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## Abstract

We study how admission policies in higher education affect enrollment decisions of men and women and the decision to apply to STEM programs. More specifically, we investigate how an increase in the relative acceptance probability for STEM programs affects these decisions. We apply our analysis to Hungary and we evaluate a policy reform that limited access to subsidized non-STEM programs. We find that this change in the selectivity of the admission system differently affected application decisions of men and women. After the reform, fewer students applied to higher education and the reform especially discouraged the participation of women. After the reform, more men and women applied to STEM programs or non-subsidized non-STEM programs in which they have to pay tuition fees. This last effect is stronger for women. As the reform affected the chance to be admitted to higher education, we estimate a structural model to analyze how the responsiveness to admission probabilities in application decisions differs between men and women. We find that women are more sensitive to admission probabilities. Finally, we use the model to simulate the impact of alternative admission policies on enrollment in STEM programs. We find that an open access policy in STEM programs would stimulate more men and women to apply to these programs.

Keywords: higher education, admission, gender differences, STEM, structural model

JEL: I21, I23, I24, J16, J24

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# A nemek közötti különbségek a felsőoktatási STEM programokba irányuló jelentkezésekben: egy magyarországi szakpolitikai változás hatásának elemzése

Koen Declercq, Joris Ghysels, Varga Júlia

Összefoglaló

A tanulmány azt vizsgálta, hogy a felsőoktatási felvételi politika hogyan hat a férfiak és nők továbbtanulási döntésére, valamit arra, hogy az u.n. STEM képzési területekre (Természettudomány, Technológia, Mérnöki tudomány, Matematika) jelentkezzenek. Azt elemeztük, hogy a STEM programokra való bekerülési esélyek relatív növekedése milyen hatással van e döntésekre. Annak  a magyarországi felsőoktatási reformnek a hatását vizsgáltuk, mely korlátozta az állami finanszírozású nem STEM képzésekre felvettek számát. Az eredmények azt mutatják, hogy a felvételi lehetőségek szelektivitása különbözőképpen hatott a férfial és nők továbbtanulási döntésére. A reform után kevesebb tanuló jelentkezett a felsőoktatásba, és a reform a nőket különösen eltántorította a felsőoktatási jelentkezéstől. A reformot követően mindkét nemből többen jelentkeztek STEM programokra és költségtérítéses nem STEM programokra is. A költségtérítéses képzésre jelentkezés különösen a nők körében nőtt meg. Mivel a reform a felsőoktatásba történő bekerülés esélyét váltiztatta meg,  egy strukturális modell segítségével azt elemeztük hogy a felvételi esélyek változásához való alkalmazkodás különbözik-e nemek szerint. Az eredmények szerint a nők érzékenyebben reagáltak a felvételi esélyek változására. Végül, a modell segítségével  egy alternatív felsőoktatási felvételi politika, a bekerülési korlátok eltörlésének hatását szimuláltuk. Azt találtuk, hogy a felvételi korlátok eltörlése több nőt és férfit vonzana a STEM programokba.

Kulcsszavak: felsőoktatás, felvételi, gender különbségek, STEM, strukturális modell

JEL:  I21, I23, I24, J16, J24

## 1. INTRODUCTION

It is well documented that the share of women enrolled in higher education has been increasing during the last decades. Now, more women than men attend and complete higher education (Vincent and Lancrin, 2008; OECD, 2015). Nevertheless, in most countries, the difference between men and women in the choice of college majors is large and persistent. Women are less likely to study Science, Technology, Engineering and Mathematics (STEM subjects) than men. In 2015, the average share of women among new entrants in higher education in OECD countries was only 19% in ICT majors, and 25% in engineering courses, while 54% of new entrants in higher education were female (OECD, 2017). We observe a similar pattern in Hungary, the focus of our analysis. In 2011, 57% of applicants to higher education were female, but the share of women applying to STEM programs was only 23%. The underrepresentation of women in STEM fields may have negative implications for the supply of qualified labor in science and engineering. As STEM degrees seem to be very profitable private investments for college graduates (Arcidiacono, 2004), differences in the choice of the field of study seem to explain a significant part of the gender wage differential amongst graduates.[1] The persistence of horizontal gender segregation may hinder the closing of the gender gap in earnings.

