College Application Choices in a Repeated Deferred Acceptance (DA) Setting: Empirical Evidence from Croatia

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Abstract

How do beliefs on admission probability influence college application choices? In this study, we empirically investigate how admission probability is reflected in application choices in a centralized admission system. We utilize a novel setting of a dynamic deferred acceptance mechanism as employed in Croatia with hourly information updates and simultaneous application choices. This setting allows us to explore within-applicant strategic adjustments as a reaction to changing signals on admission probability. We show in an RDD analysis that applicants react to negative signals on admission probability with an increased propensity to adjust their application choices by 9% and thereby reduce their likelihood of admission to the respective program even though admission probability is strictly positive. Additionally, we show how application strategies evolve over time, while applicants learn about their admission probability. The about 20% of applicants with a high initial risk of not being admitted to any ranked program manage to improve their application choices over time by exchanging programs with a low admission probability for safer programs. Yet, we also identify a popular and potentially harmful strategy of applying to safer programs before applying to more risky "reach" programs. About a fifth of applicants have the potential to improve their application choices by resorting their application choices.

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1 Introduction

The decision of where and what to study strongly influences future income prospects (Altonji et al., 2014). Consequently, poor college application choices can have detrimental long-run consequences for life outcomes. One factor contributing to poor application choices are information frictions (Bettinger et al., 2012; Dynarski et al., 2021; Hoxby and Turner, 2015). Removing such frictions can support students in making better application choices and ultimately gain admission to a study program that suits their interests and abilities. Centralized application systems mitigate information frictions by offering easily accessible information on program characteristics, admission criteria and often a proxy for admission probability. Still, it remains unclear whether applicants are able to correctly process this information, thereby making better fitting application choices.

According to the canonical school choice model by Abdulkadiroğlu and Sönmez (2003), applicants in a centralized admission system based on a Deferred Acceptance (DA) algorithm fare best when ranking their application choices according to their true preferences. Yet, a growing literature shows that applicants incorporate admission probability in their choices and thus misrepresent their preferences over study programs. For one part, this can be explained with biased beliefs on admission probability. Applicants over- or underestimate their admission chances (Arteaga et al., 2022; Larroucau et al., 2024) and consequently apply to too few programs or omit feasible programs from their application. For another part, applicants deviate from classical fully rational preferences, signaling a preference for study programs with higher admission probability but lower returns (Artemov et al., 2020; Hakimov and Kübler, 2021; Hassidim et al., 2021; Shorrer and Sóvágó, 2024). While the former bias can be addressed by providing more accurate information about admission probabilities, the latter behavior persists and may lead to significant application mistakes that result in a sub-optimal admission outcome.

In this study, we show how applicants develop their application strategy over the course of the application period and how signals on admission probability contribute to this process. We exploit the unique setting of a dynamic DA mechanism that is employed to assign applicants to study programs in Croatia. Here, applicants observe a proxy for admission probability in the form of preliminary admission outcomes for all ranked programs. At each full hour, these preliminary admission outcomes are updated based on revised application choices. Compared to the proxy on admission probability provided in other (static) systems, the proxy provided in Croatia can be regarded as more informative as it is based on application choices and competition of the current cohort. Yet, the proxy fluctuates as a result of each applicants' own and their competitions' adjustments of the application choices and should thus be regarded as a fuzzy signal on admission probability. This setting allows us to investigate within-applicants adjustments of the application strategy to fluctuating signals on admission probability.

In the first part of our study, we explore the dynamic nature of the Croatian system, which distinguishes it from the more commonly applied static system. Applicants participating in the dynamic system are exposed to fluctuating signals on admission probability, which are a consequence of their strategic adjustments. Depending on the type of program they apply to, the signal can be more or less fuzzy. Programs with a larger quota experience more cutoff score fluctuations, while the magnitude of the fluctuations are higher for programs with lower quotas. Both types of cutoff score fluctuations indicate uncertainty about admission but potentially in different ways. The cutoff score of most programs declines over the adjustment period, such that at the end, towards the application deadline, the final admission criteria are lower than the initial signals indicated. This adds further uncertainty to the signal on admission probability. We argue that applicants adjust their application choices as a response to updated beliefs on admission probability due to the (fuzzy) signal they receive. A first indicator of this is the increase in strategic adjustments in the beginning and towards the end of the adjustment period. In the beginning, applicants receive the first signal on admission probability based on which they can adjust their innate beliefs on admission probability. This initial belief-updating is likely the strongest one and induces many strategic adjustments. In the end of the adjustment period, application choices are closer to being binding, which makes reactions to updated beliefs more likely. We examine this more thoroughly in the second part.

In the second part of our study, we leverage a Regression-Discontinuity-Design (RDD) based on sharp (preliminary) admission cutoffs to show that applicants react to the signals on admission probability and consider their beliefs on admission probability in their application choices. Applicants start the application process with their initial beliefs on admission probability and update their beliefs to the signals they receive. The strongest signal for admission probability is whether applicants are tentatively above or below the sharp admission cutoff. Thus, we consider applicants above the cutoff as receiving a positive signal, while applicants below the cutoff receive a negative signal on admission probability. As cutoff scores fluctuate, admission probability for applicants just around the admission cutoff is highly comparable. This implies that adjusting the application choices as a response to a negative signal is not justified by a lower admission probability. Still, we observe that applicants who receive a negative signal on admission probability have a 9% higher probability to adjust their application choices. In particular, we find that when applicants receive a negative signal, the probability that they omit the affected program from their application is 6% higher compared to applicants who receive a positive signal. This shows that beliefs on admission probability are influenced by the information signal and shape application choices.

In the third part, we broaden our analysis from one program to the full application strategy, that is, the composition and ordering of study programs in the application choices. We investigate how admission probability is reflected in the application strategy and whether this changes over time. To this end, we compute a measure of admission probability for each applicant and program by simulating admission cutoffs for random samples of applicants. Based on this applicant $\times$ program specific measure we determine for each hourly application strategy each applicants' risk of not being admitted to any ranked program. In each cohort, 14-20% of applicants have a particularly high initial risk to remain unmatched. As they start receiving information signals on admission probability, this group of applicants manages to reduce this risk by up to 25 pp. They achieve this by swapping programs with a low admission probability for programs with a higher admission probability, rather than by extending their (relatively short) rank-ordered list (ROL) of study programs. The large majority of applicants has a particularly low initial risk to remain unmatched of only 0-1%. Although this risk remains low, also these applicants adjust their application strategy with respect to admission probability. While initially they ranked more risky "reach" programs in the top-3 positions, this quickly changes as they receive signals on admission probability. At the application deadline, they rank programs with a higher admission probability on the top-3 ranks and more risky programs on the lower ranks. Under the assumption that applicants have a preference for competitive programs, which is supported by the initial application choices, this contradicts the theory of optimal application strategies (Abdulkadiroğlu and Sönmez, 2003; Ali and Shorrer, 2025), according to which the ranked programs should be ranked according to one's true preferences. Yet, this behavior has also been observed in experiments (Y. Chen and Sönmez, 2006; Pais and Pintér, 2008) and fits the behavioral concept of expectation-based loss-aversion (Dreyfuss et al., 2022).

As behavioral bias can already be reflected in the initial application choices, we additionally compare applicants' initial application choices to their reported true preferences over study programs to investigate whether beliefs on admission probability are reflected in the initial application choices. In a survey conducted before the beginning of the adjustment period in 2019, we asked applicants for their top-3 most preferred programs and expected admission probability thereto. In the previous exercise we assume that applicants have a preference for more competitive programs and correctly assess their admission probability. Now, we observe applicants true preferences and their subjective innate beliefs on admission probability and can compare these to their initial application choices prior receiving any signal on their admission chances. While about 30% of applicants apply according to their reported true preferences, 17% of applicants rank none of their reported true preferences in their initial application choices. These strategies are strongly related to applicants' expected risk of not being admitted to any of their top-3 truly-preferred programs. Among the group with a particularly high expected risk, the share of applicants who do not rank any of their true preferences is significantly higher, at 40%. Meanwhile, 35% of applicants in the group with a particularly low expected risk rank their initial application choices according to their true preferences. Additionally, subjective beliefs on admission probability are reflected in the initial application choices of 26% of applicants. Of those, more than 80% omit programs for which they expect admission probability to be lower. This shows that already in the initial application choices applicants misrepresent their preferences. In particular, they do so by omitting programs with a lower expected admission probability. In the dynamic system the initial application choices are not binding. Thus, applicants have no reason to omit any of their most preferred study programs, even if they expect admission probability to be low. The cost of this application strategy is a missed opportunity of receiving an information signal and, thus, learning about their true admission probability.

In the last part of our study, we investigate whether the observed application strategies, i.e., sorting by admission probability and omitting programs with a low admission probability, are consequential for applicants' admission outcome. To this end, we simulate two counterfactual scenarios by replicating the assignment mechanism based on alternative application choices. For the first simulation we resort applicants final set of applications by admission probability in ascending order such that they apply to risky programs first. By that, we assume that applicants have a preference for the most competitive ranked program. Comparing the simulated and observed admission outcome we find that about 18% of applicants could be admitted to a more competitive program, simply be resorting their applications. For the second simulation we additionally fill empty slots in the application strategy (which consists of at most 10 programs) with the most-competitive programs an applicant ever considered over the adjustment period. In this counterfactual scenario, 25.9% of applicants are admitted to a more competitive program compared to the observed admission outcome. Both of these strategic adjustments come at no cost to the applicant (no increased search cost and no increase in risk). This shows that better-fitting admission outcomes that benefit the applicant are possible if application strategies rely less on beliefs on admission probability and the related behavioral biases.

Overall, we show that beliefs on admission probability are reflected in application choices. We identify two popular strategies, a) omitting programs with a low(er) admission probability and b) sorting ranked programs by admission probability. The former strategy keeps applicants from learning about their true admission probability in the beginning of the adjustment period and from being admitted to a potentially feasible program at the application deadline. The latter strategy results in applicants being admitted to less-competitive than possible programs and could be corrected at no cost. Similar application strategies are attributed in the literature to a behavioral bias referred to as expectation-based loss aversion (Dreyfuss et al., 2022; Kleinberg et al., 2024; Meisner and Von Wangenheim, 2023). Whether the Croatian setting enhances this behavioral bias e.g., due to signaling uncertainty via fluctuating signals, remains to be investigated.

The Croatian system is unique in its' way of providing up-to-date and applicant-specific information on admission probability. We show that applicants overreact to this information as they adjust their application choices to negative signals besides strictly positive admission probabilities. This is true in particular since admission cutoff scores decline over the adjustment period, implying that omitting a program in response to an early negative signal may result in applicants not applying to preferred and (unexpectedly) feasible programs. Thus, although applicants in Croatia are more informed than applicants in the more commonly applied static system, the fluctuating signal on admission probability cannot fully eliminate information bias due to applicants misinterpreting the information. Yet, we also show that applicants who initially make the most risky choices improve their application choices over time. On them, the information signal seems to have the desired information-bias-correcting effect.

With our research we contribute to three strands of literature. First, we contribute to the literature that demonstrates a gap between theoretically optimal and observed application strategies in strategy-proof school choice mechanisms. According to the canonical school choice model by Abdulkadiroğlu and Sönmez (2003), applicants in a strategy-proof school choice mechanism should always apply according to their true preferences. Although strategy-proofness dissolves when applicants are constrained in the number of programs they are allowed to rank (Calsamiglia et al., 2010; Haeringer and Klijn, 2009), it remains an optimal strategy to rank the constrained set of selected programs according to one's true preferences (Ali and Shorrer, 2025). Yet, experimental (see Hakimov and Kübler, 2021 for an overview of laboratory experiments; L. Chen and Pereyra, 2019; Rees-Jones and Skowronek, 2018; Ye, 2023) and empirical evidence (Artemov et al., 2020;

Hassidim et al., 2021; Larroucau and Rios, 2019; Shorrer and Sóvágó, 2024) showing that applicants deviate from truthtelling by following application strategies is growing. In particular, applicants base their application strategy on admission probability. In experiments participants rank options with a lower payoff but higher chances of assignment above options with a higher payoff but lower chances. In empirical settings, true preferences are harder to identify. For this reason, empirical studies in this literature focus on identifying clearly dominated choices such as ranking a program without financial aid above the same program but with financial aid (Artemov et al., 2020; Hassidim et al., 2021; Shorrer and Sóvágó, 2024). Among the various behavioral explanations for this behavior (Rees-Jones and Shorrer, 2023) , expectation-based loss aversion (Dreyfuss et al., 2022) is a particularly prominent one. By misrepresenting their preferences, applicants lower the reference point for expectations and thus mitigate potential disappointment (Meisner and Von Wangenheim, 2023). Introducing reference dependent preferences in a model of application choices can explain the application behavior observed in experiments (Dreyfuss et al., 2022). We contribute to this literature by providing empirical evidence for strategic application choices based on admission probability. In contrast to other studies, our unique setting allows us to investigate a broader set of application strategies for the full universe of applicants rather than restricting the analysis to one particular clearly dominated strategy.

Second, we contribute to the literature investigating information interventions in centralized admission systems. This literature shows that applicants have biased beliefs on admission probability. Here, a particular focus is on overconfident applicants, who submit truncated applications and thereby risk to remain unmatched (Arteaga et al., 2022; Larroucau et al., 2024). Providing information to applicants in experiments in the field, Arteaga et al. (2022) and Larroucau et al. (2024) show that applicants update their beliefs on admission probability and improve their application choices accordingly. Bobba and Frisancho (2022) model the belief-updating process and show that upward-biased beliefs on students position in the skill distribution can be corrected with applicant-specific information on test performance. We contribute to this literature by showing how applicants react to an applicant-specific, up-to-date but fluctuating information signal on admission probability provided within the application system. In line with the literature, we find that the information can encourage applicants at risk of remaining unmatched to make better application choices. Yet, we also show that the provided information cannot improve all applicants' choices. In the Croatian setting, applicants tend to overreact to the provided information signal, potentially due to misinterpreting it. This emphasizes the importance of how information is provided.

Third, we contribute to the growing literature on dynamic school choice mechanisms, in which applicants interact with the application platform during the assignment process. By that, dynamic systems allow applicants to gather information on their tentative admission outcomes, real-time cutoff scores or their competitors' application choices. The majority of this literature investigates properties of dynamic mechanisms in laboratory experiments (Bó and Hakimov, 2020; Gong and Liang, 2025; Klijn et al., 2019; Stephenson, 2022) or theoretically (Grenet et al., 2022). Most literature finds that dynamic mechanisms enhance truthtelling compared to static systems due to the enhanced information setting of applicants (Bó and Hakimov, 2020), particularly in highly complex choice settings (Gong and Liang, 2025). Empirical literature on dynamic application systems is scarce, potentially due to few applications of dynamic systems worldwide (see L. Chen et al. (2022) for an overview). The empirically-investigated real-world applications of dynamic school choice mechanisms are sequential mechanisms, where applicants apply in groups, starting with the highest scoring applicants. This allows lower-scoring applicants to gain valuable information on admission probability before making their final application choices. In Tunisia, this information enhances truthtelling (Luflade, 2017), but in Inner Mongolia the theoretical benefits of the system (Gong and Liang, 2025) do not translate into practice (Kang et al., 2023). The Croatian dynamic admission system is a novel setting in which applicants make simultaneous choices (rather then sequentially) while learning about their admission probability. Thus, we contribute to the literature on dynamic school choice mechanisms by providing evidence for application strategies in a yet-unstudied dynamic setting.

The remainder of the paper is structured in the following way: In Section 2 we provide a detailed summary of the Croatian application system. In Section 3, we describe the data. In Section 4, we provide descriptive statistics on the dynamics of the Croatian system, which distinguishes it from other application systems. In Section 5 we provide the results of our RDD analysis and in Section 6 we show how applicants develop their application strategy over time while learning about admission probability. Last, in Section 7, we investigate the consequences of following the application strategies we identify in the previous sections. Section 8 concludes.

2 The Repeated DA in Croatia

In Croatia, more than 30,000 high school graduates apply for higher education each year. They choose among more than 700 study programs that are offered by public and private universities and universities of applied sciences throughout the country. Here, a study program is defined as a major in a specific institution. As part of the high school graduation they participate in a centralized school leaving examination, henceforward the state exam, which is held nationwide. All students take three mandatory subject tests in Math, Croatian and a foreign language and can additionally opt for examination in multiple other subjects.

On a central online application platform, applicants rank up to 10 study programs to which they want to apply. Based on applicants' ranking of study programs, their rank-ordered list (ROL), a Deferred Acceptance (DA) mechanism is employed to match applicants to study programs. The DA mechanism matches each applicant to the highest-ranked program for which they can compete with the other applicants. Each applicant is admitted to at most one study program from their ROL or remains unmatched.

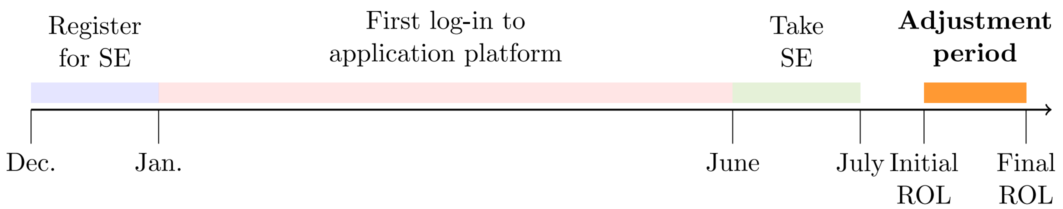
The underlying priority criteria is a score that is composed of weighted high school and state exam grades as well as points awarded for special achievements such as participating in a national competition. Each study program decides autonomously about the weights assigned to the subject grades, the aggregate grades, or the special achievements. This implies that the same applicant can have different admission chances for two programs, even when competing against the same applicants. The last applicant within a programs' quota, i.e., the lowest scoring admitted applicant, determines the minimum score required for admission. Applicants with a score above this cutoff score are admitted, all others are rejected.

The special feature of the Croatian system is that the DA matching process is repeated on an hourly basis. Within a window of about 5-11 days, the application platform publishes information on preliminary matching outcomes. These are the result of running the DA mechanism on the submitted applications (ROLs) of the current hour. Applicants can log in to the application platform to learn their preliminary admission outcome at the current state of applications. Next to observing to which program they are preliminarily admitted, applicants observe the full ranking of applicants and their position therein for each program on their ROL.

Upon receiving this information on the preliminary rankings, applicants can make adjustments to their ROLs. These adjustments can be based on the information they receive, but can also be completely independent thereof. As a consequence of aggregate adjustment behavior, preliminary matching outcomes and the cutoff scores required for admission to each program fluctuate over time.[1] Only at the application deadline do the submitted ROLs become final and cannot be changed anymore. For the last time, the DA mechanism determines a matching based on the final ROLs and applicants are informed of their binding match. This is the study program to which they gain admission.

Hypothetically, applicants must pay the study fees for the program to which they are admitted, regardless of whether they choose to attend or not. However, since this is not enforceable, the only cost of being admitted and not attending is that applicants have to wait for a year to reapply. Applicants who are not admitted can reapply in autumn but compete only for the left-over seats. They can also retake the state exam subject tests, although, if they passed in the first round, only at a cost. Although this option to participate in a second round improves applicants' outside option, admission chances in the second round are lower than in the first as most seats are already taken.

Figure 1: Timeline



The exact timing of the events in the application period is shown in Figure 1. From mid-December to mid-January, applicants register for the state exam subject tests they want to take. As different study programs require passing or assign weight to the

[1] Specifically, if an applicant with a score higher than the cutoff score decides to add a program to the top of their ROL, she drives out the previously last admitted applicant. The previously second to last admitted applicant now moves to the lowest rank within the quota and determines the new cutoff score. The cutoff score increases. Meanwhile, if an applicant with a score below the cutoff score applies to the program, the cutoff score remains unchanged. Additionally, the cutoff score of another program is affected by the one applicant's decision as well. The applicant who was driven out of the quota now applies to his next-ranked program and potentially drives out the last admitted applicant to this program himself. In this way, cutoff score fluctuations are passed on from one program to the next, even if only one applicant decided to adjust their ROL.

grade achieved in a specific state exam subject test, applicants have to be informed about their preferences over study programs already at this early stage. Starting in January, applicants can log into the centralized application platform for the first time. They can already start to construct their ROL and observe preliminary matchings. At this time, the information is not yet conclusive as the matchings are based only on the high school grades of applicants who already registered and constructed their ROL. During the whole month of June, applicants take the state exam subject tests. The grades for all the subject tests are published jointly and the applicants are given a few days to review. After all issues have been resolved, the first informative preliminary matchings are determined and published on the application platform at a time that was publicly communicated. This kicks off the adjustment period, in which applicants receive hourly information updates on preliminary matches. For our research, we focus on the adjustment period, starting with the initial ROL, which are the preference rankings submitted just before the first preliminary matchings are published. The exact timing of events differs between cohorts, but all dates are publicly communicated. We provide an overview of the exact event timing in the Appendix (Panel a) of Table A1).

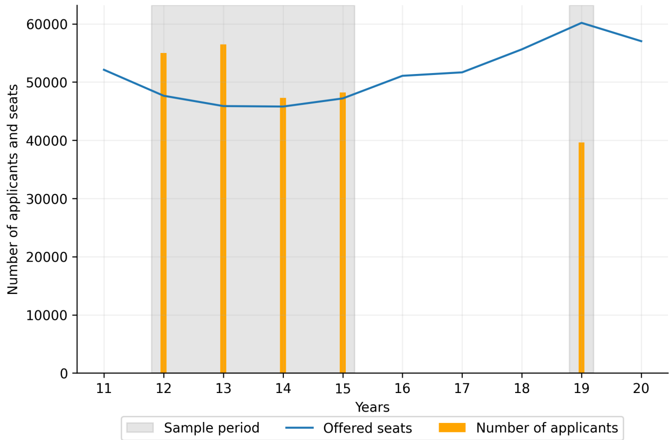
3 Data

The data used in this project is administrative data from the centralized admission system in Croatia provided by the Agency for Science and Higher Education. For the whole universe of applicants in the cohorts 2012 - 2015, we observe hourly application choices (ROLs) and the corresponding preliminary admission outcomes. This includes information on the program to which each applicant is temporarily admitted, as well as each applicant's rank position in the programs' ranking of applicants. In addition, we observe the scores with which applicants apply to each program if an applicant ever adds the program to their ROL. At the program level, we observe the number of seats or quota offered by each program. On the applicant level, we observe all high school subject grades, state exam subject grades, and their gender. By combining quotas, program's rankings of applicants, and applicants' scores, we compute a cut-off score for each program in every hour within the adjustment period. Based on this, we compute for each applicant the distance to the cut-off in terms of points and rank positions.

In 2019, we conducted a survey on the universe of applicants. Before registering on the application platform, the applicants responded to our survey in order to proceed with the log-in. The questions in the survey appeared one by one. Applicants were asked: 1) *"Imagine a situation where you can enroll in any study program in Croatia, regardless of the points you have achieved. Which study program would you choose?"* 2) *"In case you give up your first choice, which study program would be your second choice?"* 3) *"In case you give up your second choice, which study program would be your third choice?"*. After they locked their top-3 preferences we asked to elicit their beliefs on admission probability to each program listed previously. Applicants could not revise their answer to the previously answered questions after observing the next question.

For our analysis in Section 6.2, we combine our survey data with administrative data similar to the data described for the earlier cohorts above. As in 2019 we do not observe hourly ROLs directly, we use data on real-time changes made by applicants to their ROLs to recreate applicants' hourly ROLs.

Figure 2: Number of applicants and seats by cohort



Note: Figure shows the number of applicants applying via the centralized application system and the number of seats offered by universities per cohort. The shaded areas highlight the years in our sample.

Overall, per cohort, we have information on about 35,000 applicants applying to more than 700 programs over an adjustment period that lasts 5-11 days, depending on the cohort. On average, applicants rank about 4 programs on their ROL per hour. This results in 8.8 - 20.7 million observations per cohort. The exact numbers for each cohort are shown in Table 1.

In Figure 2 we show the number of applicants relative to the number of seats offered by universities per cohort. Although in 2012 and 2013 demand for seats exceeds supply, demand can be largely met in 2014 and 2015. Only in 2019 more seats are offered than applicants apply for. This implies that the competition for programs changes over time. In a nutshell the real measure of demand is the number of applicants times the number of choices, which is always far greater than number of available seats. From year to year the demand for programs is not necessarily equally distributed, we show in Panel b) of Table A1 in the Appendix the number of overdemanded programs and the magnitude of overdemand per cohort.

