0	2.5	-0.25	-0.75	0.25	-1.75	-0.75
	Jkylä, BE	11.75	6.25	7	1.5	1.25	0	0.5	-0.25	-0.5	-1	-1
4	Pori	15.25	11	11.75	3.25	5	6	0	2	4	0.5	2.75
	Oulu	15.25	10	11.25	2.5	3.75	4.25	1.5	0	2	-0.75	2
	Kuopio	14.25	9.75	11	2	3.5	4	1	0.25	0	-0.5	1.75
	Joensuu	17.25	11.75	13	4.5	5.5	6	3.5	2	4	0	3.75
	Jkylä, E	16.25	9.75	11.25	3.5	3.25	4.5	2.5	1.75	2	1	0

Note: The cells of the table are determined as $\max_{a,t} c_{mta} - c_{m'ta}$, where c_{mta} is the entry threshold of programme m in year t with respect to admission type a, and programme m is the programme determined by the column and programme m' by the row. The underlined cells demonstrate that for every year and every criterium, $\max_{m,m',a,t} c_{mta} - c_{m'ta} < 1$ if programme m comes from group n and programme m' from group n' such that $n > n'$. The cells coloured in dark grey demonstrate that for at least one year and one criterium, $c_{mta} - c_{m'ta} > 2$ if programme m comes from group n and programme m' from group n' and $n < n' - 1$, except for Kuopio and Vaasa. Lranta stands for Lappeenranta.