Previous literature has already investigated why women are less likely to enroll in STEM programs. Several explanations have been suggested. A first strand of the literature shows that students consider expected earnings when making educational choices (See for example Montmarquette et al., 2002, Varga, 2006, Boudarbat, 2008, and Arcidiacono et al. 2012). However, women expect smaller earnings gains from higher education studies than men even when controlling for the field of study. Additionally, women are less responsive to expected earnings than men and therefore they are less likely to enroll in study programs that lead to higher labor market returns such as STEM programs. Other studies investigated the role of gender differences in abilities. Paglin and Rufolo (1990) found that the difference in mathematical ability is the main reason for the difference in the major choice by gender. The findings of other research show that ability sorting is less able to explain the underrepresentation of women in STEM majors as the gender gap in

[1] See for example Daymont and Andrisiani (1984), Machin and Puhani (2003), and Black et al. (2008).

mathematics achievement and aptitude is small and has decreased for several decades (Friedman, 1989; Xie and Shauman 2003; Goldin et al. 2006).[2]

Another strand of the literature investigated the role of differences in risk aversion by gender (Bertrand, 2010; Croson and Gneezy, 2009; Eckel and Grossman, 2008; Gneezy et al., 2003) and gender differences in overconfidence and competitiveness (Reuben et al. 2015). These studies found that women are more risk-averse and are less self-confident about their academic abilities than men. This also explains gender differences in the choice of field of study and why women are less likely to apply to more competitive study programs than men.

Other research concludes that the above channels are less important in explaining gender differences in enrollment in STEM programs and investigates the role of preferences. Zafar (2013) finds that gender differences in college majors can mainly be explained by differences in preferences and tastes between male and female students and differences in beliefs about future earnings explain only a small part of the gap. Gemici and Wiswall (2014) show that gender differences in the distribution of major-specific skills, while significant, are far less important in explaining the gender gap and that differences in preferences for majors are the main driving force behind the gender gap in college major choice.

Taken together, research suggests that preferences may be an important reason for the under-representation of women in STEM fields. However, preferences are usually considered to be constant over time in previous research. This paper contributes to the literature by investigating whether changes in admission standards affect the choice of STEM programs and could thereby affect the gender composition in STEM programs. We use an exogenous shock to the likelihood of selection for a college major which was relatively favourable for STEM-programs in Hungary and investigate how women and men adapted their choices for STEM majors in response to this shock. Limiting the number of state-funded places in non-STEM programs makes applying to these programs more competitive. If women are more risk-averse, they would be more affected by such a

[2] Wang et al. (2013) found that the pattern of gender differences in math and verbal ability may result in females having a wider choice of careers, in both STEM and non-STEM fields, compared with males. They found that mathematically capable individuals who also had high verbal skills were less likely to pursue STEM careers than were individuals who had high math skills but moderate verbal skills and that the group with high math and high verbal ability included more females than males.

policy reform and decide not to apply to higher education anymore or apply to other fields of study if they perceive programs in other fields of study as adequate substitutes.

We apply our analysis to Hungary where students are selected before enrollment by high school results and matriculation exam scores. Students submit their ranking of preferred study options and can choose between state-funded places in which they do not have to pay tuition fees or self-funded places in which they pay for the full costs of their education. As fewer students apply for self-funded places, the odds of being admitted to these programs are larger. Ranking at least one self-funded option can be a good strategy in order to increase the probability of admission.

We consider multiple outcomes and evaluate the impact of the reform on (1) the decision to apply to higher education, (2) the number of study options ranked on the preference list, (3) the choice between STEM and non-STEM programs, and (4) the probability of choosing for a self-funded place.[3] To uncover the behavioral mechanisms that lead to the realized outcomes, we estimate a structural model of program and institution choice. As the reform affected the chance to be admitted to higher education, we assess how responsive men and women are to the odds of being admitted to a program when making their application decisions. We estimate the model on a cohort before the policy change and externally validate the model on the cohort that was affected by the reform. We show that our model performs reasonably well in predicting major choices out-of-sample. Finally, we use the model to simulate how an alternative policy that stimulates enrollment in STEM programs without discouraging students to apply for other programs, would affect application decisions of men and women.

Our main finding is that admission policies differently affect application decisions of men and women. After the reform, fewer students applied to higher education. This effect is larger for women. After the reform, more men and women apply for STEM and self-funded programs. This last effect is stronger for women and after the reform, proportionally more women switched to a self-funded non-STEM program. The structural model provides further explanations for these findings and shows that women have lower preferences for STEM programs, but they are more responsive to admission probabilities when making their choices. We show that an open access policy in STEM programs would stimulate more men and women to apply to these programs. Under this alternative policy,

[3] The reform reduced the number of state-funded options in which students do not have to pay tuition fees in non-STEM programs. After the reform, almost no students were admitted to state-funded programs in economics, while the number of students admitted to state-funded STEM programs was almost not affected.

more men than women will substitute to STEM programs. This policy will, therefore, further increase the gender gap in STEM programs.