Table 1: Summary statistics

	2012	2013	2014	2015
# programs	727	759	767	780
# overdemanded programs	313	296	251	358
# applicants	34,735	34,922	35,938	36,759
# hours	83	118	216	98
avg. length ROL	4.07	3.87	3.57	4.58
# observations	8,790,011	12,053,877	20,669,729	13,378,643

Note: Table shows the total number of study programs, the number of study programs with overdemand, the number of applicants, the number of hours, the average number of ranked programs and the total number of observations in each sample (2012, 2013, 2014 and 2015).

4 Dynamics of the Repeated DA

The main feature that distinguishes the Croatian system from other applications of the DA is its iterative character. While in other systems, applicants construct their preference ranking without any individual-specific information, applicants in Croatia receive hourly information signals on their preliminary matching outcome under the current status of application. We consider the preliminary match result an information signal on applicant- and program-specific admission probability. From preliminary matchings, but also from applicants' distance to the cut-off, i.e., by how close they did or did not make it, they can deduct a proxy for applicant-specific admission probability.

Based on updated beliefs about admission probability, applicants can continue searching for programs to add to their ROL. For example, an applicant who observes a low admission probability to all programs in their ROL might want to add a program with a higher admission probability. Another applicant with a high admission probability to most of their ranked programs might want to look for a more ambitious program. Additionally, since application choices are not final until the application deadline, applicants can experiment with their choices over the course of the adjustment period. Only by adding a program to their ROL they can receive a signal and learn about admission probability.

As a consequence of applicants adjusting their ROLs to the new information, the Croatian system develops its own dynamic. With new applicants entering the competition for programs, the cutoff scores fluctuate. Thus, even an applicant who does not make any changes to their application choices from one hour to the next may observe a change in information signals about admission probability. First, this implies that the information signal should be regarded as a fuzzy signal rather than a fully informative one on the final admission probability. Second, fluctuating cut-off scores add further uncertainty, which might influence applicants' choices. In this first part of our research, we investigate the dynamic implications of the repeated DA.

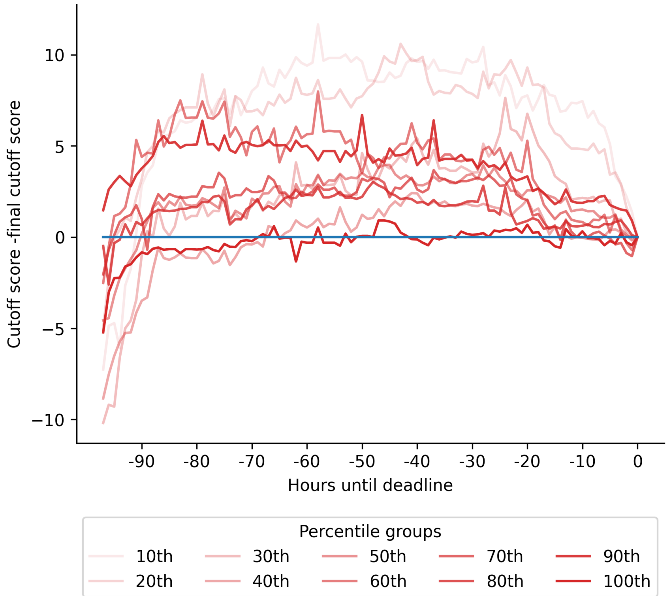
4.1 Volatility in Program Cutoffs

Unlike in a static DA, where there is only one program-specific cut-off for a cohort, applicants in a repeated DA setting observe hourly fluctuating admission cut-offs for every program. On one hand, this imposes additional informational uncertainty for programs with high cutoff score volatility. On the other hand, this system allows applicants to explore other options outside their initial set of preferences and to learn about admission chances.

In Figure 3 we show for 2015 how the cutoff score evolves over time. We group programs into 10 groups according to their absolute cutoff score. Programs in the highest percentile group are the most competitive programs with the highest final cut-off score. The y-axis shows the group average of the relative cutoff score, i.e., the hourly cutoff score deviation from the final cutoff score. The x-axis shows the time left until the application deadline, when the application choices are final. Apart from the very first hours, the hourly cutoff score lies above the final cutoff, implying higher preliminary admission criteria than the relevant final one. On average, the hourly cutoff score for each group never deviates by more than 10 points from the final cutoff. However, the magnitude of cutoff score deviations differs by percentile groups, with the least competitive programs showing larger average deviations from the final cutoff score. This pattern is even clearer in the cohort 2012 - 2014 as shown in Figure A1 in the Appendix.

Similarly, Figure 4 shows the change in the cutoff score from the beginning of the

Figure 3: Cutoff score fluctuations over time (relative to the final cutoff), 2015



Note: Figure shows cutoff score fluctuations over the adjustment period. The y-axis shows the difference between the current and the final cutoff score. A positive value means that the current cutoff score is higher than the final cutoff score. We aggregate the deviations from the final cutoff score of 10 percentile groups of programs based on the final cutoff score. The 100th percentile group are the 10% of programs with the highest final cutoff score, i.e., the most competitive programs.

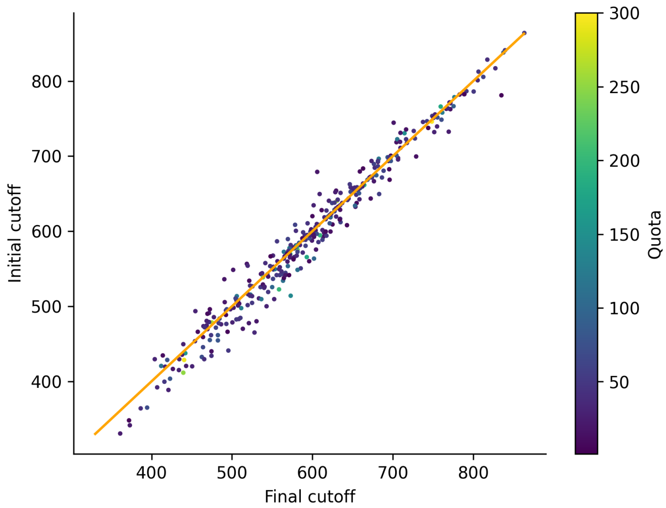
adjustment period (initial ROL) to the application deadline for single programs. Each program is represented by a marker. Markers below the 45-degree line are programs whose final cut-off score lies below the initial cutoff score. Across the full distribution of programs by final cutoff score, there are programs which experience an increase and a decrease in cutoff scores over time. However, larger changes in the cutoff score seem more common for programs with lower to medium final cutoff scores. At the upper end, markers are distributed closer around the 45-degree line. Although we observe this pattern by competitiveness, cutoff score changes seem not to be correlated to the programs quota. The figure looks similar for the other cohorts (Figure A2). Panel c) of Table A1 in the Appendix shows the absolute number of programs with an increasing, decreasing, or constant cutoff score between the initial and final ranking. In all cohorts, but 2015, the number of programs with a decreasing cutoff score is 2-3 times higher than the number of programs with an increasing cutoff score. Only in 2015 the number of programs with an increasing and decreasing cutoff score are comparable.

Next, we investigate whether programs differ in their number of cutoff score fluctuations. Panel a) of Figure 5 shows the share of hours in which the cutoff score of a program changes relative to the previous hour in 2015. Although some programs cutoffs change in almost 60% of hours, other programs cutoff scores remain largely constant over time. The cutoff score of the average program changes in 32.18% of hours. In the previous cohorts the number of changes are slightly lower but comparable (see Figure A3).

Additionally, programs differ in the magnitude of fluctuations.[2] Panel b) of Figure 5 shows that, conditional on the cutoff score changing, the average cutoff score fluctuates

[2]As cutoff score fluctuations are often partly reversed in a following hour, we use the absolute change to compute the average as otherwise positive and negative fluctuations cancel each other out.

Figure 4: Initial and final cutoff scores

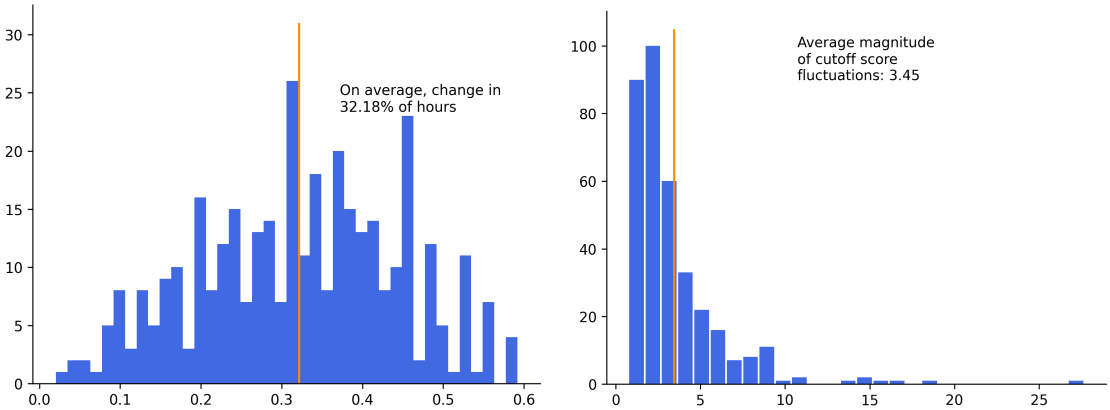


Note: Figure shows for each program the initial cutoff score at the beginning of the adjustment period and the final cutoff score. Each program is represented by one marker, colored by the program's quota size. Programs above the 45-degree line are programs whose cutoff score decreases over time, programs below the 45-degree line are programs whose cutoff score increases over time.

Figure 5: Distribution of programs by number and avg. magnitude of fluctuations

(a) Share of hours with fluctuations

(b) Avg. magnitude of fluctuations



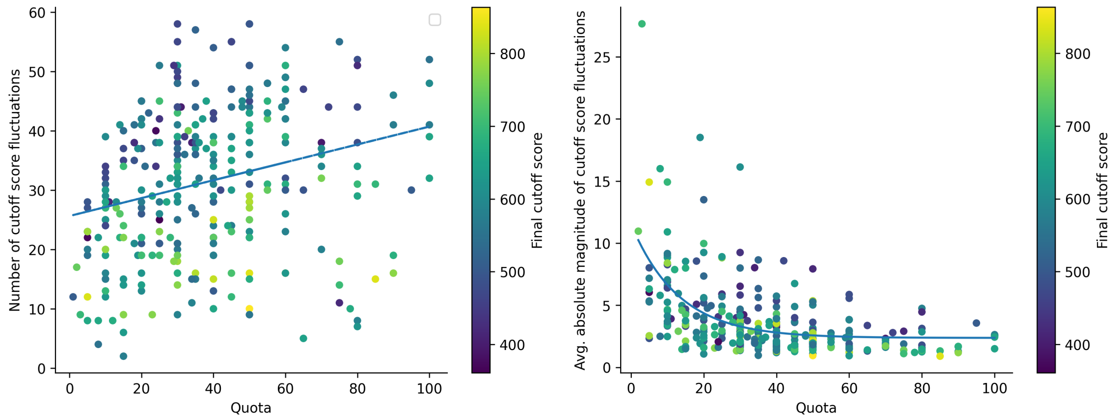
Note: Panel a) shows the distribution of programs by the share of hours in which their cutoff score changes. For Panel b) we aggregate the the (absolute) cutoff score fluctuations of each program over the adjustment period conditional on the cutoff score fluctuating. We show the distribution of programs by their average absolute magnitude of cutoff score fluctuation.

by 3.45 points. Some programs have average cutoff score fluctuations of only one point while few programs experience average cutoff score fluctuations by more than 10 points. Figure A4 in the Appendix shows the results for the other cohorts.

Last, we investigate whether the number and magnitude of fluctuations are correlated with program characteristics, i.e., quota and competitiveness. Panel a) of Figure 6 shows that larger programs experience more cutoff score fluctuations while, conditional on the quota, the cutoff score of more competitive programs fluctuates less frequently. Panel b) of Figure 6 shows that larger programs experience fluctuations of lower magnitude. Thus, although the cutoff score of programs with a higher quota fluctuates more frequently, the fluctuations are of lower magnitude. As cutoff score fluctuations are driven by changes in the set of applicants above the cutoff, larger programs are more likely to experience a change. Figures A5 and A6 show the results for the other cohorts.

Figure 6: Number and magnitude of fluctuations by program characteristics

(a) Number of changes (b) Magnitude of fluctuations



Note: Panel a) shows programs by their number of cutoff score fluctuations and quota. Each marker represents a program colored by their final cutoff score. Programs with a higher quota experience more cutoff score fluctuations and conditional on the quota, programs with a higher cutoff score also experience fewer fluctuations. Panel b) shows programs by their average absolute magnitude of cutoff score fluctuations, conditional on the cutoff score fluctuating and by their quota. Programs with a higher quota experience fluctuations of smaller magnitude.

4.2 Adjustment behavior and updating beliefs on admission probability

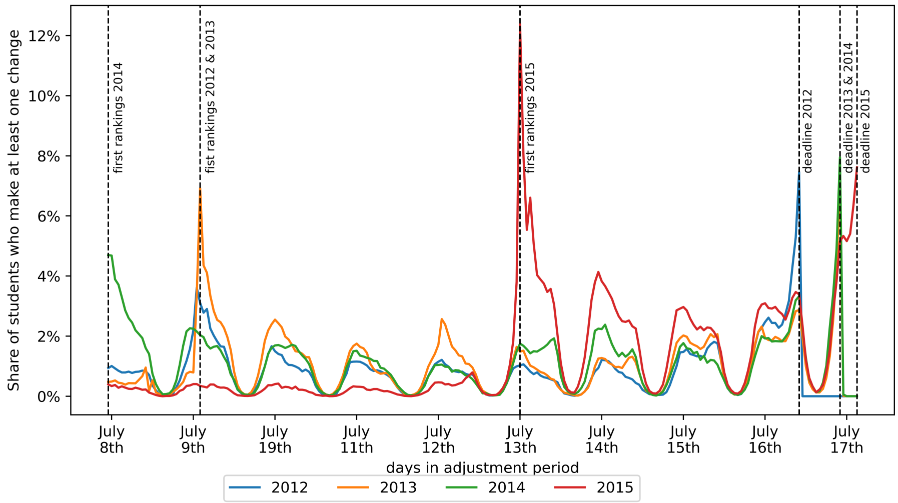
While changes in the cutoff scores induce applicants to adjust their choices, it is the aggregate adjustments that drive the cutoff score fluctuations. Thus, adjustments induce further adjustments.

In Figure 7 we show the share of applicants who make at least one change to their ROL in an hour of the adjustment period for all 4 cohorts of 2012 - 2015. The dashed vertical lines show the start and end date of the adjustment period per cohort, which differ slightly across the years. Yet, the cohorts exhibit similar behavioral patterns. First, the share of applicants who make at least one change is particularly high in the very beginning of the adjustment period. Depending on the cohort, 5 - 12% of applicants adjust their ROL in the very first hour of the adjustment period. A potential explanation for this is that at this time, applicants receive the very first signal on admission probability. As prior beliefs are only subject to applicants' subjective assessment of admission probability, the first information signal likely induces the strongest belief-updating and consequently the strongest reaction.

The following fluctuations reflect day-night cycles, where up to 4% of applicants adjust their ROL in a single hour during the day and hardly anyone adjusts their ROL at night.

In the last hour of the adjustment period, the share of applicants who adjust their ROL increases again. About 8% of the applicants adjust their ROL just before the application deadline. But also in the hours leading up to the application deadline, the share of changing applicants is higher. As applicants approach the application deadline, the information signal becomes clearer and more relevant. An increasing number of applicants approach their final choices as they experimented with all programs they consider relevant and evaluated their choices in the previous hours. This can also be seen in Figure 3, which

Figure 7: Share of applicants who adjust their ROL



Note: Figure shows the share of applicants making at least one change to their ROL in each hour of the adjustment period for the cohorts 2012-2015. The vertical dashed lines mark the beginning and the end of the adjustment period.

shows that the cutoff scores converge to their final value over the last few hours of the adjustment period. In addition, applicants approach their final choices and might take the information signals more seriously.

As this is only suggestive evidence and we hypothesize about explanations for observed behavior, we provide additional evidence for applicants' reaction to signals on admission probability in the next chapter.

5 Reaction to signals on admission probability

In the second part of our paper, we investigate whether applicants consider the probability of admission in their application choices. Via the application platform, applicants to higher education in Croatia receive hourly information signals on admission probability. Although applicants can derive admission probability from their distance to the cut-off in terms of points or rank positions, the strongest signal they receive is the information on whether they are, at the current state of applications, above or below the cut-off. We take advantage of the sharp (preliminary) admission cutoff that sorts applicants into groups that receive either a positive or negative preliminary admission signal.

Applicants above and below the cutoff point are arguably very similar. First, they are highly comparable in their high school GPA and state exam GPA as reflected in the score based on which applicants are admitted. Second, they chose to apply to the same study program. Third, although the approximate range of the cutoff is known, in a narrow bandwidth around the cutoff applicants are exogenously distributed to receive a positive or negative preliminary admission signal due to fluctuating cutoff scores. As cutoff score fluctuations are driven by other applicants' choices, a single applicant cannot influence the signal she receives.

5.1 Methodology

We estimate a pooled RDD with multiple cutoffs, centering applicants' rank position of each program × hour × year cell around the program's quota. The running variable can thus be interpreted as the distance to the admission cutoff in terms of rank positions. This approach of pooling RDDs by normalizing multiple cutoffs to zero is common practice (Cattaneo et al., 2016). For our main results, we estimate the following local linear regression using a triangular kernel within a data-driven mean squared error optimal bandwidth following Calonico et al. (2014):

$$\text{Change}_{i,t,p,y} = \beta_1 \text{Below}_{i,t,p,y} + f(Dist_{i,t,p,y};\theta) + \alpha_{p,y} \times \gamma_t + \epsilon_{i,t,p,y} \tag{1}$$

where $\text{Change}_{i,t,p,y}$ equals 1 if applicant i at time t in year y makes any change to the study program p that is currently on the first rank position of their ROL. $\text{Below}_{i,t,p,y}$ is a dummy that indicates whether an applicant has a score below the admission cut-off and therefore receives a negative preliminary admission signal. $\text{Dist}_{i,t,p}$ is our running variable and indicates an applicant i's rank position relative to the quota of program p. $\alpha_{p,y}$ are program-fixed effects. If the same programs appears in multiple years it is accounted for as multiple different programs. γ_t are time fixed effects for each hour in our sample. Our results should thus be interpreted within-program × hour cell.

By

$$f(Dist_{i,t,p,y};\theta) = \theta_0 Dist_{i,t,p,y} + \theta_1 Dist_{i,t,p,y} \times \mathbb{1}\{Dist_{i,t,p,y} \geq 0\} \tag{2}$$

we control for the running variable and allow the slope above and below the cutoff to differ.

Due to data restrictions, we do not observe whether an applicant logs in to the application platform and observes the signal on admission probability. To partly account for this, we further restrict the sample of the RDD regression to the last 10 hours before the application deadline. Towards the end of the adjustment period the share of applicants who make at least one change increases, which increases the probability that they logged in to the application platform and actually observed the signal. Yet, this does not fully solve our data limitation, which is why our results can be regarded as lower bounds.

5.2 Results

First, we show that applicants react to the information signals in a reduced form analysis. We use two different information treatments, which both signal admission probability. Moving up by one rank position relative to the cutoff increases admission probability by bringing applicants below the cutoff closer to it and increasing the distance to the cutoff for applicants above the cutoff. Applicants below the cutoff reduce the rank distance while applicants above the cutoff increase the rank distance to the cutoff. For both, this implies an increase in (perceived) admission probability. As a second information signal we use the dichotomous signal of being positioned above or below the cutoff, which is arguably the signal perceived most strongly by the applicants.

For this analysis, we restrict the sample to include only the highest ranked program of each applicant and by a bandwidth around the cutoff of 40 rank positions[3] Table 2 shows a positive and statistically significant correlation between receiving a negative signal

[3] A bandwidth of 40 is a lower bound of the bandwidths chosen with the mean-squared error optimal bandwidth selection in our main analysis.

Table 2: Reduced form: information signals and probability to change

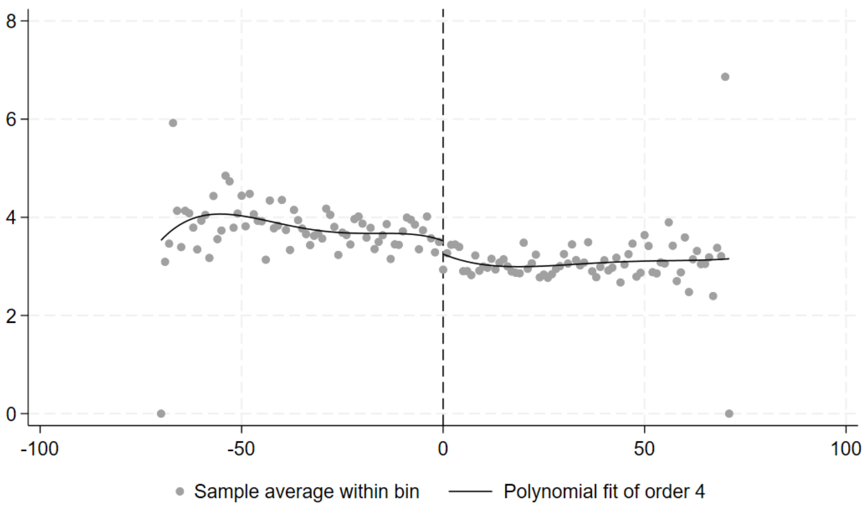
	Dep. var.: 1[Change] × 100		
	(1)	(2)	(3)
Neg. signal	0.231***		0.233***
	(0.020)		(0.036)
Distance		0.005***	-0.000
		(0.001)	(0.001)
Obs.	4,149,570	4,149,570	4,149,570

Note: Table shows the coefficients of regressing two types of information signals on a dichotomous variable that equals 1 if an applicant changes a program at time t. The information signal in Column 1 is a dichotomous signal and equal to 1 if an applicant is above the cutoff and zero otherwise. Applicants below the cutoff are 0.231 pp more likely to adjust their ROL. The information signal in Column 2 is the rank distance to the cutoff. Below the cutoff, the distance is negative, above the cutoff it is positive. The coefficient of 0.005 means that as applicants below the cutoff move further away from the cutoff (or applicants above the cutoff move closer) by one rank position, their probability to change increases by 0.005 pp. Robust standard errors in parentheses. * p-value $< .1$, ** p-value $< .05$, *** p-value $< .01$.

and the probability to adjust the affected application choice. Applicants who receive a negative signal are 0.23 pp more likely to adjust the application choice. Additionally, applicants also seem to react to the weaker signal of distance to the cutoff in terms of rank positions. Moving one rank distance away from the cutoff increases the probability to adjust the affected application choice by 0.005 pp. In Column (3) of Table 2 we estimate the correlation of the probability to change with both signals jointly. Although the signal on the rank distance to the cutoff reduces the signaling of being positioned below the cutoff, the point estimate remains highly statistically significant and similar in magnitude.

When analyzing the magnitude of the coefficients we have to consider that applicants do not always observe the hourly information signals as they have to log in to the application platform to do so. Yet, we treat applicants as receiving the signal on an hourly basis as we do not observe their log-in behavior. This puts a strong downward pressure on our estimated results. To circumvent this issue in our analysis, we reduce the sample to only the last 10 hours of the adjustment period for two reasons. First, as can be seen in Figure 7 the share of applicants who make a change increases significantly in the last hours, which indicates that many applicants log-in to the application platform. Second, as only the last submitted ROL is relevant for the final admission outcome, more applicants might be inclined to log-in in order to receive the more relevant information. Thus, restricting the time observations in our sample to the last 10 hours should reduce the concern of underestimation although it cannot be eliminated.

Figure 8: Probability to adjust application choices and signal on admission probability



Note: Figure shows a binned scatter plot with observations grouped by their rank distance to the admission cutoff. The y-scale displays the probability to adjust an application choice. The black line represents the local polynomial fit of order 4.

Exploiting the RDD setting outlined above, we show that applicants' strategic behavior is driven by changing beliefs on admission probability. Figure 8 depicts a clear discontinuity in the probability to adjust the application choices at the cutoff. We show the corresponding coefficients in Table 3. Column (1) shows that applicants who receive a negative signal on admission probability are 0.293 pp more likely to adjust the affected application choice. Compared to the baseline probability to change, i.e. the mean conditional probability to change just above the cutoff of 3.18%, this corresponds to an increase in the probability to change by 9.2%. In Columns (2) - (4) we add program, hour and program $\times$ hour FE to account for systematic differences in the uncertainty of admission between programs (e.g. due to differences in frequency and magnitude of cutoff score fluctuations), and differences in the average probability to change between hours/time of the day. The coefficients remain highly statistically significant and similar in magnitude.

We interpret these results as applicants reacting to the negative information signal by downward-adjusting their beliefs on admission probability and adjusting application choices accordingly. They omit or rank down study programs from their application choices for which admission seems less likely. Our results thus show that applicants incorporate perceived admission probability into their application choices and act strategically.

5.2.1 Additional results

To get a better understanding of the type of changes applicants make as a response to the signal, we repeat the analysis for two specific types of changes. First, we investigate whether applicants are more likely to drop a program from their application choices completely as a response to the negative signal on admission probability. Second, we investigate whether they are more likely to add a new program to their application choices, which can be understood as a measure to reduce the risk of remaining unmatched to any ranked program.

As shown in Columns (1) and (2) of Table 4, applicants who receive a negative

Table 3: Probability to change

	Dep. var.: 1[Change] × 100			
	(1)	(2)	(3)	(4)
Neg. signal	0.285**	0.299***	0.251**	0.263**
	(0.111)	(0.112)	(0.106)	(0.105)
Program FE	No	Yes	No	Yes
Hour FE	No	No	Yes	Yes
Obs.	731,114	731,114	731,114	731,098
Bandwidth	51	49	45	44
Obs. in bw	448,710	444,249	424,745	413,717
Baseline	3.18	-	-	-

Note: Table shows the regression results from Equation 1. Column (1) shows the result without FE, Column (2) with program FE, column (3) with only hour FE and Column (4) with program and hour FE. We select the bandwidth in a data-driven way and it ranges between 60 and 44, depending on the specification. We report the baseline probability to adjust the highest ranked application choice, which lies at 3.18%. Bias-corrected and robust standard errors are reported in parentheses. * p-value < .1, ** p-value < .05, *** p-value < .01.

Table 4: Probability to change by type of change

	Dep. var.: 1[var] × 100					
var:	Delete any		Delete first		Extend	
	(1)	(2)	(3)	(4)	(5)	(6)
Neg. signal	0.189**	0.180***	0.092	0.085	0.256*	0.420***
	(0.074)	(0.069)	(0.097)	(0.090)	(0.155)	(0.074)
Program FE	No	Yes	No	Yes	No	Yes
Hour FE	No	Yes	No	Yes	No	Yes
Obs.	1,674,804	1,674,804	731,114	731,098	1,824,496	1,824,496
Bandwidth	62	54	64	53	40	44
Obs. in bw	1,017,521	940,169	499,522	461,588	863,476	906,096
Baseline	2.84	-	2.72	-	12.20	-

Note: Table shows the regression results from Equation 1 where the dependent variable reflects the probability to drop the affected program from the ROL (Columns (1) and (2)), the probability to drop the affected program when we restrict the sample to the highest-ranked program (Columns (3) and (4)) and the probability to extend the ROL as a response to a negative signal for the highest ranked program (Columns (5) and (6)). We select the bandwidth in a data-driven way and it ranges between 64 and 40, depending on the specification. We report the baseline probability to adjust the highest ranked application choice, which lies at 2.84% for the probability to delete any affected program, 2.72% for the probability to delete the highest ranked affected program and 12.2% for the probability to extend the ROL. Bias-corrected and robust standard errors are reported in parentheses. * p-value < .1, ** p-value < .05, *** p-value < .01.

Table 5: Probability to change by gender

	Dep. var.: 1[Change] × 100			
	Female		Male	
	(1)	(2)	(3)	(4)
Neg. signal	0.246*	0.228*	0.409**	0.332**
	(0.142)	(0.132)	(0.160)	(0.145)
Program FE	No	Yes	No	Yes
Hour FE	No	Yes	No	Yes
Obs.	422,709	422,417	308,405	307,828
Bandwidth	54	48	67	61
Obs. in bw	272,511	254,962	212,203	202,554
Baseline	3.21	-	3.08	-

Note: Table shows the regression results from Equation 1 run separately for a sample of women (Columns (1) and (2)) and men (Columns (3) and (4)). We select the bandwidth in a data-driven way and it ranges between 67 and 48, depending on the specification. We report the baseline probability to adjust the highest ranked application choice, which lies at 3.21% for women and at 3.08 for men. Bias-corrected and robust standard errors are reported in parentheses. * p-value < .1, ** p-value < .05, *** p-value < .01.

signal on admission probability for a program are 0.18 pp more likely to drop the affected program. Compared to the conditional mean probability to change just above the cutoff, this corresponds to an increase in the probability to delete a program by 6.6%. Yet, this is only statistically significant if considering all programs regardless of where the applicant ranked them. Applicants who receive a negative signal for their highest ranked program are not significantly more likely to drop it. Meanwhile, a negative signal for the highest ranked program induces applicants to extend their application choices by adding a new program to their ROL. Yet, compared to the baseline probability to extend the application choices by adding a new program, the negative signal increases this probability by only 2%.

Additionally, we investigate gender differences in the reaction to the signal. The results are shown in Table 5. While women have a slightly higher baseline probability to change, men react slightly stronger to the negative signal on admission probability. Their probability to change increases by 0.41 pp, which corresponds to an increase of 13% compared to the baseline probability. For women who receive a negative signal the probability to change increases by only 0.25 pp or 7.6% compared to the baseline.

5.2.2 Selection

In RDD it is standard practice to provide evidence for no other discontinuities in confounding factors at the cutoff. Due to the dynamic nature of the Croatian system, this does not directly apply to our case. As a result of heterogeneous reactions to the signal on admission probability, selection may occur over time.

We investigate discontinuities in the three confounding factors we observe in the data: the share of women, and weighted state exam and high school grades. As shown in Table 6, there are minor but statistically significant discontinuities in all three variables. Below the cutoff, the share of women is 0.005 pp lower than above the cutoff, applicants below the cutoff have a slightly higher GPA in the state exam by 1.4 points and a slightly lower high school GPA by 0.5 points. Although statistically significant, these differences are minor in terms of magnitude. Arguable, applicants with a high school GPA of 500 and 499.5 are comparable, when the GPA ranges from 25 to 960.

Table 6: Probability to change: Selection

	Share female (1)	(2)	(weighted) State Exam grade (3)	(4)	(weighted) High School grade (5)	(6)
Neg. signal	-0.011***	-0.005**	-1.105	1.423***	-1.351*	-0.502*
	(0.003)	(0.002)	(1.036)	(0.508)	(0.710)	(0.302)
Program FE	No	Yes	No	Yes	No	Yes
Hour FE	No	Yes	No	Yes	No	Yes
Obs.	799,430	799,413	799,430	799,413	799,430	799,413
Bandwidth	59	47	16	8	16	12
Obs. in bw	528,745	477,877	224,510	127,004	213,105	164,881
Baseline	0.61	-	303.03	-	248.86	-

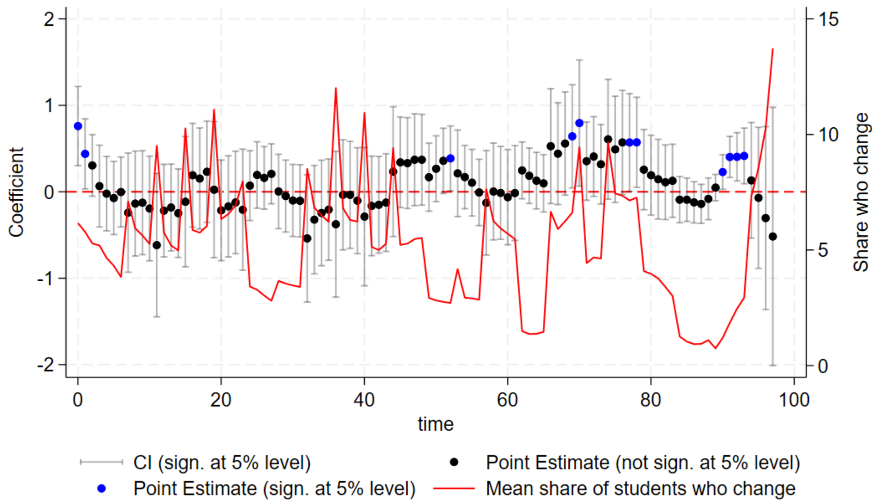
Note: Table shows the regression results from Equation 1 where the dependent variable is either the share of women (Columns (1) and (2)), the weighted state exam grade (Columns (3) and (4)) or the weighted high school grade (Columns (5) and (6)). We select the bandwidth in a data-driven way and it ranges between 59 and 8, depending on the dependent variable and specification. We report the baseline share of women (61%), mean weighted state exam score at the cutoff (303.03 points) and the mean weighted high school score at the cutoff (248.86). Bias-corrected and robust standard errors are reported in parentheses. * p-value < .1, ** p-value < .05, *** p-value < .01.

Table 7: Probability to change and selection in beginning of adjustment period 2015

	1[Change] × 100 (1)	(2)	Share female (3)	(weighted) State Exam grade (4)	(weighted) High School grade (5)
Neg. signal	0.748***	0.760***	0.006	2.778	-0.135
	(0.236)	(0.234)	(0.009)	(1.872)	(1.031)
Program FE	No	Yes	Yes	Yes	Yes
Hour FE	No	Yes	Yes	Yes	Yes
Obs.	60,129	60,116	60,116	60,116	60,116
Bandwidth	93	93	68	17	23
Obs. in bw	38,004	37,991	32,603	11,827	16,029
Baseline	0.86	-	-	-	-

Note: Table shows the regression results from Equation 1 with differing dependent variables based on a sample of the first where the dependent variable is either the share of women (Column (1)), the weighted state exam grade (Column (2)) or the weighted high school grade (Column (3)). Here, we restrict the sample to the first hour of the adjustment period. Due to data limitations we can show this for 2015 only. We select the bandwidth in a data-driven way and it ranges between 68 and 17, depending on the dependent variable and specification. Bias-corrected and robust standard errors are reported in parentheses. * p-value < .1, ** p-value < .05, *** p-value < .01.

Figure 9: Reaction to the signal over the adjustment period



Note: Figure shows the regression coefficients of Equation 1 over the adjustment period. The x-axis represents hours in the adjustment period. Each marker represents one regression coefficient, for a regression based on a restricted sample of observations within a symmetric 5-hour window centered on each hour.. We show the 5% confidence band (based on robust and bias-corrected s.e.) in gray and additionally highlight statistically significant coefficients (5% level) in blue. The red line represents the share of applicants who make at least one change to their highest ranked program in the respective hour.

The one point in time, at which we should not observe selection is in the beginning of the adjustment period. Here, applicants learn about the preliminary admission cutoffs for the very first time. This implies that at this point in time, selection cannot occur as a response to heterogeneous reactions to the signal on admission probability. This can be seen in Columns (3) - (5) in Table 7. In the first three hours of the adjustment period, applicants just above and below the cutoff do not differ in the share of women and weighted state exam and high school score. Still, we find that also in the first hours applicants react to the negative signal with an increase in the probability to change by 0.76 pp (Columns (1) and (2) of Table 7).

Additionally, we show in Figure 9 how the treatment effect changes over the adjustment period. We estimate the reaction to a negative signal separately for each hour. To increase statistical power, we pool observations within a symmetric 5-hour window centered on each hour. The x-axis shows the hours of the adjustment period, with the highest value representing the application deadline. Point estimates that are statistically significant at the 5% level are shown in blue. The share of applicants who adjust any of their application choices is shown in red.

In most hours, the reaction to a negative signal does not differ significantly from that to a positive signal. Yet, if they do differ, all point estimates point in the same direction. Particular in the beginning and towards the end of the adjustment period, applicants who receive a negative signal are significantly more likely to adjust their application choices. We attribute this to the larger share of applicants logging in on the application platform and actually observing the signal on admission probability.

Last, we repeat this analysis for the three confounding factors share of women, high school and state exam GPA to show how selection changes over time. Figure A7 in the Appendix shows that there seems to be no clear selection trend. Over most part of the adjustment period, women are slightly higher represented below than above the cutoff, which changes only in the last few hours. For parts of the adjustment period applicants below the cutoff have a slightly higher weighted state exam grade but for other parts their weighted state exam grade is slightly lower. This looks similar for the weighted high school grades, although, if the coefficients are statistically significant, applicants below the cutoff always have a slightly lower weighted high school grade by about 2 points.

Overall, these results show that although there are hours in which we observe statistically significant differences in observable characteristics between applicants above and below the cutoff, there is no clear trend in selection over time.

6 Developing a strategy

In chapter 5.2 we established that applicants react to signals on admission probability, which implies that beliefs on admission probability feed into application choices. Applicants who receive a negative preliminary admission signal are more likely to change or delete the affected program and more likely to extend their ROL. So far, we only looked at single decisions that are driven by the information provided by the repeated DA system. Only jointly these decisions compose a strategy and only at the end of the adjustment period applicants' strategy is binding. Before then, applicants can play with their choices to gather information on the probability of admission and to develop their final strategy. In this chapter, we investigate how applicants develop their final application strategy over time.

6.1 Risk to remain unmatched

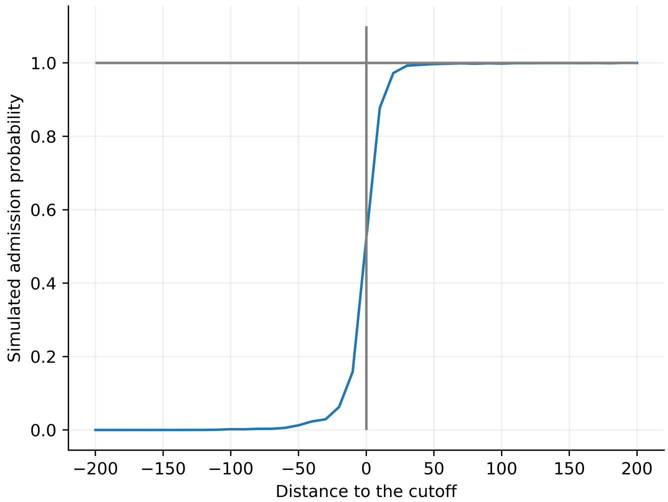
The most consequential application error is to compose a ROL with a high risk of not being matched to any ranked option. Due to overestimating admission probability to the ranked programs, applicants who rank low-probability programs only and/or (additionally) submit a shorter than allowed ROL, might end up unmatched although feasible programs that they prefer over their outside option are available. As applicants in the Croatian system receive signals on admission probability and observe if they are unlikely to be matched to any ranked program, the repeated DA mechanism might help to diminish this risk.

To investigate how the risk of remaining unmatched evolves over the adjustment period, we compute for each applicant $\times$ program combination a measure of admission probability. Drawing from the set of observed final ROLs with multiple-drawing, we create 100 artificial samples, each containing the number of applicants who apply to at least one program at the application deadline. By restricting the set of ROLs from which we draw to contain only those submitted in the last hour before the application deadline, we ensure that our results are not driven by time trends in application choices. Each sample reflects the final application choices based on which the binding matchings are computed. We replicate the DA mechanism as it is implemented in Croatia and rerun it for each of the 100 artificial samples. From this we obtain matching results for each of the 100 samples and can compute the admission cut-off for each program. In this way, we obtain a distribution of possible cut-off scores for each program and can determine the share of scenarios in which each applicant has a score higher than the cutoff score. This share reflects the probability of admission of an applicant for a specific program. The computed admission probability does not vary over time and is therefore independent of cutoff score trends.

However, the probability of remaining unmatched can change over time as a result of applicants changing the composition of their ROL.

Figure 10 shows for 2015 how our simulated admission probability evolves around the admission cutoff. Admission probability increases as applicants approach the admission cutoff and increasingly so, following an S-curve. Applicants up to 20 points below the cutoff have an admission probability of more than 10%. Exactly at the cutoff admission probability is 50% on average. About 130 points above the cutoff, admission probability converges to 100%. The results are similar for the other cohorts (see Figure A8 in the Appendix).

Figure 10: Simulated admission probability around the admission cutoff, 2015



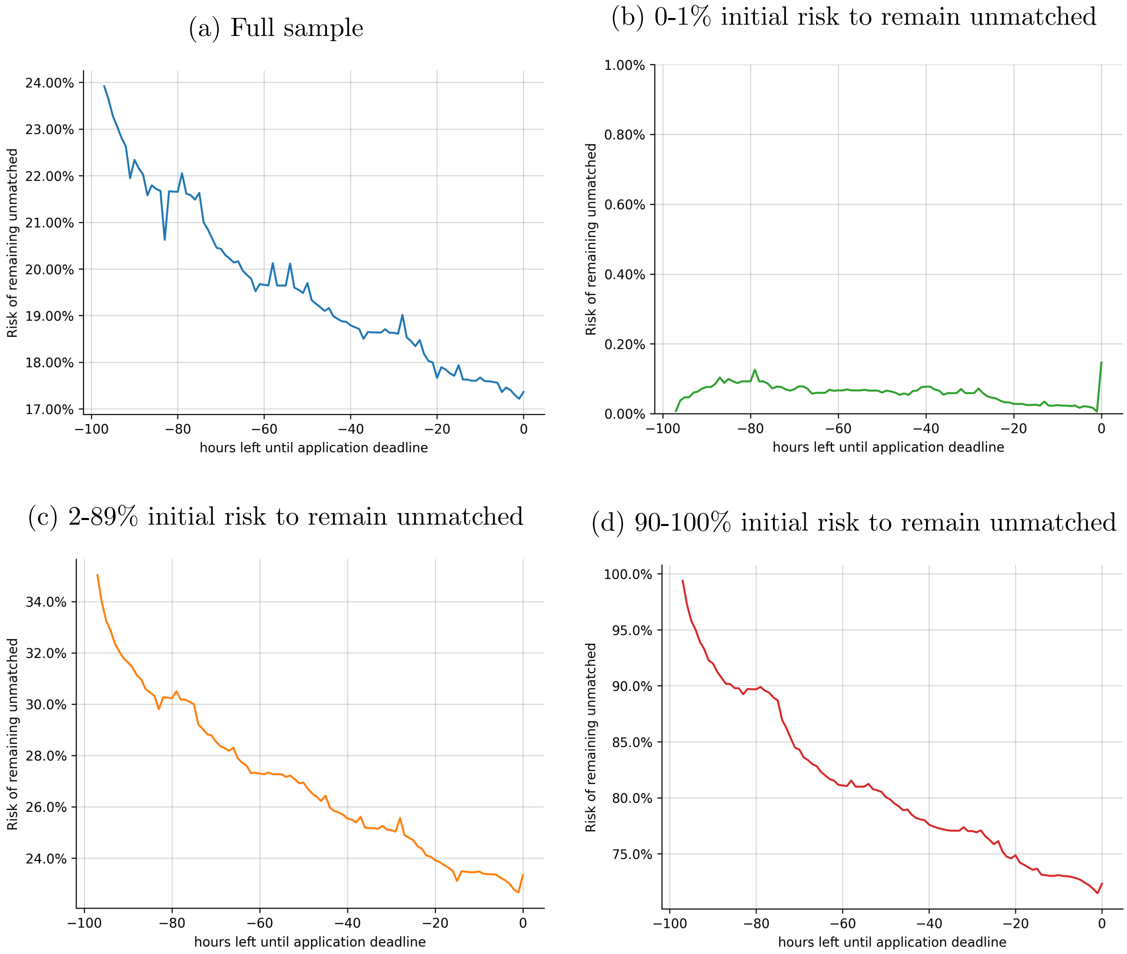
Note: Figure shows how the simulated admission probability evolves around the admission cutoff. The vertical line shows the final cutoff.

Using the simulated admission probabilities, we computed for each of applicants' ROLs the risk to remain unmatched as the product of each ranked program's specific risk of being rejected.

We show in Panel a) of Figure 11 how the risk to remain unmatched evolves during the adjustment period. Here, the x-axis denotes the time left to make adjustments in hours until the application deadline, when the time left is zero. The aggregate risk to remain unmatched declines by about 6 pp from an initial risk of 24% to a risk of 17.5% at the application deadline. This aggregate trend hides a significantly sharper decline for the most-at-risk applicants as can be seen in the subgroup analysis in Panels b) - d) of Figure 11. While the risk of applicants with an initial risk of 0-1% does not change significantly, applicants with an initial risk of 2-89% (Panel c)) and 90-100% (Panel d)) experience a strong decline of more than 10 pp and 25 pp respectively on average. The results for 2012, 2013 and 2014 are similar. Low-risk applicants' risk to remain unmatched remains largely constant while the risk of applicants with a high initial risk declines by 6 to 25 pp. Figures A9, A10 and A11 in the Appendix show the results for the other cohorts.

A decline in the risk of remaining unmatched can be driven by two types of application choices. First, applicants might extend their ROL by adding more programs, as long as the maximum length of 10 programs is not yet reached. As long as admission probability to a program is strictly positive, adding the program to the ROL reduces the

Figure 11: Average risk to remain unmatched over time, by initial risk (2015)

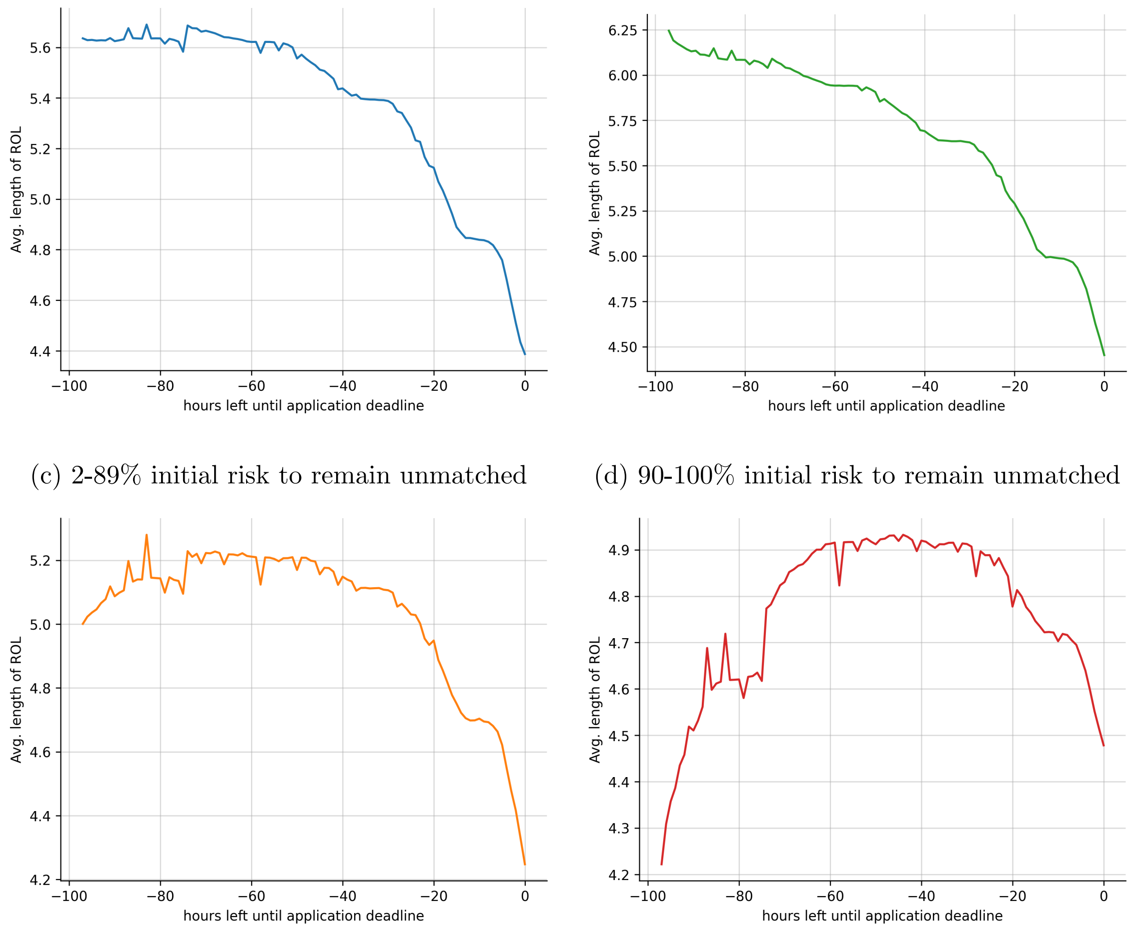


Note: Figure shows how the average risk to remain unmatched evolves over time for two subgroups. In Panel a) we show the average risk for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 67.7%, the group with an initial risk of 1-89% makes up 12.8% and the group with an initial risk of 90-100% makes up 19.5%.

risk to remain unmatched. Panel a) in Figure 12 shows that in aggregate applicants reduce the length of their ROL by about 1.2 programs on average. In 2012-2014 the decline is of similar magnitude (see Panel a) of Figures A12, A13 and A14). This aggregate trend is largely driven by applicants with a low initial risk to remain unmatched. Applicants with a 90-100% initial risk to remain unmatched slightly extend their ROL in 2015 (Panel d) of Figure 12), do not change the length of their ROL in 2014 and slightly shorten their ROL by about 0.5 programs in 2012 and 2013 (see Figures A12, A13 and A14) for all cohorts). Meanwhile, applicants with a low initial risk to remain unmatched shorten their ROL by about 1.5 programs in all four cohorts.