The remainder of this paper is organized as follows. Section 2 provides an institutional overview of higher education in Hungary and the admission system and discusses the policy reform. Section 3 takes a first look at the rich register-based data, describing application decisions before and after the reform. Section 4 evaluates the causal impact of the reform. Section 5 sets up and estimates the structural model and assesses how well the model predicts choices within and out-of-sample. Finally, section 6 simulates the impact of an alternative admission policy that stimulates enrollment in STEM programs.

## 2. INSTITUTIONAL BACKGROUND

### 2.1 ADMISSION TO HIGHER EDUCATION IN HUNGARY

All high school graduates who successfully passed the matriculation exams, that is whose results exceeded the 25 % threshold, are entitled to apply to academic higher education.[4] The Hungarian secondary school system is stratified with three types of secondary schools. The academic secondary schools and the vocational secondary schools provide matriculation exams while the vocational training schools do not, that is students finishing vocational training schools are not entitled to apply for higher education studies. Students finishing their studies in academic secondary schools or vocational secondary schools have to take matriculation exams of Hungarian literature and grammar, mathematics, history, one foreign language and at least one subject of the student's choice (this can be anything that they have learned before for at least 2 years).[5] The choice of the additional

[4] We study application decisions to academic higher education. There are two types of academic programs: academic bachelor programs and undivided programs. Academic bachelor programs last for three or four years. After completing an academic bachelor program, students can apply or a master program. Undivided programs are for example medicine or law. These programs provide first degrees, but their duration is longer than that of the bachelor programs. The undivided programs last at least for five years (in the case of medicine 6 years). Students can also apply to study options in vocational higher education. As these options differ from academic higher education and typically take only one or two years of studying, we do not consider these options in our analysis.

[5] For each high school graduate, we observe the result on all matriculation exams that this student has taken. All high school graduates of academic and vocational secondary schools take matriculation exams in mathematics, Hungarian language and history. As we observe for all potential applicants only exam scores on these three courses, our analysis considers only these three courses.

matriculation exams depends on the programs students apply for (e.g. if a student applies for engineering, she has to take a matriculation exam for physics).

In February, prospective students can apply for a given orientation (such as economics, education, medical studies) at a specific institution for the next academic year.[6] Students may apply to as many study options as they want, but they must state their preference ranking. Students pay a fixed fee of approximately 30 euro when they apply to higher education and they are charged an additional fee for every program of about 10 euro after the third program they rank. Most applicants, therefore, limit their ranking to at most 4 programs. Higher education institutions, irrespective of being state-owned or private, offer state-funded and fee-paying places for applicants. The amount of the tuition fee is determined by higher education institutions in accordance with regulations stipulated by government decrees and differs between programs. The tuition fee corresponds approximately to the minimum monthly wage (around 300 EUR) charged for each semester (Biro, 2011), but differs between programs. Tuition fees are on average higher for STEM than for non-STEM programs although medical training is the most expensive as in most other countries. The applicants must also indicate whether they are willing to pay the contribution or whether they are applying for a state-financed place regarding each program in their lists. (For example, the first choice of a student may be a state-financed place in economics at institution A, her second choice might be a state-financed place in law in institution B, and her third choice can be a privately-financed place in economics again at institution A and so on.) When making the decision to apply to a privately-financed place, students trade off the higher costs of applying to such a study option with the higher odds of being accepted to at least one program.

The matching scheme is based on a centralized scoring system. The scores are coming from students' secondary school grades and the results of the matriculation exams.[7] Students take these matriculation exams in May and June after they have submitted their applications. Students can choose between normal or advanced matriculation exams. An advanced matriculation exam may result in extra scores, but these are more difficult to pass. Exams are centralized, but a student may have different scores for different

[6] We consider only applications to full-time academic higher education. There are also some part-time programs, but almost all high school graduates apply for full-time academic programs.
[7] Before 2000, the system was less centralized and universities could hold interviews (Biro, 2011).

programs, as only the relevant subjects are considered.[8] Extra scores can be obtained if the applicant has a certificate in foreign languages, or if the applicant is from a disadvantaged family background. The specific algorithm used in the matching process is a variant of the deferred acceptance algorithm (Shorrer and Sovago, 2018). Students obtain a score for each program they applied to.

Each year, the Ministry of Human Resources determines the number of students admitted to tuition-free, state-financed places by field of study and institutions. The number of students admitted to fee paying places is also determined by the government. Based on the scores of all students and the capacity of the program, the government announces a minimum score in July that students have to achieve in order to be admitted to the program. Each student gets at most one offer if he or she achieved the minimum admission score to one or more study programs at specific institutions. If a student achieved the minimum admission score for an institution/field specialization he or she has applied for with a better preference ranking, he or she will be refused automatically from other institutions/fields of specialization even if he or she has achieved the minimum admission score of the latter institutions, as well. Students accepted to a degree program in a certain field of study follow an established program of courses and exams. Mobility is low between programs, and it is difficult to change fields of study once accepted to a specific degree program. Students who are not admitted in a main round that ends in July can participate in the second matching round for unfilled programs at the end of the summer.[9]

## 2.2 THE POLICY REFORM

In December 2011, the Hungarian government announced that it would substantially decrease the number of state-financed places in higher education in 2012. Figure 1 shows that the total number of students admitted to full-time state-funded academic higher education for first degrees decreased from 39000 in 2011 to 31000 in 2012. The reason for this reform was that according to the government, too many students were attending higher education which leads to overinvestments in general and in some fields of studies. The aim of the reform was to decrease the number of students in higher education,

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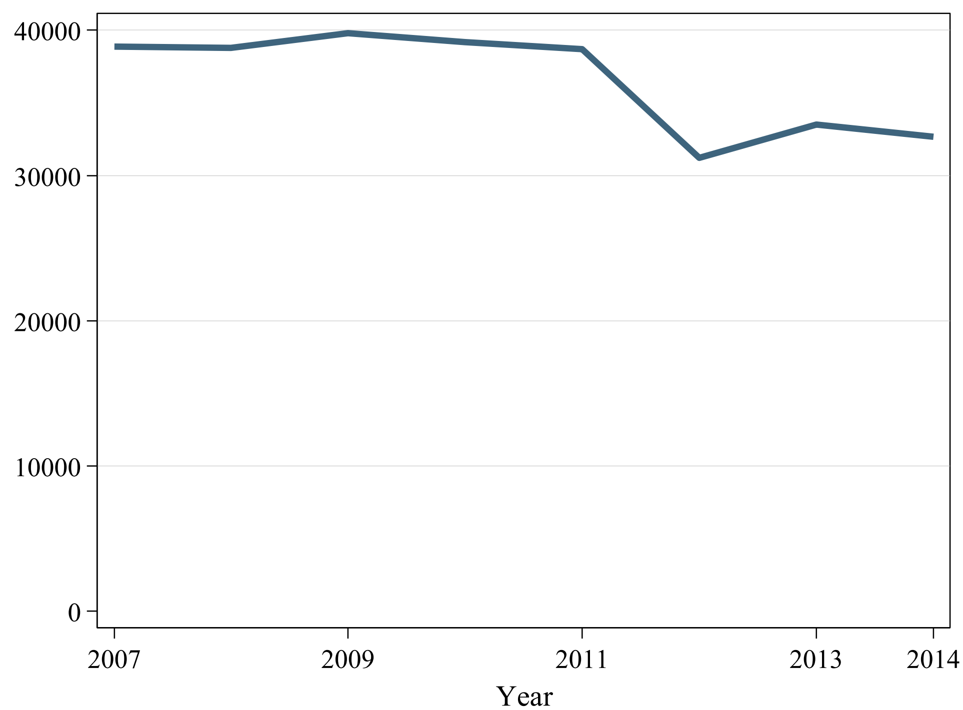
[8] For example: for computer science programs, the grades and exam scores for physics are counted, but for economics, the exam score of economics is considered instead, besides the main subjects such as mathematics, Hungarian literature and grammar and history.
[9] In our analysis, we consider only applications for the first main round that ends in July.

especially in non-STEM programs. A further aim was to cut public expenses and increase cost-sharing in higher education in order to reduce the public debt. In more recent years, the Hungarian government again increased the number of places, but to a lower level as before the reform.

*Figure 1*

**Number of admitted students to academic programs**




*Note:* Total number of admitted students in academic programs full-time education. Based on own calculations.

Table 1 shows the changes in the number of admitted students to STEM and non-STEM programs and by more detailed fields of study. There was a large decrease in the number of admitted students to state-funded places to non-STEM programs between 2012 and 2011. The number of admitted students in 2012 was only 69% of the number of admitted students in 2011 (or a decrease from 20599 to 14170). The decrease was much smaller for STEM programs. More than 94 percent of the number of admitted students to state-funded places in STEM programs was admitted in 2012. The number of admitted students to self-funded places moved in the opposite direction. For non-STEM programs, there was a 30% increase while for STEM programs there was a decrease of about 20%. The fact that fewer students were admitted to state-funded non-STEM programs and that the number of students admitted to state-funded STEM programs did almost not change, increased the relative probability of acceptance for state-financed STEM programs. This could have stimulated more students to apply for state-funded STEM programs.