Although applicants tend to shorten their ROL, their risk to remain unmatched does not increase as shown in Figure 11 (other cohorts: Figures A9, A10 and A11). Applicants with a low initial risk to remain unmatched might have enough ”safe” options to retain their low risk besides shortening their ROL. This is possible even if they drop some of their ”safe” choices, as long as one ”safe” option remains on their ROL. Applicants with a high initial risk to remain unmatched do not have that option. To avoid an increase in the risk to remain unmatched while shrinking their ROL, high-risk applicants have to

Figure 12: Average number of ranked programs over time, by initial risk (2015)



(a) Full sample

(b) 0-1% initial risk to remain unmatched

(c) 2-89% initial risk to remain unmatched

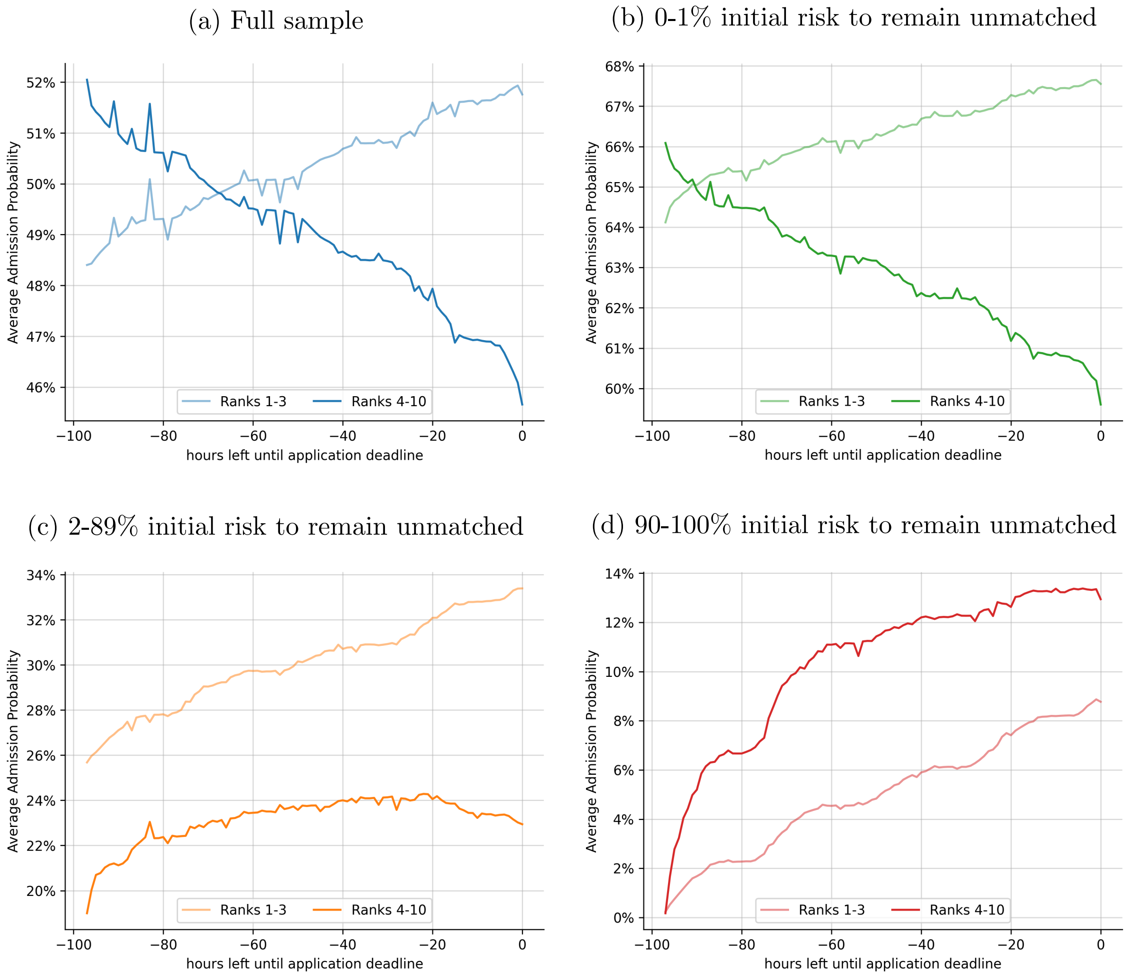
(d) 90-100% initial risk to remain unmatched

Note: Figure shows how the average number of ranked programs evolves over time for two subgroups. In Panel a) we show the average length of the ROL for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 67.7%, the group with an initial risk of 1-89% makes up 12.8% and the group with an initial risk of 90-100% makes up 19.5%.

replace programs with a low admission probability with higher-probability programs.

The second application choice that might drive the decline in applicants' risk to remain unmatched is exchanging ranked programs for programs with higher admission probability. Panel a) of Figure 13 shows how the average admission probability of programs on ranks 1-3 and on ranks 4-10 evolve over time. While the admission probability of programs on ranks 1-3 increases by 4.5 pp, admission probability of programs on ranks 4-10 decreases by about the same magnitude. The results are similar for 2012-2014, although the magnitude of change is lower in earlier years (see Figures A15, A16 and A17). Again, disaggregating the trend by initial risk to remain unmatched shows significant group differences (Panels b), c) and d) of Figure 13). While the behavioral pattern of low-risk applicants matches the aggregate pattern, applicants with a high initial risk to remain unmatched replace programs on all ranks with programs with higher admission probability. Admission probability to programs on ranks 1-3 increases from 0% to about 8%, that of programs on ranks 4-10 increases to 18% on average. Combined with Panel d) of Figure 12, this shows that for high-risk applicants the risk to remain unmatched declines largely due to exchanging low-probability with high-probability programs and particularly so for programs on lower ranks.

Figure 13: Average admission probability over time, by initial risk (2015)



(a) Full sample

(b) 0-1% initial risk to remain unmatched

(c) 2-89% initial risk to remain unmatched

(d) 90-100% initial risk to remain unmatched

Note: Figure shows how the average admission probability of the three highest-ranked programs and of all lower-ranked programs evolves over time for two subgroups. In Panel a) we show the average admission probability for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 67.7%, the group with an initial risk of 1-89% makes up 12.8% and the group with an initial risk of 90-100% makes up 19.5%.

Another interesting finding from Figure 13 is that low-risk applicants seem to rank high-probability programs above programs with a lower admission probability. Assuming that applicants have a preference for more competitive programs, this application behavior is never optimal. As the gap in the average admission probability of programs on ranks 1-3 and 4-10 increases over time, receiving information signals on admission probability seems to exacerbate this strategic error. Of course, applicants might have a preference for program characteristics other than competitiveness but in this case we should not observe any pattern in average admission probability between higher- and lower-ranked programs.

Meanwhile, high-risk applicants follow the weakly dominant strategy by placing lower-probability programs on ranks 1-3 while filling lower ranks with safer options. Although they start with an average admission probability of approximately zero for all programs, this pattern emerges. In the context of the DA mechanism, this implies that applicants try for low-probability "reach" programs first and apply for safer options only in case they are not admitted to any of the higher-ranked programs.

Although the application choices of low-risk applicants are irrational in the framework of the canonical school choice model (Abdulkadiroğlu and Sönmez, 2003) and also under newer advances of the literature including incomplete preferences due to costly search (Artemov, 2021; Bucher and Caplin, 2021; Arteaga et al., 2022) and constrained choice (Calsamiglia et al., 2010; Ali and Shorrer, 2025), we are not the first to provide empirical evidence for applicants sorting programs by admission probability. Experiments show that 15-18% of applicants follow this application strategy (Pais and Pintér, 2008 and Y. Chen and Sönmez, 2006). Yet, in experiments it is particularly the high-risk applicants who sort programs by admission probability (Featherstone and Niederle, 2016) whereas in our case it is the low-risk applicants. Also in real-world applications of the DA mechanism applicants consider admission probability or their beliefs thereof when making their choices (Arteaga et al., 2022; Bobba and Frisancho, 2022; L. Chen and Pereyra, 2019; Larroucau et al., 2024; Shorrer and Sóvágó, 2023; Shorrer and Sóvágó, 2024). Rees-Jones and Shorrer (2023) suggest, among others, expectation-based loss aversion as an explanation for the observed application behavior.

6.2 Beliefs on admission probability and the initial ROL

In the previous analysis, we have to assume that applicants have a preference for competitive programs. For this reason we conclude from Figure 13 that the average applicant misrepresents their preferences by sorting programs by admission probability. In this section, we draw on survey data on applicants' true preferences and their expected admission probability thereto to study preference misrepresentation based on a more applicant-specific measure of preferences.

In 2019, applicants responded to the survey when first logging in to the application platform. This can be as early as January, when the application platform opens, but applicants might also register at a later time. At this time, although the application deadline is not due for long, applicants already (at least partly) established their preferences over study programs. This is because the registration for state exam subject tests closes in January. As some programs require the passing or weight the grade of non-mandatory subject tests, applicants should know about the admission requirements of study programs to which they want to apply. Thus, already in January, applicants should be (at least partially) informed about their preferences.

In our previous analyses we show that applicants adjust their application strategy to signals on admission probability. This could occur in two forms. First, applicants might consider admission probability in their choices, i.e., omitting zero or low-probability programs or sorting programs by admission probability. Second, the information signal on admission probability might encourage applicants to reevaluate their preferences by investing more search into feasible programs. For this reason, elicited survey preferences might not be stable over time. Yet, as applicants do not receive any signal on admission probability prior to submitting their initial ROL, reported survey preferences and expectations on admission probability should still be accurate at the beginning of the adjustment period.

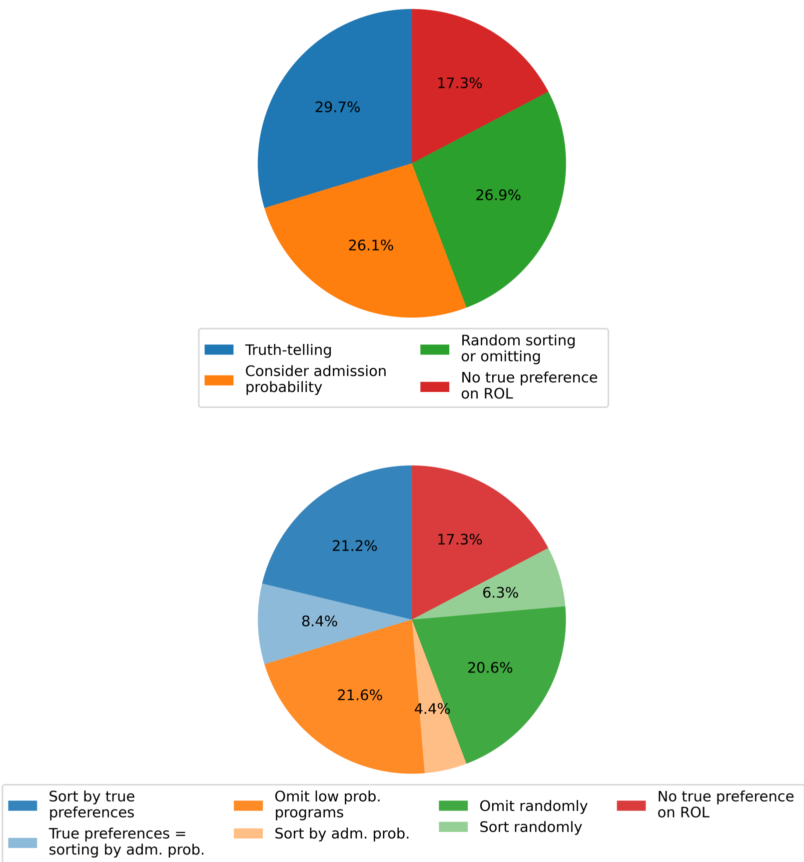
Thus, we investigate to what extend survey preferences are reflected in the initial ROL and whether this is influenced by applicants' expected admission probability. To this end, we distinguish four groups of applicants: Applicants who we consider as "truth-telling" are those who have all of their reported survey preferences on their initial ROL and rank them in the order reported in the survey. Here, we allow applicants to rank their true preference in non-consecutive order as long as the ranking is kept in order. For example, an applicant might rank their most-preferred program first, a random program on rank 2 and their second- and third-most preferred program on ranks 3 and 4. This applicant would still be considered truth-telling. The second group of applicants are those who consider admission probability by either reordering their true preferences by their expected admission probability (in descending order) or by omitting programs with a lower expected admission probability. Again, for the former case, programs can be ordered non-consecutively as long as programs with a higher expected admission probability are ranked higher. For the latter case, we allow the minimum expected admission probability required for an applicant to rank a program on their initial ROL to differ between applicants. If all programs that an applicant omits have a strictly lower expected admission probability than all programs that the applicant ranks, the applicant is accounted to this group. The third group consists of applicants who either omit or reorder their reported survey preferences but not according to their expected admission probability. The pattern according to which they misrepresent their preferences in unobserved by us. We call this group "Random sorting and omitting". The last group of students rank none of their reported survey preferences on their initial ROL.

Due to the way in which we conducted the survey, a single survey preference is represented by multiple program IDs. We cannot distinguish highly similar programs (i.e., offered by the same faculty and with the same program name) with different program IDs. For our analysis this implies that if applicants apply to a highly similar program but e.g. with a different minor than their true preference, we consider them as applying to their true preference. Thus, we slightly loosen the definition of truth-telling. As a consequence of this, we observe that some applicants report the same program as their most, second-most and third-most preferred program. We classify these cases as applicants having only one survey preference. For these applicants it is enough to rank this one program ID on their initial ROL to be considered truth-telling. This implies that we likely over-estimate truth-telling in our results.

Figure 14 shows the group shares. We find that 29.7% of applicants are "truth-telling", i.e., apply according to their reported true survey preferences in their initial ROL. With 26.1% the group of applicants whose innate belief on expected admission probability is reflected in their initial ROL is of similar size. Among those, the majority of applicants omits programs for which they expect admission probability to be low. Overall, only 4.4% of applicants sort programs by admission probability. The smallest group with 17.3% is the group of applicants who add none of their survey preferences on their ROL. Last, the remaining 26.9% of applicants misrepresent their preferences in a way unobserved by us. These applicants either omit some of their survey preferences but not necessarily those with the lowest expected admission probability (20.6%) or sort their survey preferences to something other that expected admission probability (6.3%).

Additionally, we also split the group of "truth-telling" applicants in two: those who apply according to their true preferences and by that forego sorting by expected admission probability and those whose reported true preferences are already sorted by

Figure 14: Strategic types



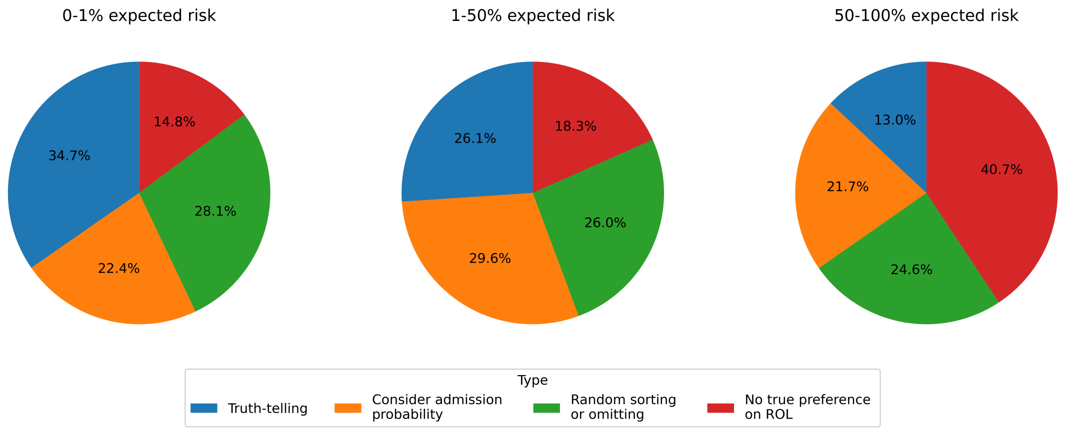
Note: Figure shows the distribution of applicants by their strategic type in the initial ROL compared to the reported survey preferences. We distinguish types by the way in which they deviate from their true survey preferences in their initial application choices.

expected admission probability. The latter group can thus sort programs by admission probability in the initial ROL while still applying according to their true preferences. With 8.4% the latter group is relatively small. Although we do not know the reason, this group of applicants seems to have a preference for safer programs.

Compared to experimental research, which reports truth-telling rates of 35 - 91.7%, the truth-telling rate we find in our real-life application of a DA is slightly below the lower bound (see Hakimov and Kübler (2021) for an overview of experiments). Still, our lower truth-telling rate is in line with the literature as truth-telling has been shown to decline in the complexity of the decision (Y. Chen et al., 2016; Y. Chen and Kesten, 2019; Pais and Pintér, 2008) and complexity in the Croatian setting with more than 700 study programs to choose from is arguably more complex than any of the experimental settings. While experiments find that 15-18% of applicants sort their choices by admission probability (Y. Chen et al., 2016; Y. Chen and Kesten, 2019; Pais and Pintér, 2008), ranking low-probability programs below more preferred programs with a higher admission probability, we find a significantly smaller share of applicants who follow this strategy. Still, the share of applicants in our setting who consider admission probability in their choices is significantly higher with 26.1%.

Last, we compare whether applicants expectation of remaining unmatched to their top-3 reported most preferred programs is related to the initial application choices we

Figure 15: Strategic groups, by expected risk to remain unmatched



Note: Figure shows the distribution of applicants by their strategic type in the initial ROL compared to the reported survey preferences. We distinguish types by the way in which they deviate from their true survey preferences in their initial application choices. We split applicants into three groups by their expected risk to remain unmatched to any of their survey preferences. This is computed using the expected admission probabilities to the top-3 most-preferred programs as reported in the survey.

observe. To this end, we compute applicants risk to remain unmatched using the expected admission probability reported in the survey to their top-3 choices. We split applicants into three groups with 0-1%, 1-50% and 50-100% expected risk to remain unmatched.

Figure 15 shows that applicants with a high expected risk of not being matched to any of their top-3 survey preferences are less than half as likely to be truth-telling. Instead, 40% of these applicants have none of their reported preferences on their ROL. Meanwhile, 34% of applicants with a particularly low risk are truth-telling and only 14.8% have none of their reported true preferences on their initial ROL. The remaining strategies, considering admission probability and random sorting or omitting do not differ much between the three risk-groups. This finding supports the previous findings that beliefs about admission probability are reflected in strategic choices. A low risk to remain unmatched "allows" applicants to be truth-telling, while applicants with a high risk to remain unmatched might feel urged to reduce their risk by submitting a safer ROL.

Due to the design of the Croatian application system, applicants do not have to hedge risk in their initial ROL. As they can adjust their ROL at a later point, the risk to remain unmatched to any of their true preferences should not play a role for the initial application strategy. Yet, we observe this behavior.

7 Consequences of application strategies

In the previous sections we show mainly two types of application strategies that might result in suboptimal admission outcomes for applicants. First, Figure 13 shows that applicants sort programs by admission probability, on average ranking programs with higher admission probability on ranks 1-3 and programs with lower admission probability on lower ranks. This is particularly the case for applicants with a low risk to remain unmatched as shown in Figure 13. Due to this application choice, applicants might be admitted to a less competitive program than they could reach for. Second, Figure 14 shows that about 21% of applicants omit programs with a low expected admission probability. By this, they reduce their chance of being admitted to this program to zero.

In this section we investigate whether these strategic application choices are consequential. To this end, we successively adjust the two application strategies described above. Based on the adjusted ROLs we replicate the DA mechanism and compare to what extend the admission outcomes improve.

Here, we assume that applicants have a preference for more competitive programs, an assumption which is not uncommon in the literature.[4] In this, we disregard that applicants might have preferences for other characteristics such as the field of study or location. To partly address this, we restrict the set of programs based on which we construct the simulated ROLs to the programs applicants add to their ROL. By that, we ensure that applicants' preferences for other characteristics are reflected in our adjusted ROLs as we base the analysis on programs that applicants actually consider.

7.1 Sorting by admission probability

First, we correct the application strategy of sorting by admission probability. For this, we consider only the programs on applicants' final ROLs and thus respect applicants' final choice on the set of programs they want to apply to. To reverse the application strategy we sort programs by their admission probability but in ascending order. Under these adjusted ROLs, applicants apply to the most competitive programs first. Only if not admitted to any more competitive program, lower ranked programs are considered. As the set of programs on applicants' ROLs does not change, the risk to remain unmatched remains constant. We adjust application choices one applicant at a time to ensure that any change in the admission outcome is driven by the adjusted applications strategy only and not due to other applicants' adjustments.

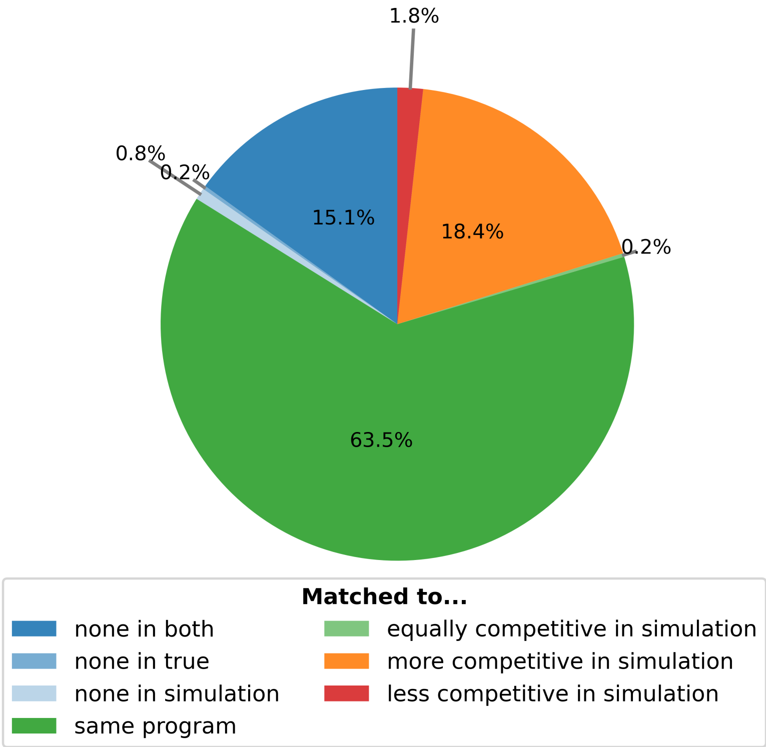
To evaluate the consequences of applicants applying to "safer" programs first, we compare the admission outcome of the simulated scenario to the original matchings observed in the data. Figure 16 shows how differences in admission outcomes are distributed in 2015. For the largest group of applicants the admission outcomes remain unchanged. This group includes the 63.5% of applicants who are matched to the same program, but also the 15.1% of applicants who are not matched to any ranked program under both scenarios. 18.4% of applicants improve their matching in the simulated scenario as they are now matched to a more competitive program.[5] [6]

[4]For example, Ali and Shorrer (2025) assume that applicants value programs with a low admission probability higher than less-competitive programs.

[5]1.8% of applicants are admitted to a less competitive program in our simulation and 0.8% are not admitted at all. As we adjust application choices one applicant at a time, we should not observe this. We attribute this error to a small inaccuracy in out replication of the DA mechanism due to the way we deal with double degree programs.

[6]The results for the cohorts 2012-2013 are shown in Figures A18, A19 and A20 in the Appendix A.5.

Figure 16: Admission outcome in the simulated vs. observed scenario, 2015



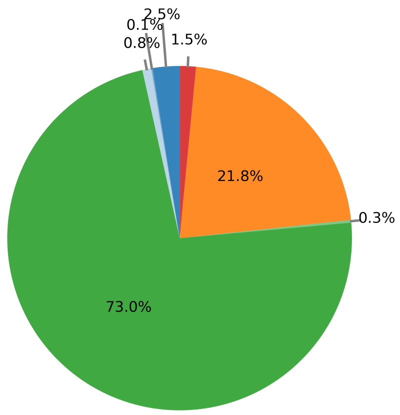
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability.

As Figure 13 shows that mostly applicants with a low initial risk to remain unmatched rank programs according to admission probability, we investigate changes in admission probability for applicants with a low and high initial risk to remain unmatched separately. Figure 17 shows the changes in admission outcomes for applicants with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100% in Panels a), b) and c) respectively. While the large majority of high-risk applicants are unmatched under both scenarios, 21.8% of applicants with a low initial risk to remain unmatched could improve their matching outcome.[7]

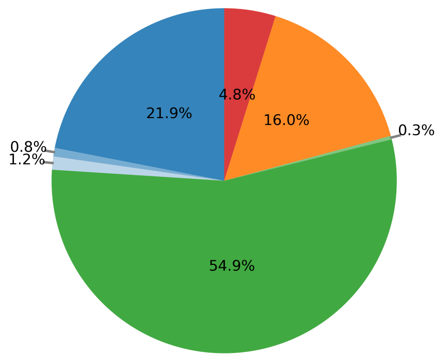
[7] The results for the cohorts 2012-2013 are shown in Figures A21, A22 and A23 in the Appendix A.5.

Figure 17: Admission outcome in the simulated vs. observed scenario, subgroups 2015

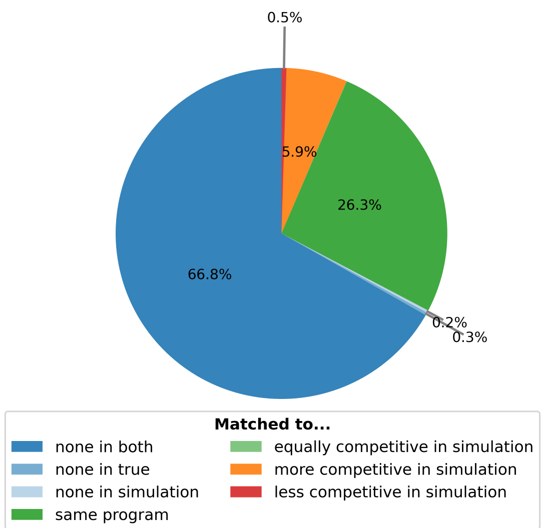
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



(c) high-risk (90-100% risk to remain unmatched)



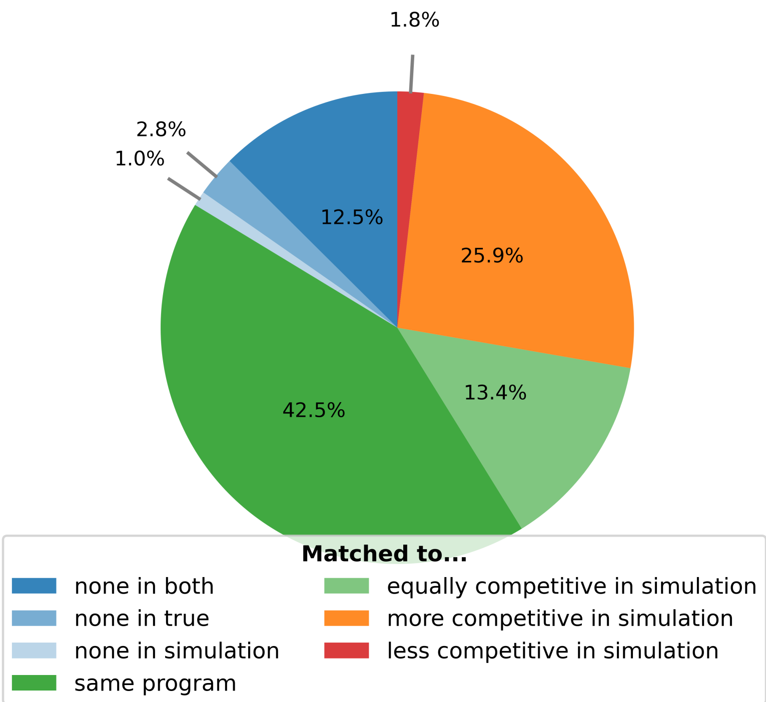
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.

7.2 Omitting programs with low admission probability

The second application strategy we address is omitting programs with low admission probability from the final ROL. Also here we respect applicants' preferences by considering only programs that applicants ever added to any preliminary ROL during the adjustment period. For applicants who apply to less than 10 programs at the application deadline, we fill the remaining slots with the most competitive programs they ever considered. We sort this set of extended final application choices by admission probability.

This adjustment of the application strategy is built on the assumption that applicants add programs to their preliminary ROLs to learn about their admission probability thereto. After observing a low admission probability, some applicants might drop a program from their ROL. The results from our RDD analysis in Section 5 provide evidence for this behavior. Thus, applicants omit programs for which they have a preference from their ROL due to their perceived admission probability being low. By constructing a ROL based on all programs ever considered we correct this application strategy. Here, we disregard that applicants might not add programs for which they expect admission probability to be zero. For these programs, applicants might not consider it worth even trying. Thus, also our adjusted ROL reflects beliefs on admission probability to some extend.

Figure 18: Admission outcome in the simulated vs. observed scenario, 2015



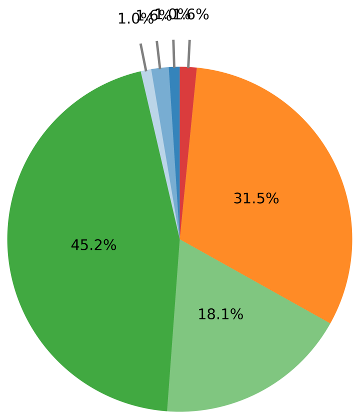
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is applying to the ten most competitive programs ever considered in the adjustment period.

Figure 18 shows that while almost 60% of applicants do not change their admission outcome in terms of competitiveness of the matched program, 25.9% of applicants can improve their application choices if they keep ever-considered but risky choices on their ROL and apply to these risky programs first. This strategy comes at no cost as applicants left the slots that we filled with risky programs empty. [8]

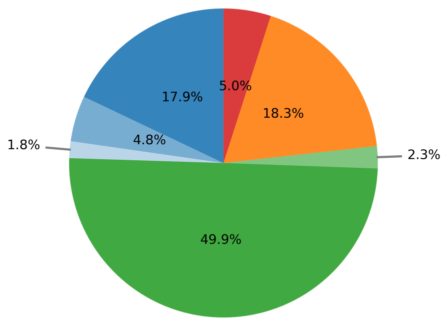
[8] The results for the cohorts 2012-2013 are shown in Figures A24, A28 and A29 in the Appendix A.5.

Figure 19: Admission outcome in the simulated vs. observed scenario, subgroups 2015

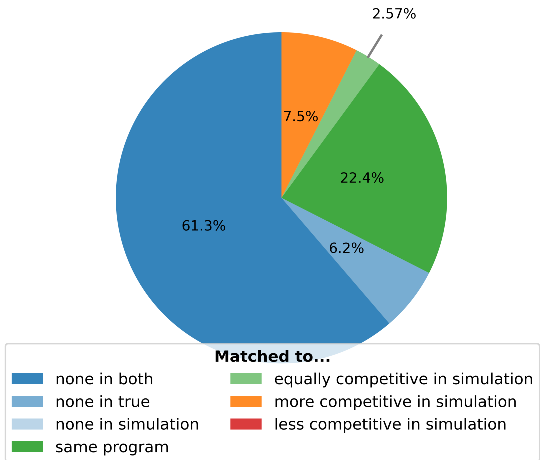
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



(c) high-risk (90-100% risk to remain unmatched)



Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices extended by the most risky ever-considered programs by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.

Also for this simulated scenario we conduct a subgroup analysis, the results of which are shown in Figure 19. Applicants with a low initial risk to remain unmatched benefit the most from this strategy as 31.5% would manage to improve their admission outcome. But also for applicants with a lower initial risk this application strategy seems beneficial as 7.5% of the most-at-risk applicants are admitted to a more competitive program in our simulation. [9]

Overall, these findings show that there is significant room for improvement in the observed application strategies that can be achieved with changes (applying to risky programs first and keeping ever-considered but risky programs in the application choices) that come with no cost or increased risk to the applicants.

8 Conclusion

In our study, we investigate the role of beliefs about admission probability for college application strategies in a repeated DA setting in Croatia. Here, applicants receive hourly information signals on admission probability, while they can still adjust their application choices. Over time, they develop their final and binding application strategies. Observing the information signals and strategic adjustments, we investigate how changing beliefs on admission probability are reflected in within-applicant changes to application choices.

In four parts, we show that applicants consider their beliefs about admission probability when deciding on the study programs to which they want to apply. First, we provide descriptive evidence on the dynamics of the repeated DA induced by strategic adjustments by applicants. Programs' cutoff scores fluctuate, resulting in hourly changes in the preliminary admission outcomes and in the information signals on admission probability that applicants receive via the system. This volatility differs between programs in frequency and magnitude. Programs with a larger quota experience more fluctuations of smaller magnitude than programs with a smaller quota.

Second, exploiting the RDD setting of a sharp (preliminary) admission cutoff, we show that applicants' subjective beliefs about admission probability feed into their application strategy. Applicants who receive a positive preliminary signal on admission probability are less likely to adjust their application choices than applicants who receive a negative preliminary signal. Compared to the baseline, the probability of changing for applicants who receive a negative signal is about 9% higher than for applicants who receive a positive signal on admission probability. In particular, applicants who receive a negative preliminary signal on admission probability are more likely to delete the affected program.

Third, we show how applicants develop their final application strategy over time and in particular how this differs between applicants with a high and low initial risk of not being admitted to any of their ranked programs. Applicants with a high initial risk to remain unmatched improve their application choices over time and by that reduce this risk by up to 25 pp on average. They achieve this by swapping programs with a low admission probability for less risky programs. Meanwhile, applicants with a low initial risk to remain unmatched shorten their ROL over time and sort programs by admission probability. Although these adjustments do not affect their risk of remaining unmatched, sorting by admission probability might result in being matched to a less competitive

[9] The results for the cohorts 2012-2013 are shown in Figures A27, A28 and A29 in the Appendix A.5.

program.

Next, we use survey data on the most preferred programs of the applicants and their expected admission probability to identify application strategies in initial application choices. We show that the initial ROL already reflects the beliefs of the applicants about admission probability, with 26% of the applicants omitting programs with lower expected admission probability or sorting the programs by admission probability.

Finally, we quantify the consequences of two potentially harmful application strategies that we identified in the previous sections by re-running the repeated DA mechanism based on alternative application choices. First, we correct the application behavior of sorting by admission probability. Assuming that applicants prefer more competitive programs, simply resorting the final ROL of applicants improves the admission result of 18% of applicants. Second, we reverse the application behavior of omitting programs with low admission probability. We fill remaining slots in application strategies with the most risky, ever-considered programs. This application strategy improves the admission outcome for a quarter of applicants while coming at to cost or increase in risk. These findings show that by correcting simple application errors, the admission outcome of a significant portion of applicants could be improved and they could be admitted to a more competitive program.

With our research, we contribute to the limited empirical literature on application strategies in real-world applications of DA mechanisms. The unique setting in Croatia allows us to exploit within-applicant changes in application behavior and show how application choices are affected by beliefs on admission probability. To our knowledge, we are among the first to quantify strategic choices for the entire universe of applicants on a repeated DA system. Our findings are relevant for the more commonly applied static DA as well. Although applicants receive precise and applicant-specific information on admission probabilities, they make suboptimal choices. In a static DA, in which applicants do not have access to this precise information, any application strategy based on inaccurate beliefs on admission probability is likely even more detrimental than we observe for the repeated DA.

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A Appendix

A.1 Volatility in program cutoffs

Figure A1: Cutoff score fluctuations over time (relative to the final cutoff)

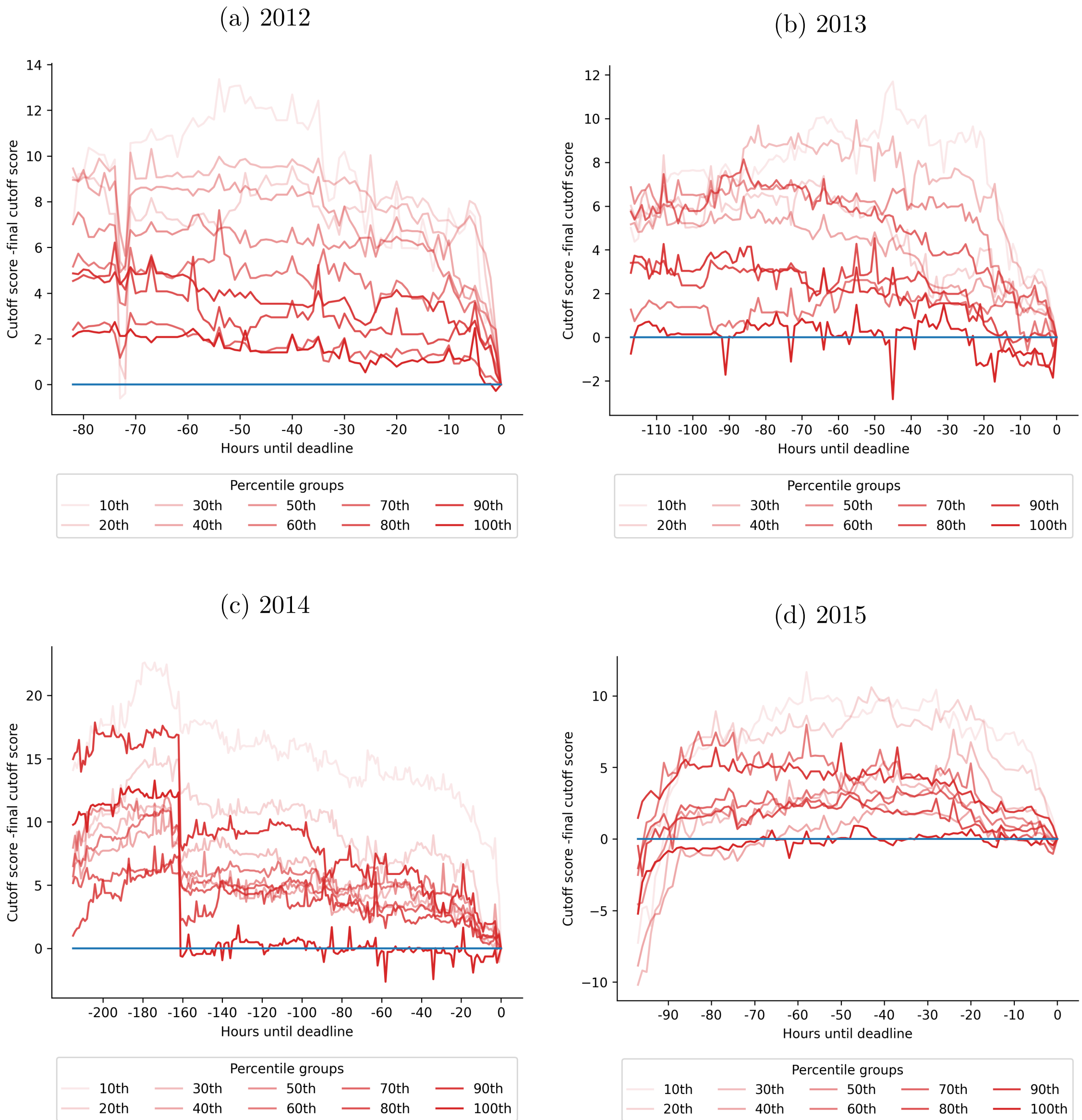


Figure A2: Initial and final cutoff scores

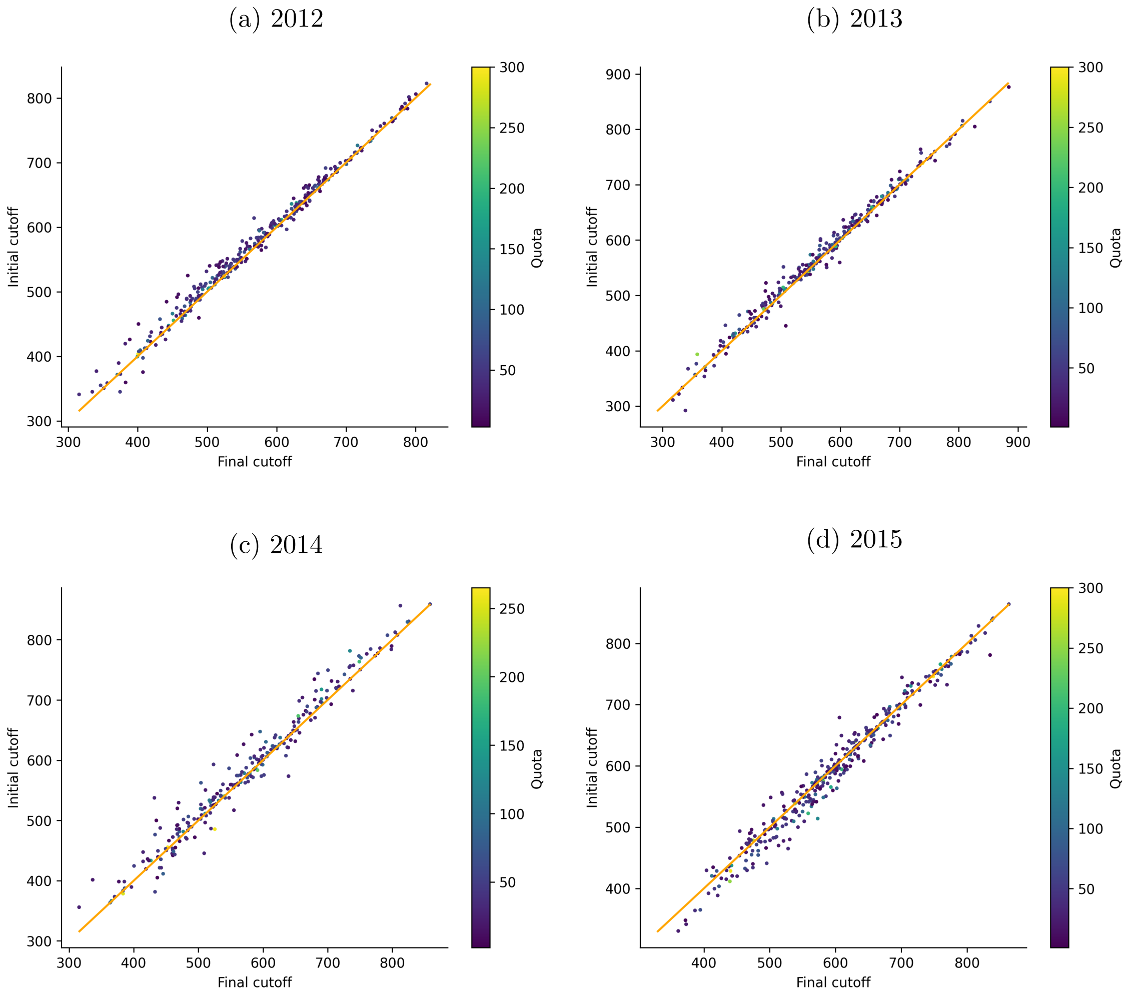


Figure A3: Distribution of programs by number of fluctuations

(a) 2012 (b) 2013

(c) 2014 (d) 2015

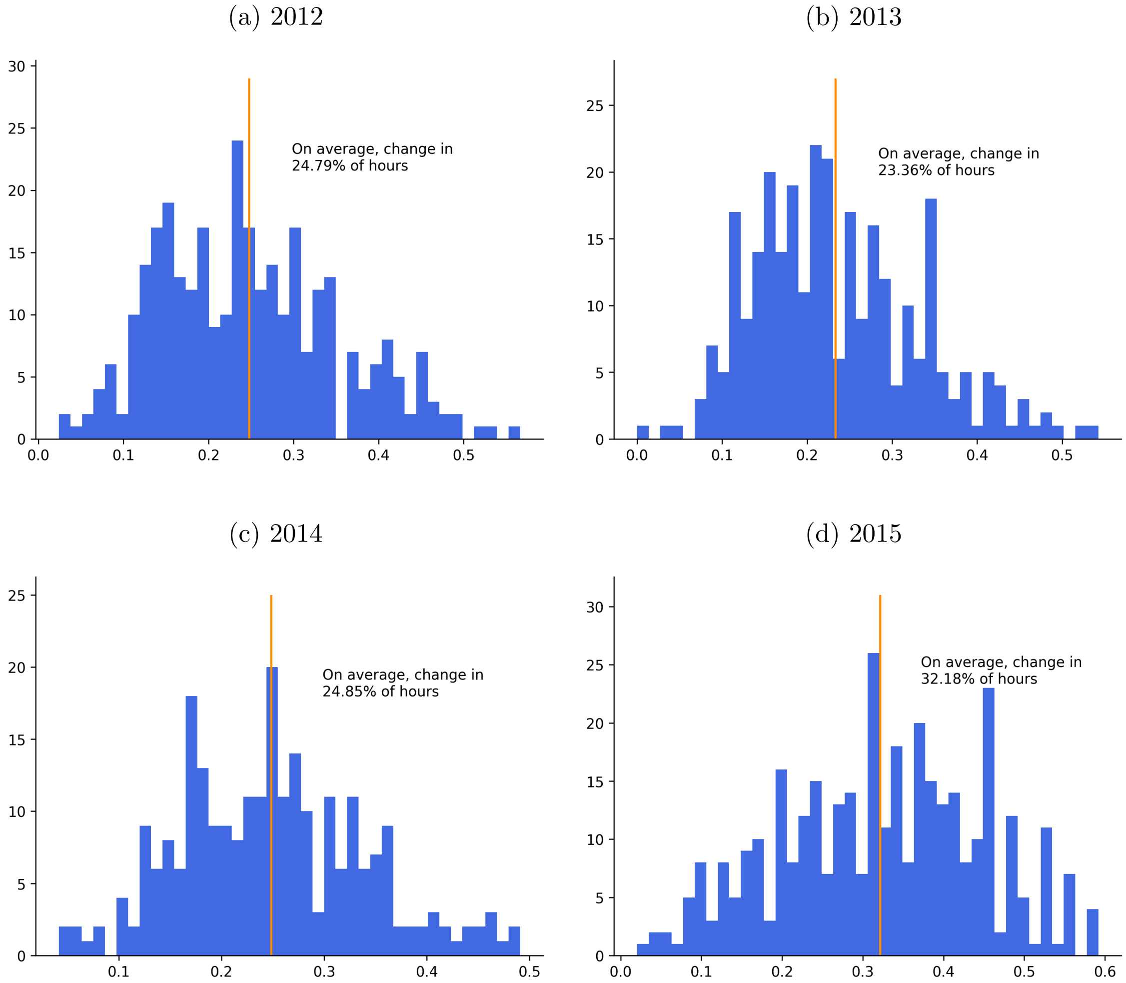
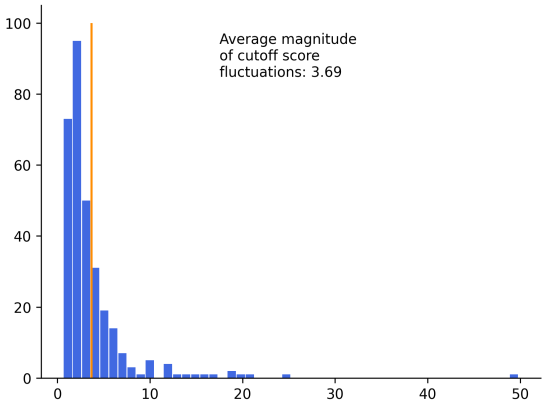
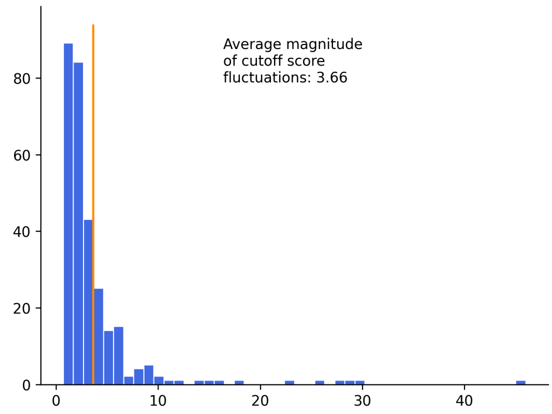


Figure A4: Distribution of programs by avg. magnitude of fluctuations

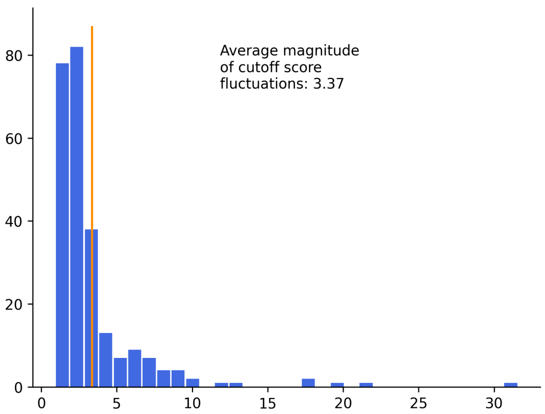
(a) 2012



(b) 2013



(c) 2014



(d) 2015

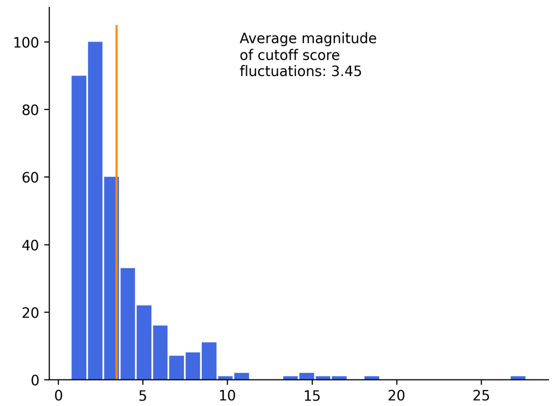
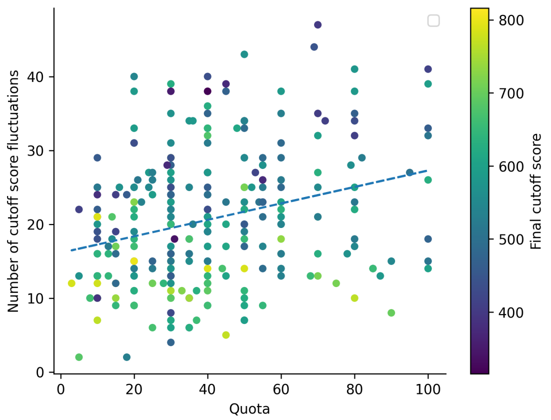
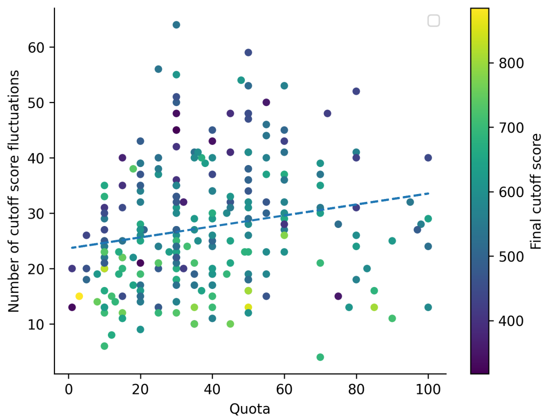


Figure A5: Number of fluctuations by program characteristics

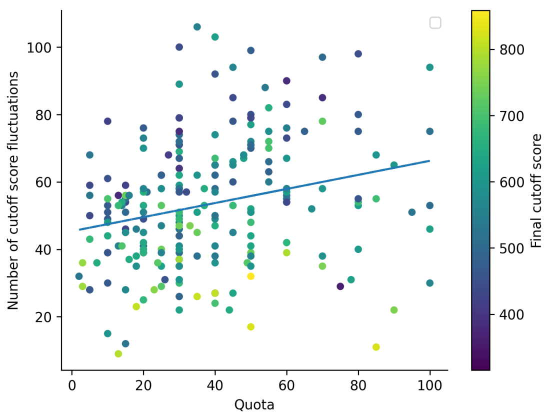
(a) 2012



(b) 2013



(c) 2014



(d) 2015

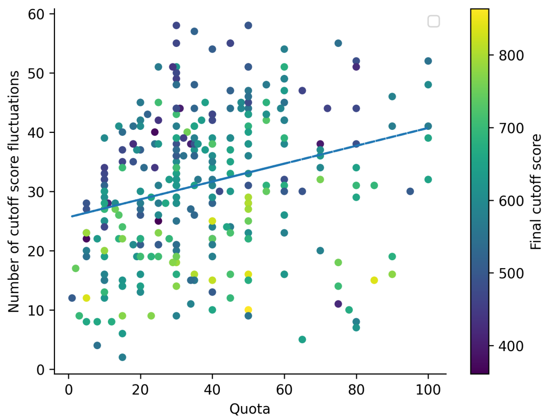
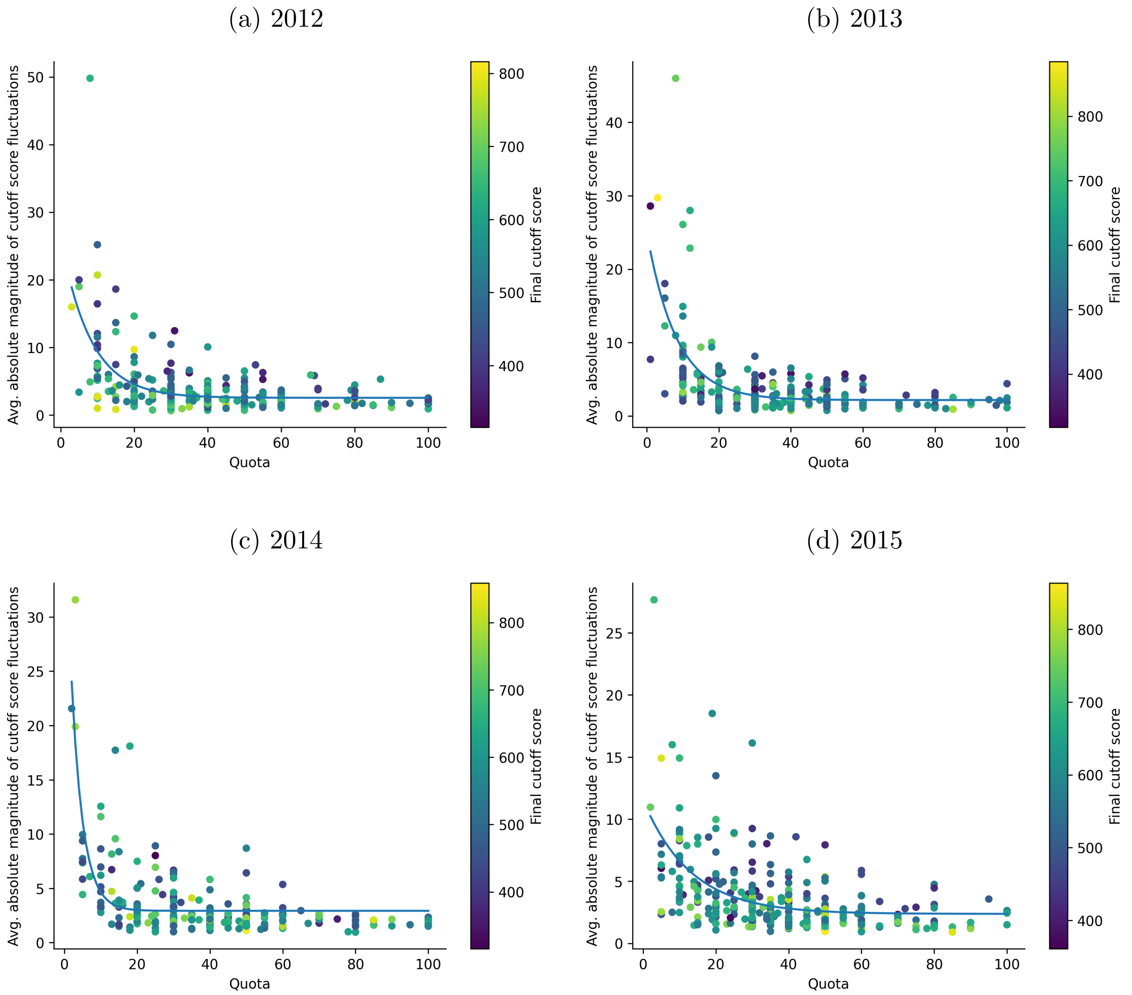


Figure A6: Magnitude of fluctuations by program characteristics



A.2 Data

Table A1: Data Summary

	2012	2013	2014	2015
Panel a) Timing				
publish SE results	9.7.	9.7.	7.7.	13.7.
end of complaints	12.7.	12.7.	14.7.	15.7.
application deadline	17.7. 00am	17.7. 12am	17.7. 12pm	17.7.4pm
Panel b) Overdemand				
# programs	717	748	762	773
w/o overdemand	305	435	440	436
with overdemand	412	313	322	337
avg. overdemand	62.3	49.9	56.1	69.4
median	43	35	39	46
25th pctl.	19	15	17	20
75th pctl.	81	64	77	92
Panel c) Direction of cutoff score fluctuations				
decrease	222	183	161	196
constant	25	33	22	18
increase	66	80	62	134

Note: In this table we summarize main characteristics of the data. Panel a) shows the dates of the beginning and end of the adjustment period in each year. Panel b) shows the number of programs with and without overdemand and the extend of overdemand. Panel c) shows the number of programs by the direction of cutoff score changes from the beginning to the end of the adjustment period.

A.3 RDD

A.3.1 RDD samples by bandwidth

Table A2: Summary statistics

Panel a): Full sample	full sample		bw=10		bw=40		bw=60	
	below	above	below	above	below	above	below	above
Share female	62.07	58.3	60.96	61.26	61.19	60.78	61.38	59.98
Score range (min/max)	492.5	2302.5	471	1152.5	492.5	1731.5	492.5	1731.5
N (in 1,000,000)	15.82	7.42	1.46	1.68	5.07	4.71	7.01	5.59

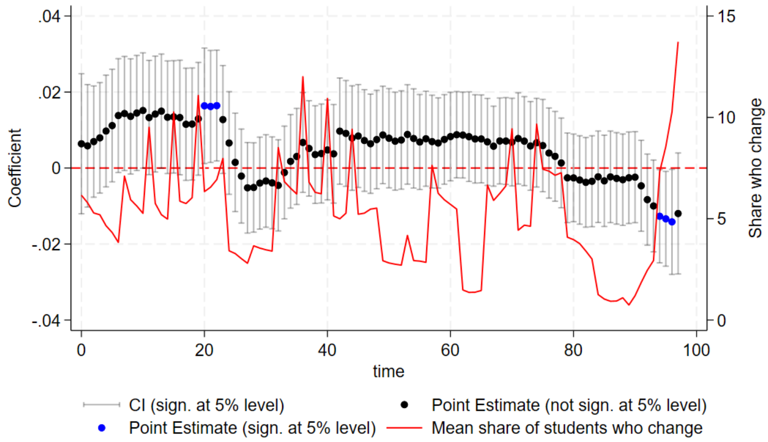
Panel b): RDD sample (last 10 hours and highest ranked program only)	full sample		bw=10		bw=40		bw=60	
	below	above	below	above	below	above	below	above
Share female	60.53	55.54	59.56	60.49	59.69	58.21	59.87	57.43
Score range (min/max)	441.5	2302.5	247	321.5	303.5	511	395.5	1083.5
N (in 1,000)	362.82	436.61	64.95	87.48	179.55	256.37	225.31	311.45

Note: Table shows the characteristics of the full sample (Columns (1) and (2)) and within a bandwidth of 10 (Columns (3) and (4)), 40 (Columns (5) and (6)) and 60 (Columns (7) and (8)) ranks around the cutoff. Panel a) shows this for a sample of all observations (within the bandwidths), Panel b) shows this for the RDD sample, where we additionally restrict the sample on the last 10 hours in the adjustment period and to the highest ranked program of each applicant only. A bandwidth of 40 is the minimum bandwidth selected in our main analysis in a data-driven way.

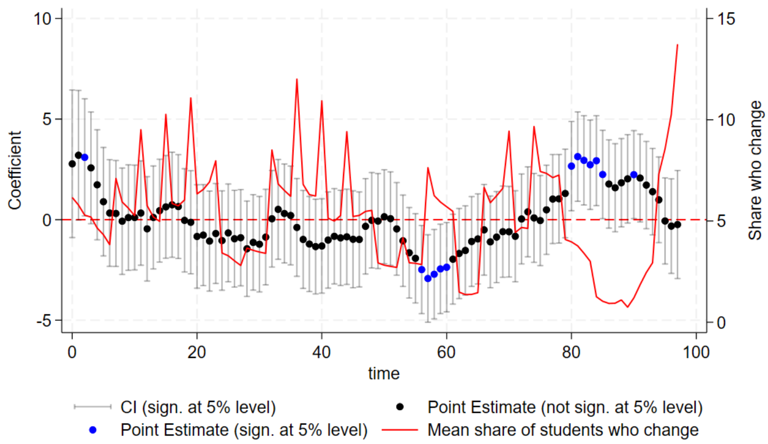
A.3.2 Selection

Figure A7: Selection over time

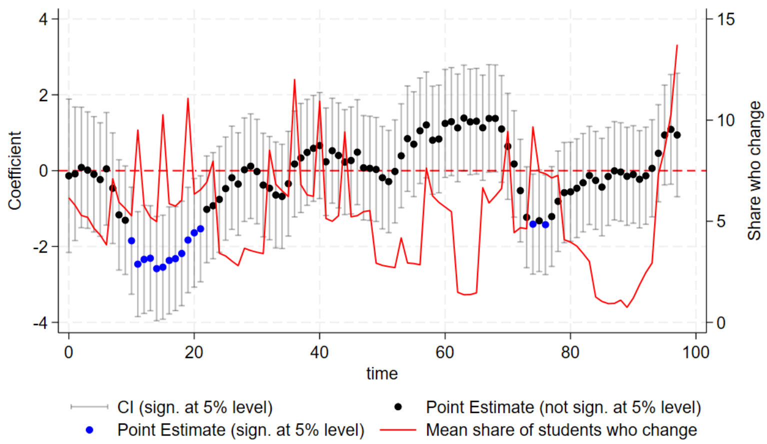
(a) Share female



(b) Weighted State Exam Grades



(c) Weighted High School Grades

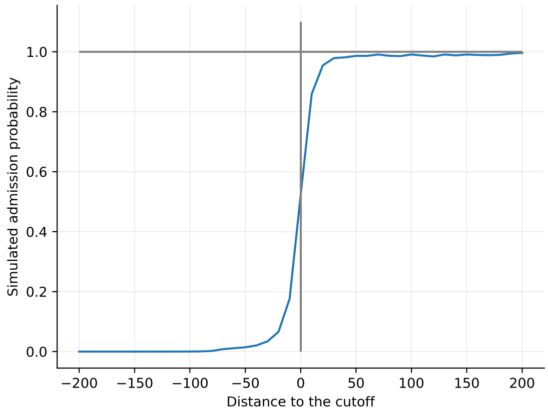


Note: Figure shows the regression coefficients of Equation 1 over the adjustment period with the female share (Panel a)), the weighted state exam grade (Panel b)) and the weighted high school grade (Panel c)) as the dependent variable. The x-axis represents hours in the adjustment period. Each marker represents one regression coefficient, for a regression based on a restricted sample of observations within a symmetric 5-hour window centered on each hour. We show the 5% confidence band (based on robust and bias-corrected s.e.) in gray and additionally highlight statistically significant coefficients (5% level) in blue. The red line represents the share of applicants who make at least one change to their highest ranked program in the respective hour.

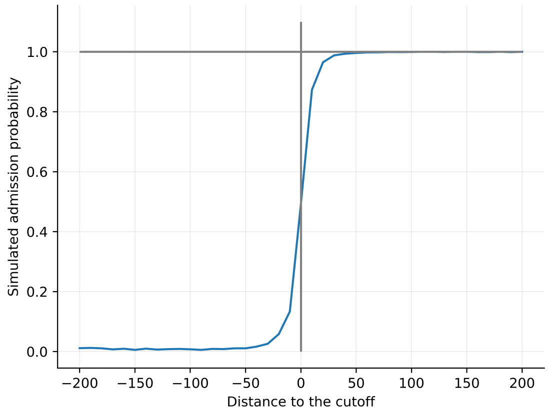
A.4 Developing a strategy

Figure A8: Simulated admission probability around the admission cutoff

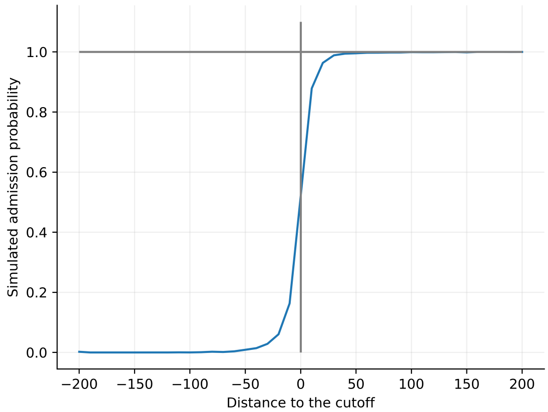
(a) 2012



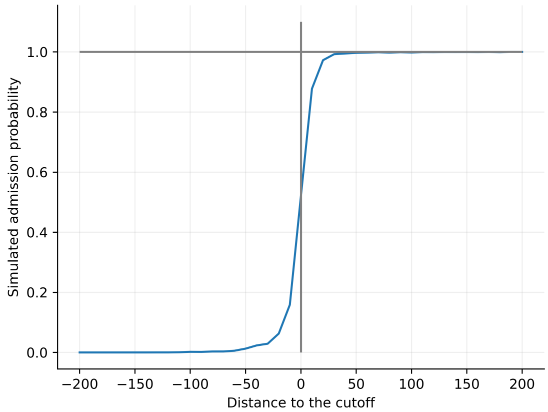
(b) 2013



(c) 2014

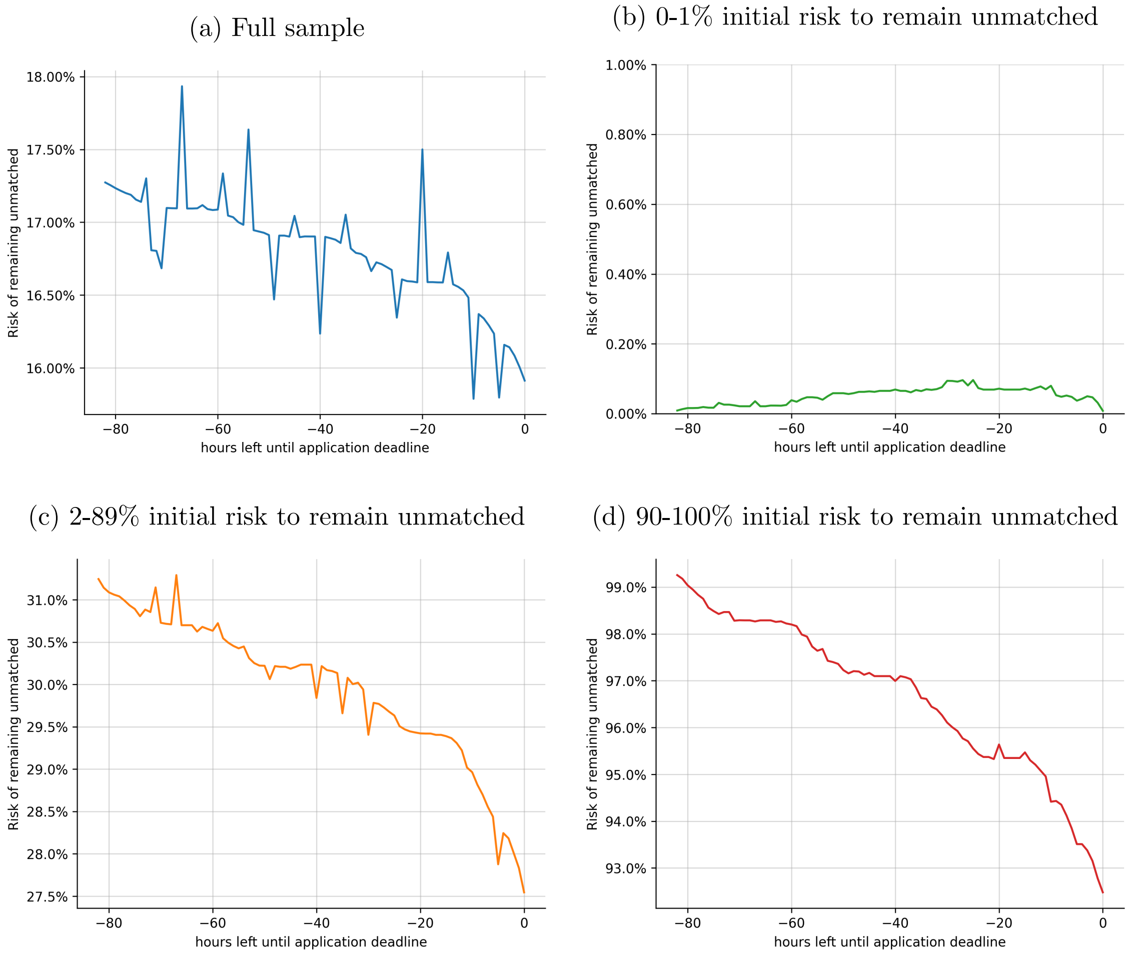


(d) 2015



Note: Figures show the simulated admission probability by the rank distance around the final admission cutoff.

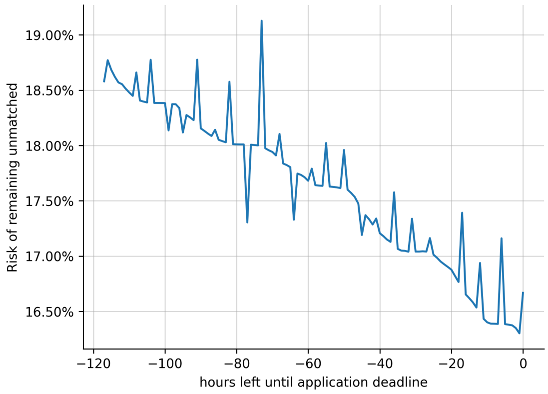
Figure A9: Average risk to remain unmatched over time, by initial risk (2012)



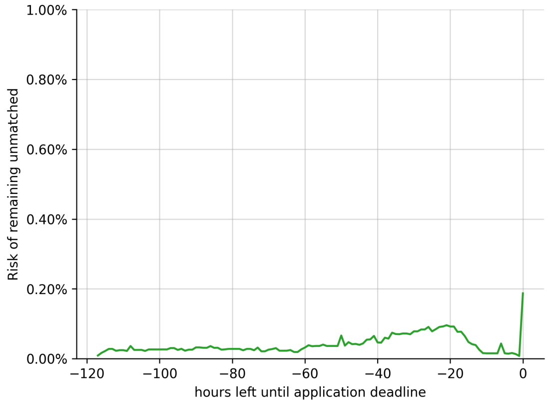
Note: Figure shows how the average risk to remain unmatched evolves over time for two subgroups. In Panel a) we show the average risk for the group with an initial risk to remain unmatched of 0-1%, in Panel b) we show the same for the group with a high initial risk of 90-100%. The group with an initial risk of 0-1% makes up 74.5%, the group with an initial risk of 1-89% makes up 11.9% and the group with an initial risk of 90-100% makes up 13.7%.

Figure A10: Average risk to remain unmatched over time, by initial risk (2013)

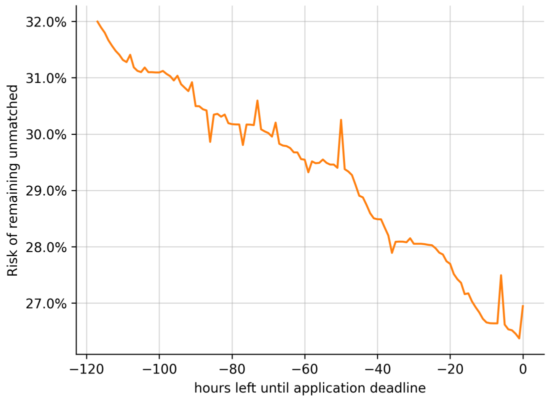
(a) Full sample



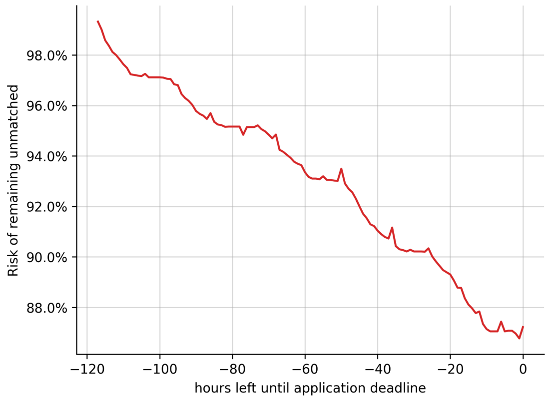
(b) 0-1% initial risk to remain unmatched



(c) 2-89% initial risk to remain unmatched

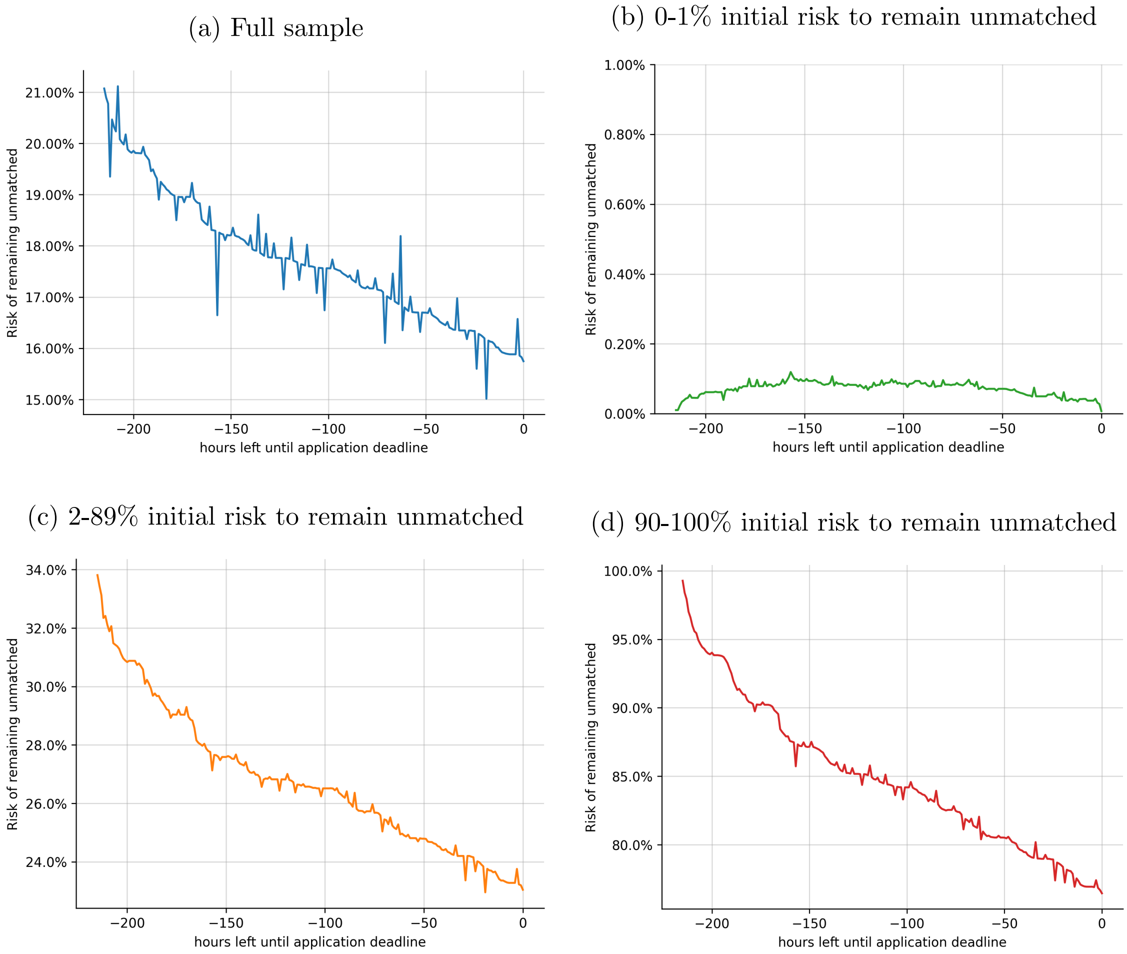


(d) 90-100% initial risk to remain unmatched



Note: Figure shows how the average risk to remain unmatched evolves over time for two subgroups. In Panel a) we show the average risk for the group with an initial risk to remain unmatched of 0-1%, in Panel b) we show the same for the group with a high initial risk of 90-100%. The group with an initial risk of 0-1% makes up 73.3%, the group with an initial risk of 1-89% makes up 11.8% and the group with an initial risk of 90-100% makes up 14.9%.

Figure A11: Average risk to remain unmatched over time, by initial risk (2014)



(a) Full sample

(b) 0-1% initial risk to remain unmatched

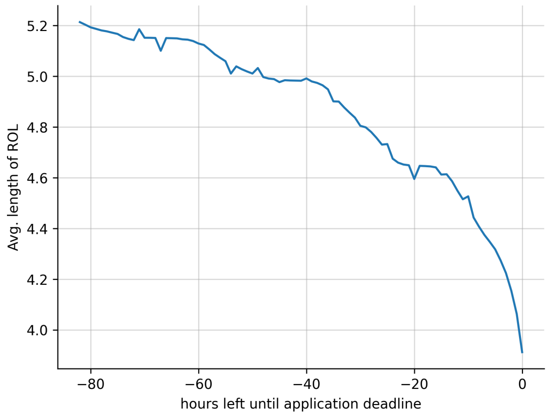
(c) 2-89% initial risk to remain unmatched

(d) 90-100% initial risk to remain unmatched

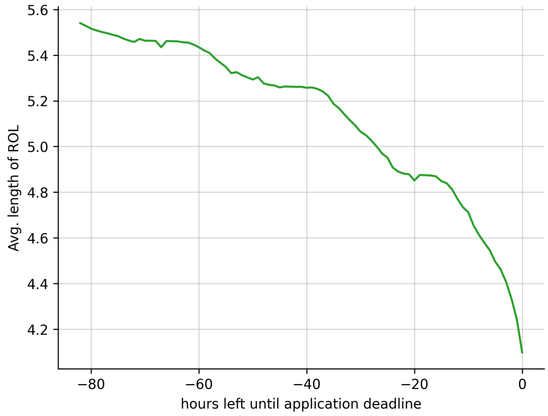
Note: Figure shows how the average risk to remain unmatched evolves over time for two subgroups. In Panel a) we show the average risk for the group with an initial risk to remain unmatched of 0-1%, in Panel b) we show the same for the group with a high initial risk of 90-100%. The group with an initial risk of 0-1% makes up 69.9%, the group with an initial risk of 1-89% makes up 13.5% and the group with an initial risk of 90-100% makes up 16.6%.

Figure A12: Average number of ranked programs over time, by initial risk (2012)

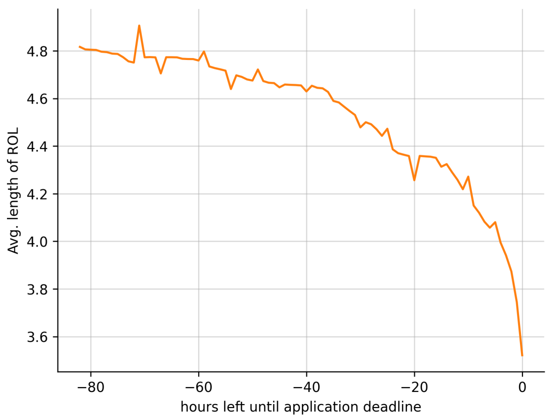
(a) Full sample



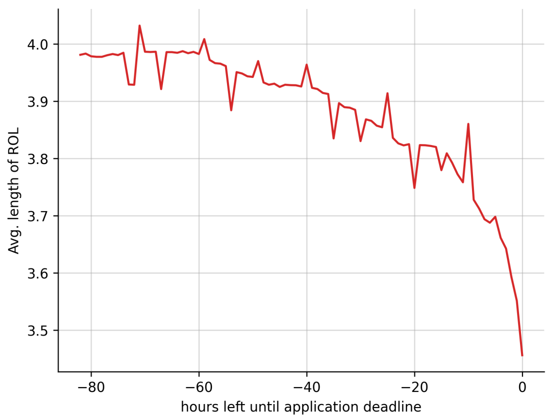
(b) 0-1% initial risk to remain unmatched



(c) 2-89% initial risk to remain unmatched



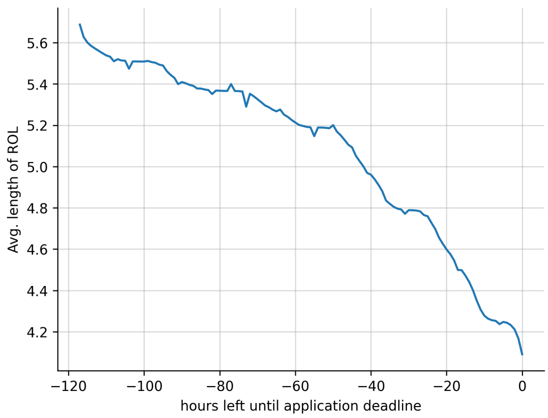
(d) 90-100% initial risk to remain unmatched



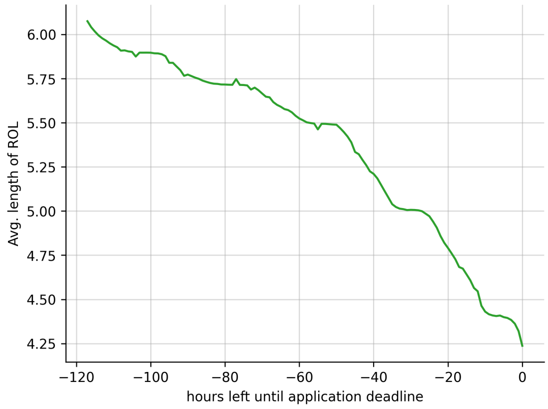
Note: Figure shows how the average number of ranked programs evolves over time for two subgroups. In Panel a) we show the average length of the ROL for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 74.5%, the group with an initial risk of 1-89% makes up 11.9% and the group with an initial risk of 90-100% makes up 13.7%.

Figure A13: Average number of ranked programs over time, by initial risk (2013)

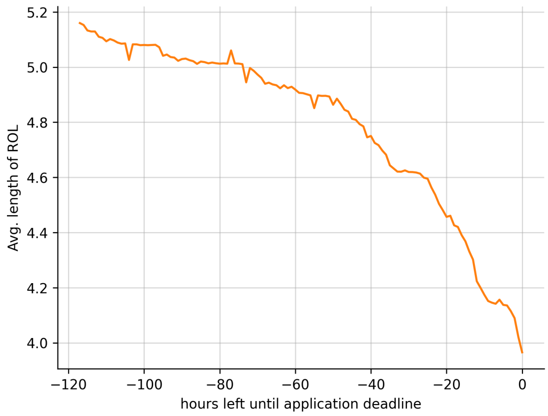
(a) Full sample



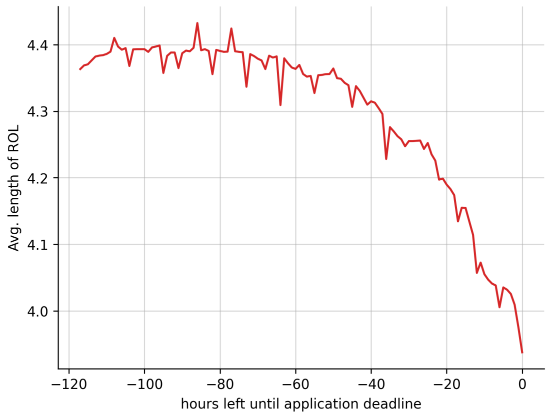
(b) 0-1% initial risk to remain unmatched



(c) 2-89% initial risk to remain unmatched

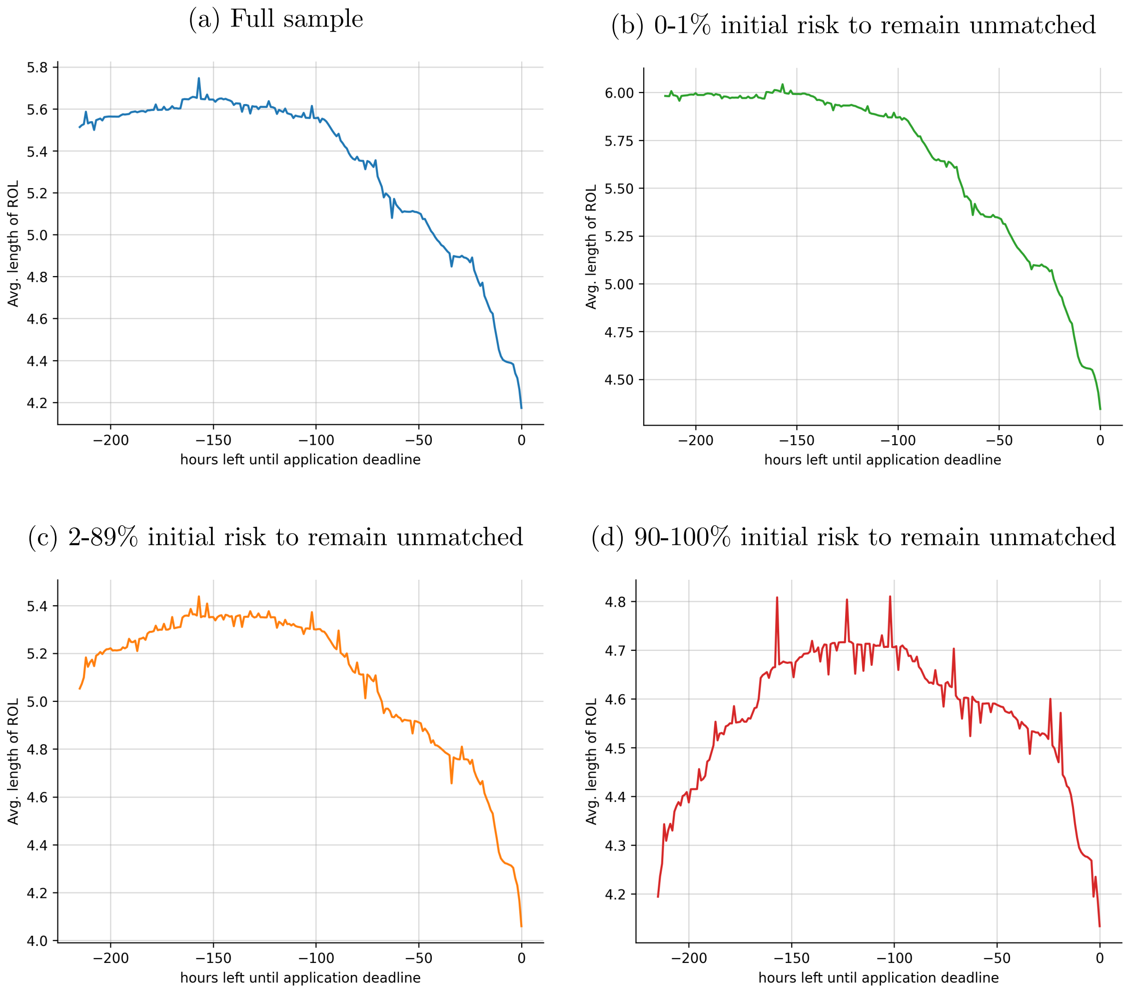


(d) 90-100% initial risk to remain unmatched



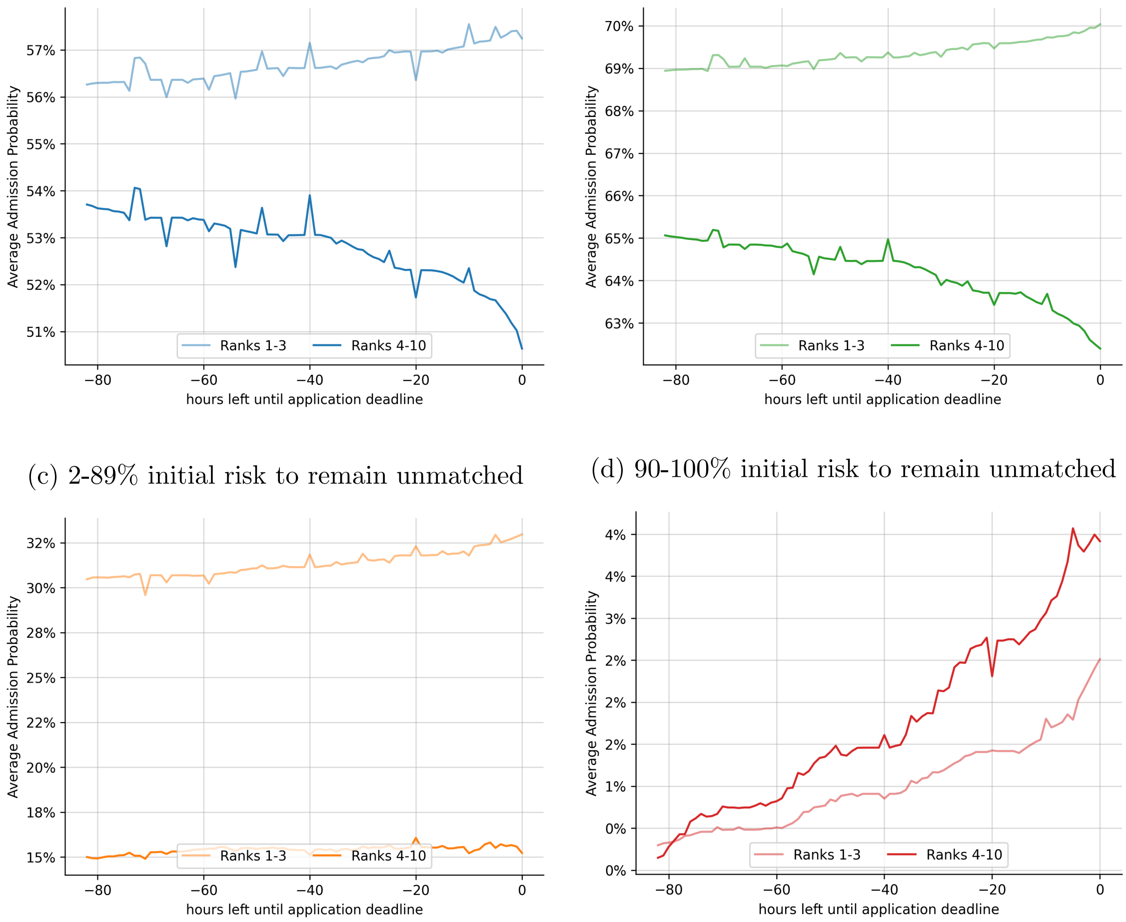
Note: Figure shows how the average number of ranked programs evolves over time for two subgroups. In Panel a) we show the average length of the ROL for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 73.3%, the group with an initial risk of 1-89% makes up 11.8% and the group with an initial risk of 90-100% makes up 14.9%.

Figure A14: Average number of ranked programs over time, by initial risk (2014)



Note: Figure shows how the average number of ranked programs evolves over time for two subgroups. In Panel a) we show the average length of the ROL for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 69.9%, the group with an initial risk of 1-89% makes up 13.5% and the group with an initial risk of 90-100% makes up 16.6%.

Figure A15: Average admission probability of ranked programs, by initial risk (2012)



(a) Full sample

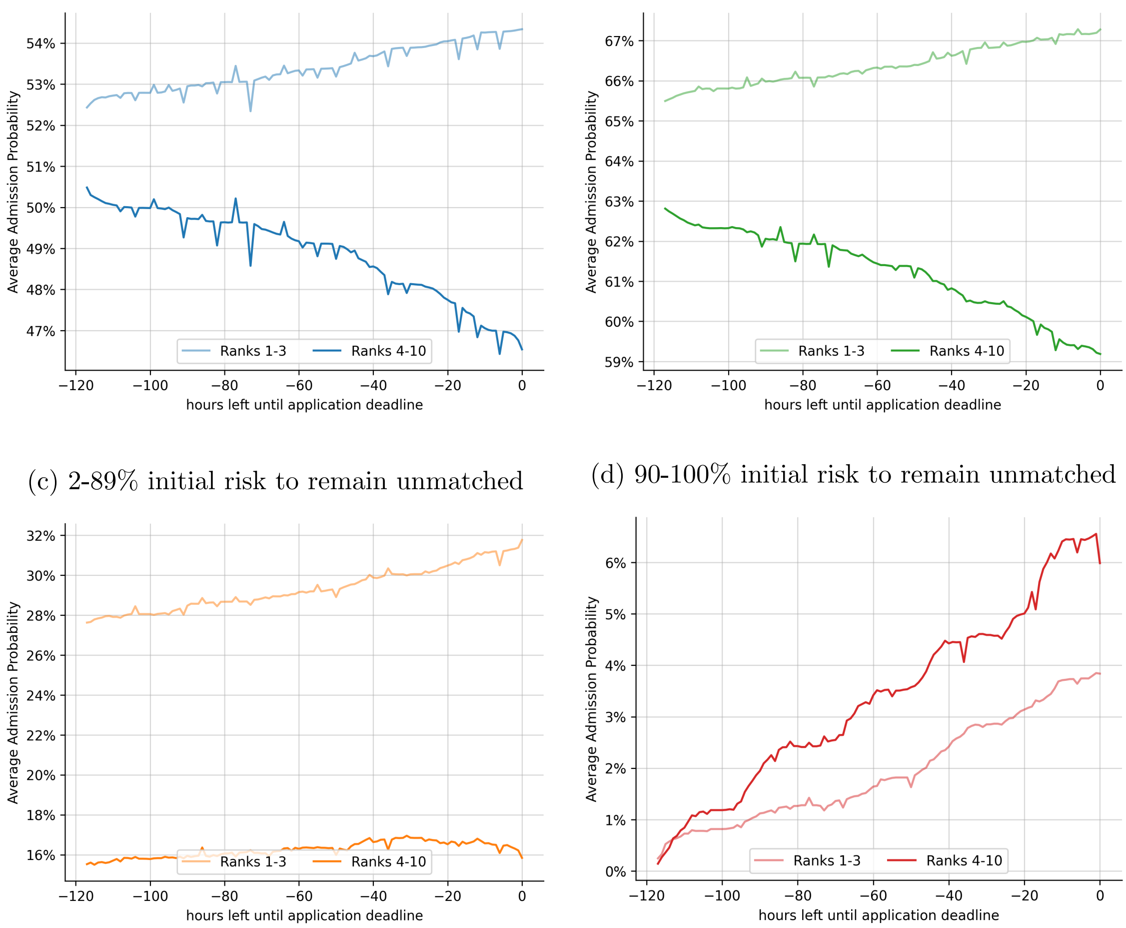
(b) 0-1% initial risk to remain unmatched

(c) 2-89% initial risk to remain unmatched

(d) 90-100% initial risk to remain unmatched

Note: Figure shows how the average admission probability of the three highest-ranked programs and of all lower-ranked programs evolves over time for two subgroups. In Panel a) we show the average admission probability for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 74.5%, the group with an initial risk of 1-89% makes up 11.9% and the group with an initial risk of 90-100% makes up 13.7%.

Figure A16: Average admission probability of ranked programs, by initial risk (2013)



(a) Full sample

(b) 0-1% initial risk to remain unmatched

(c) 2-89% initial risk to remain unmatched

(d) 90-100% initial risk to remain unmatched

Note: Figure shows how the average admission probability of the three highest-ranked programs and of all lower-ranked programs evolves over time for two subgroups. In Panel a) we show the average admission probability for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 73.3%, the group with an initial risk of 1-89% makes up 11.8% and the group with an initial risk of 90-100% makes up 14.9%.

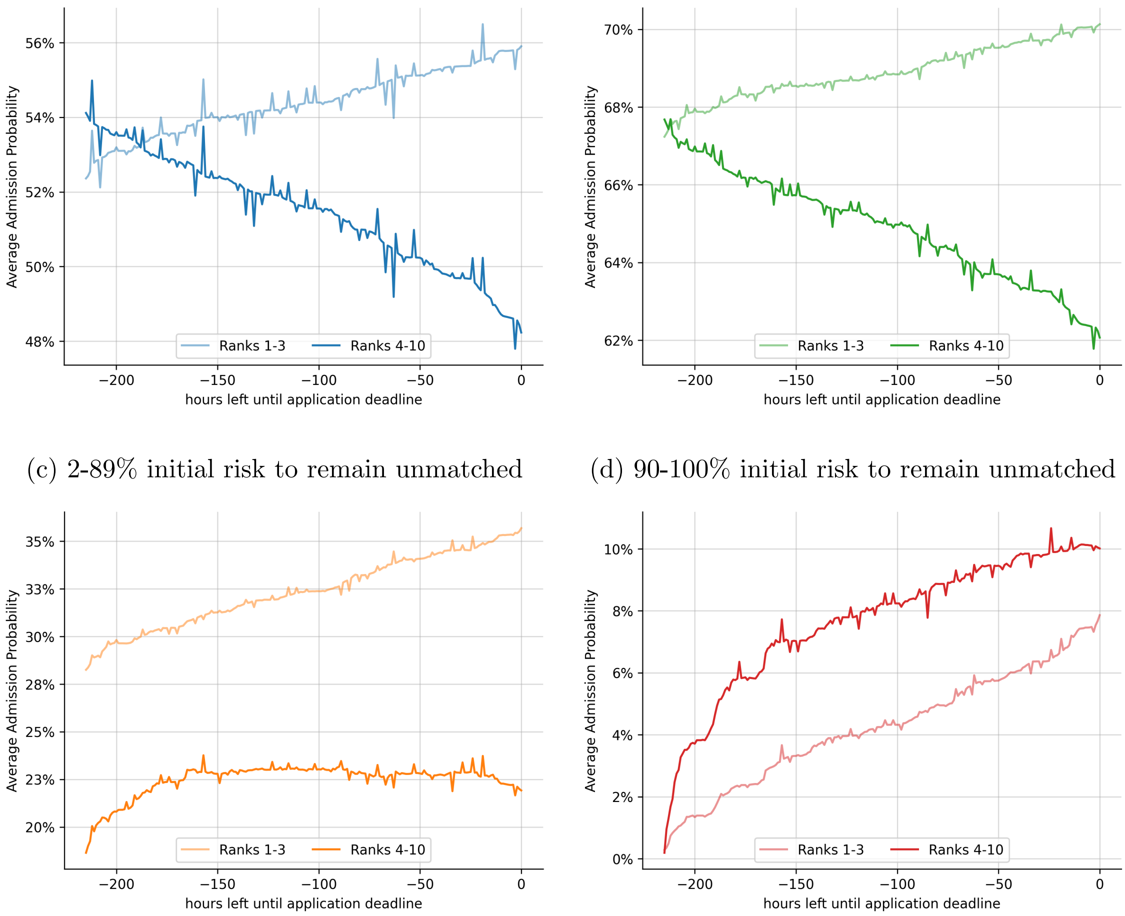
Figure A17: Average admission probability of ranked programs, by initial risk (2014)

(a) Full sample

(b) 0-1% initial risk to remain unmatched

(c) 2-89% initial risk to remain unmatched

(d) 90-100% initial risk to remain unmatched

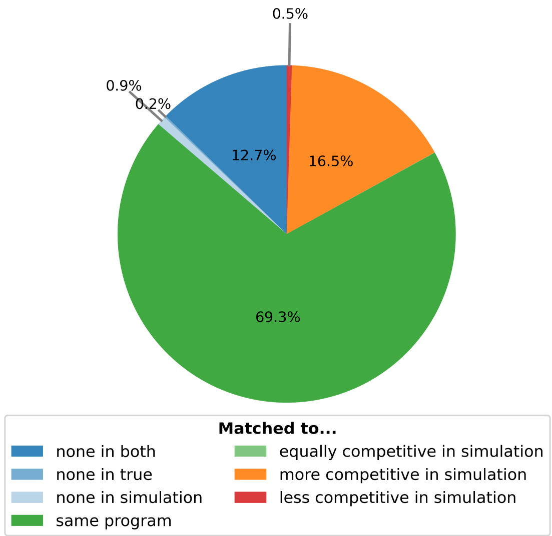


Note: Figure shows how the average admission probability of the three highest-ranked programs and of all lower-ranked programs evolves over time for two subgroups. In Panel a) we show the average admission probability for the full sample, in Panel b), c) and d) for the subgroup of applicants with initial risks to remain unmatched of 0-1%, 2-89% and 90-100% respectively. The group with an initial risk of 0-1% makes up 73.6%, the group with an initial risk of 1-89% makes up 13.2% and the group with an initial risk of 90-100% makes up 13.2%.

A.5 Consequences

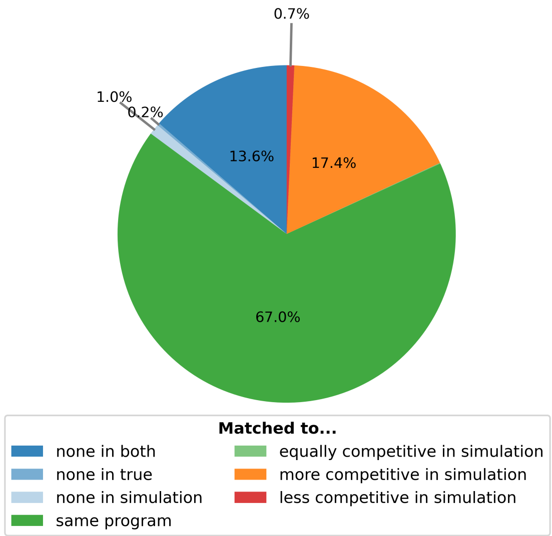
A.5.1 Sorting programs by admission probability

Figure A18: Admission outcome in the simulated vs. observed scenario, 2012



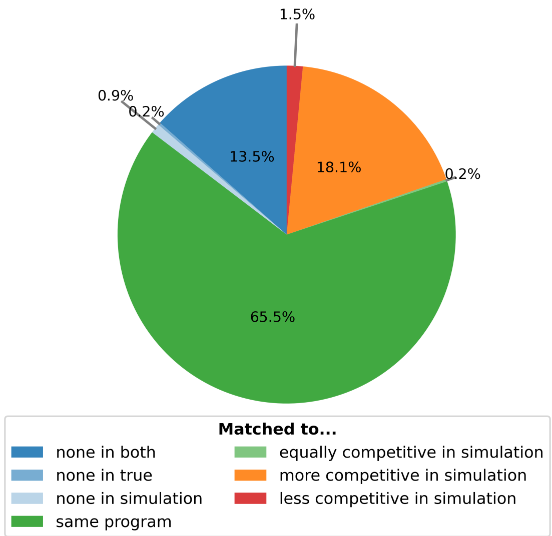
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability.

Figure A19: Admission outcome in the simulated vs. observed scenario, 2013



Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability.

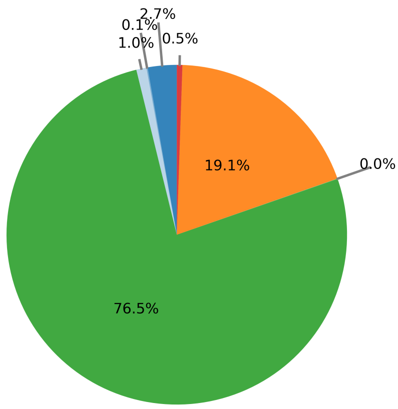
Figure A20: Admission outcome in the simulated vs. observed scenario, 2014



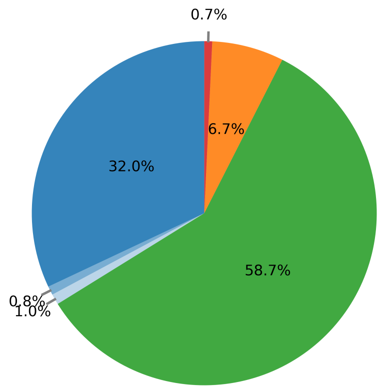
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability.

Figure A21: Admission outcome in the simulated vs. observed scenario, subgroups 2012

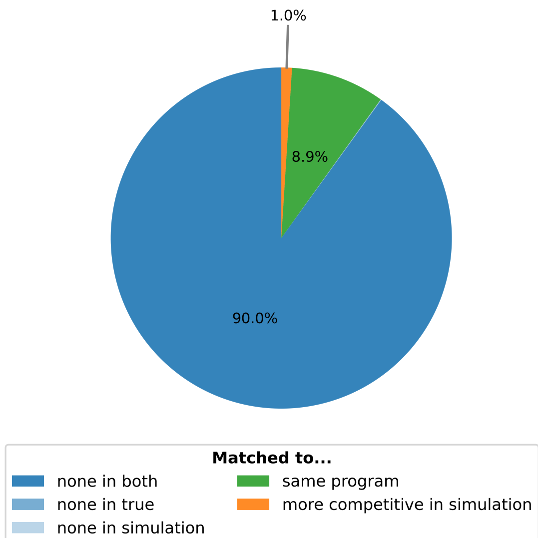
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



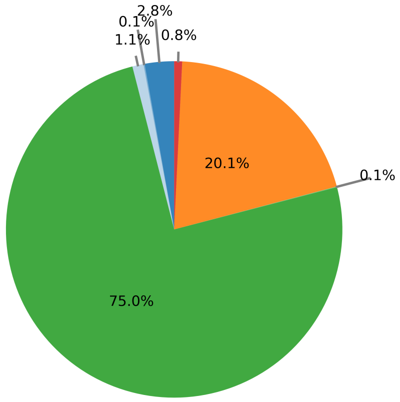
(c) high-risk (90-100% risk to remain unmatched)



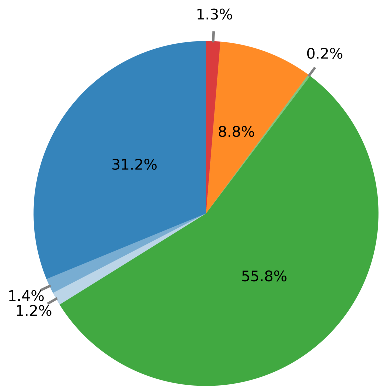
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.

Figure A22: Admission outcome in the simulated vs. observed scenario, subgroups 2013

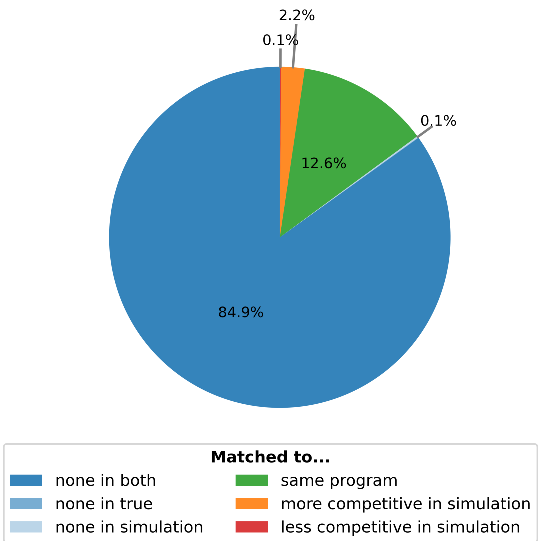
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



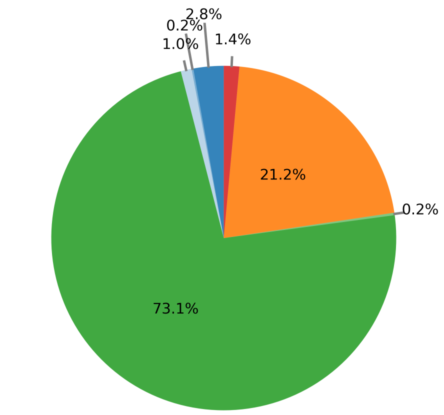
(c) high-risk (90-100% risk to remain unmatched)



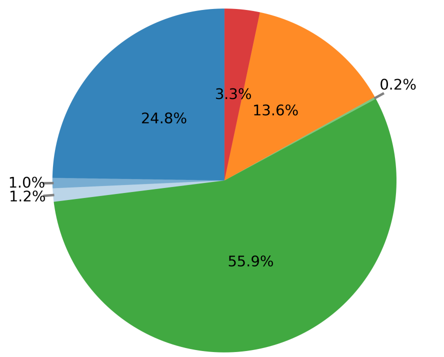
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.

Figure A23: Admission outcome in the simulated vs. observed scenario, subgroups 2014

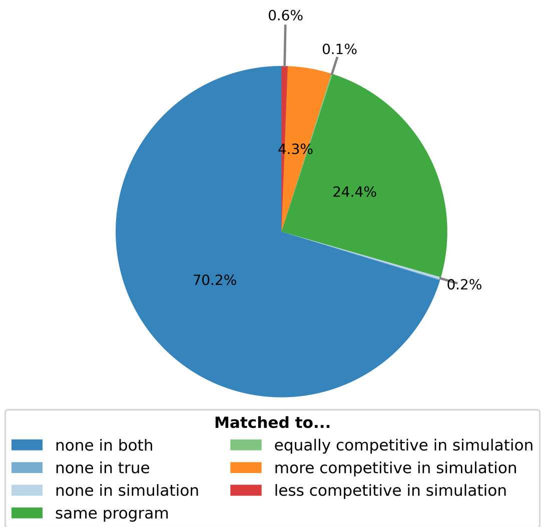
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



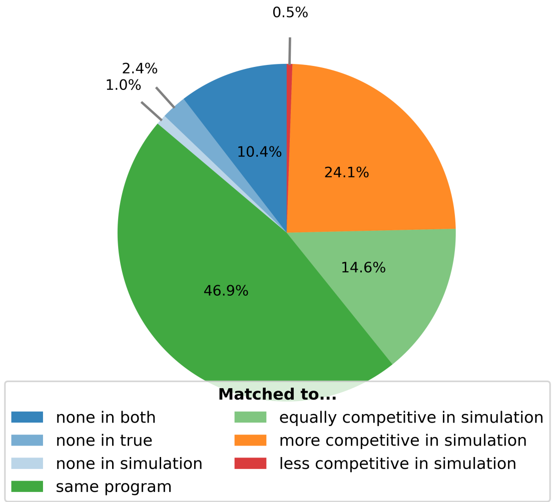
(c) high-risk (90-100% risk to remain unmatched)



Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.

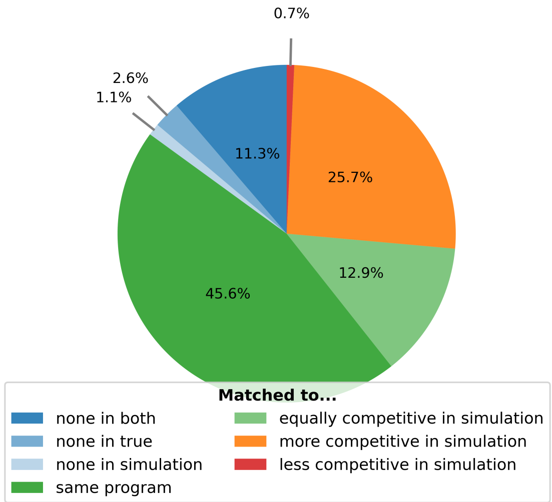
A.5.2 Omitting programs with low admission probability

Figure A24: Admission outcome in the simulated vs. observed scenario, 2012



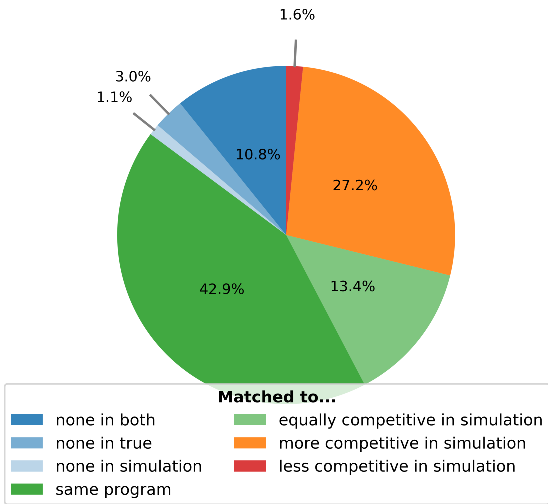
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is applying to the ten most competitive programs ever considered in the adjustment period.

Figure A25: Admission outcome in the simulated vs. observed scenario, 2013



Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is applying to the ten most competitive programs ever considered in the adjustment period.

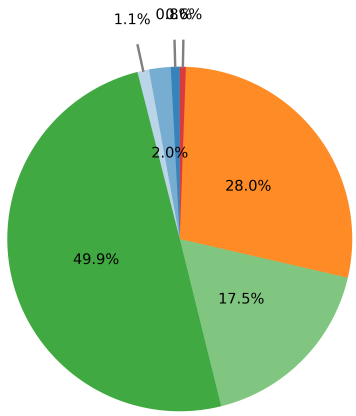
Figure A26: Admission outcome in the simulated vs. observed scenario, 2014



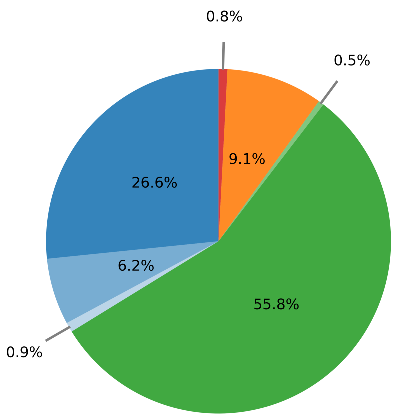
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is applying to the ten most competitive programs ever considered in the adjustment period.

Figure A27: Admission outcome in the simulated vs. observed scenario, subgroups 2012

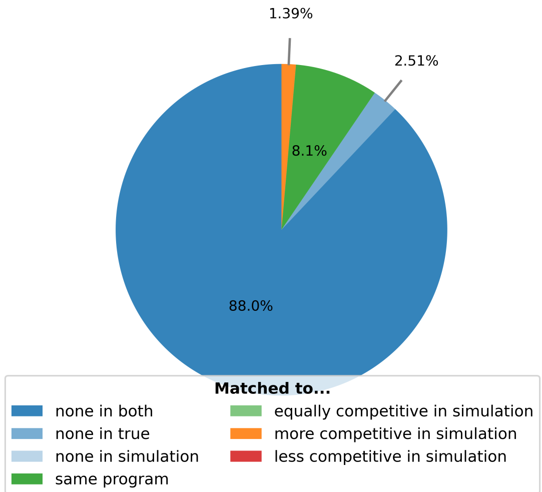
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



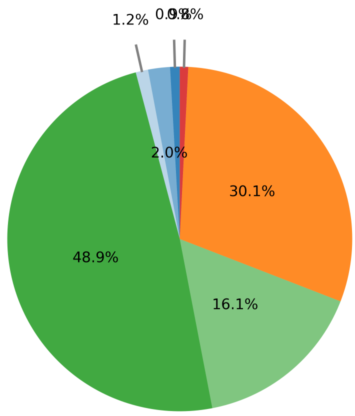
(c) high-risk (90-100% risk to remain unmatched)



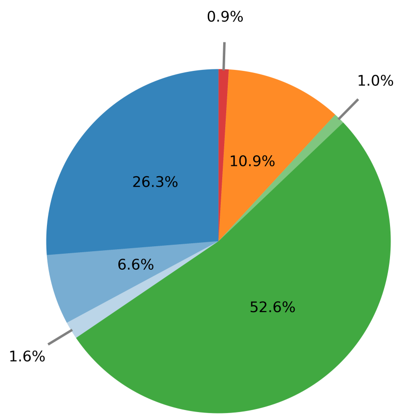
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices extended by the most risky ever-considered programs by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.

Figure A28: Admission outcome in the simulated vs. observed scenario, subgroups 2013

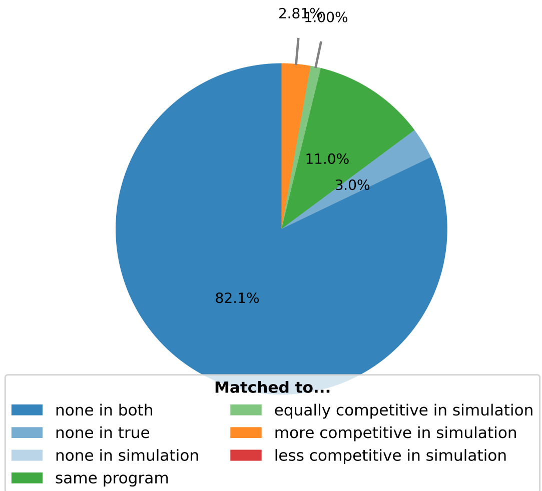
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



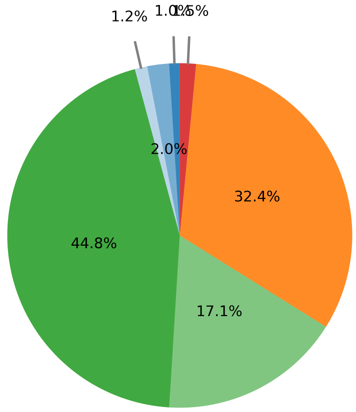
(c) high-risk (90-100% risk to remain unmatched)



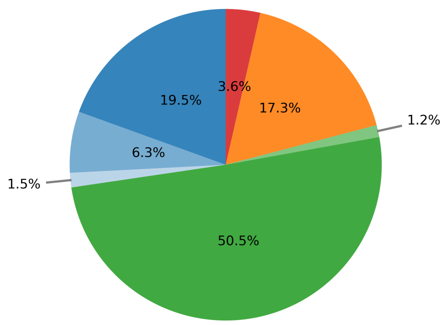
Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices extended by the most risky ever-considered programs by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.

Figure A29: Admission outcome in the simulated vs. observed scenario, subgroups 2014

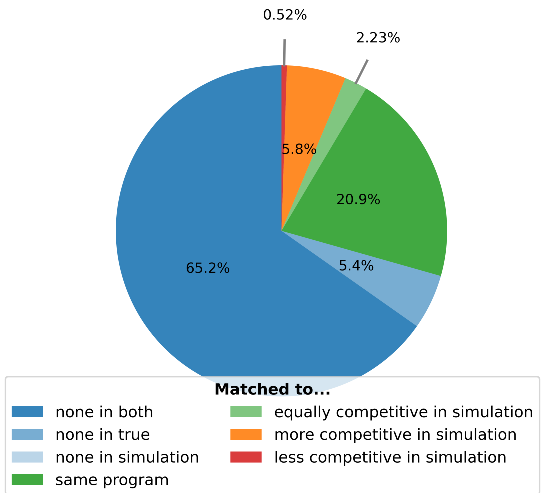
(a) low-risk (0-1% risk to remain unmatched)



(b) medium-risk (1-90% risk to remain unmatched)



(c) high-risk (90-100% risk to remain unmatched)



Note: Figure shows the shares of applicants by the type of change in their admission outcome due to following the adjusted application strategy. Here, the adjustment is a resorting of the final application choices extended by the most risky ever-considered programs by admission probability. We show the results for three subgroups, with an initial risk to remain unmatched of 0-1%, 1-90% and 90-100%.