*Table 1*

**Number of admitted students to academic higher education**

| | 2011 | | | 2012 | | | 2012/2011 % | | |
|---|---|---|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| STEM-fields | | | | | | | | | |
| ENG | 13994 | 763 | 14757 | 13635 | 464 | 14099 | 97.4 | 60.8 | 95.5 |
| SCI | 4066 | 90 | 4156 | 3389 | 211 | 3600 | 83.3 | 234.4 | 86.6 |
| Total | 18060 | 853 | 18913 | 17024 | 675 | 17699 | 94.3 | 79.1 | 93.6 |
| Non-STEM fields | | | | | | | | | |
| SSCI | 5715 | 3556 | 9271 | 3530 | 4452 | 7982 | 61.8 | 125.2 | 86.1 |
| ECON | 4486 | 4630 | 9116 | 246 | 7337 | 7583 | 5.5 | 158.5 | 83.2 |
| TEACH | 1797 | 399 | 2196 | 1530 | 505 | 2035 | 85.1 | 126.6 | 92.7 |
| HEALTH | 3833 | 245 | 4078 | 4051 | 156 | 4207 | 105.7 | 63.7 | 103.2 |
| AGRI | 1818 | 648 | 2466 | 2049 | 503 | 2552 | 112.7 | 77.6 | 103.5 |
| LAW | 1454 | 1798 | 3252 | 1028 | 1881 | 2909 | 70.7 | 104.6 | 89.5 |
| ARTS | 1496 | 780 | 2276 | 1736 | 853 | 2589 | 116.0 | 109.4 | 113.8 |
| Total | 20599 | 12056 | 32655 | 14170 | 15687 | 29857 | 68.8 | 130.1 | 91.4 |
| Total | 38659 | 12908 | 51568 | 31194 | 16362 | 47556 | 80.7 | 126.8 | 92.2 |

*Note:* Total number of admitted students in academic programs full-time education in 2011 and 2012. Based on own calculations. The numbers in the last three columns present the number of students admitted in 2012 relative to the number of students admitted in 2011 and are expressed in percentages.

Nevertheless, there were differences by more detailed field specializations within the STEM and non-STEM groups. Between 2011 and 2012 the number of admitted students to state-funded places in Engineering and Computer Sciences (ENG) decreased by less than 3 percent while the number of students admitted to state-funded places in Natural Sciences (SCI) decreased about 17 percent. As for non-STEM programs: there were large cuts in the number of students admitted to state-funded places in Economics (ECON), Law and Administration (LAW), Humanities and Social Sciences (SSCI), and teacher training (TEACH). These are the fields where women were traditionally overrepresented. The cuts were largest in the field of economics. In 2011, 4486 students were admitted to a state-funded place in economics. After the reform, this number decreased to 246. There we observe large shifts from state-financed to privately-financed programs. Before the reform, 4630 students were admitted to a self-funded program in economics. This number increased to 7337 after the reform. This shows that many students are willing to pay the tuition fee in order to attend higher education. There were also small increases in the number of students admitted to some non-STEM programs such as Health, Agricultural Sciences (AGRI), and culture and languages (ARTS).

## 3. APPLICATIONS TO HIGHER EDUCATION IN HUNGARY

### 3.1 DATA

To analyze how the reform affected application decisions, we make use of a rich administrative dataset. We observe the full sample of high school graduates from academic and vocational high schools in the matriculation examination data of the Hungarian Education Office. Our sample contains all students who took the matriculation exams in 2011 and 2012. For each student, we have detailed information on the exam results for mathematics, Hungarian language, and history. We also observe gender, date of birth, and secondary school. Based on a unique student identification number, we merge this dataset with the full sample of application-admission data of the Higher Education Admission Office.[10] The application-admission dataset contains data for all applications of the students: the institution/faculty where the students made an application, name of the program, level of the program, a form of funding, and the program where the applicant was admitted.[11] We omit applications to vocational higher education from the preference ranking of students because we limit the analysis to application decisions to academic higher education. In principle, students can rank as many study options as they want but we observe that only 0.7% of applicants ranks more than 6 options. The variable cost that students have to pay for each study program they rank after the third ranked program, can be a possible explanation for the fact that students do not rank more options. Because only

[10] Based on a personal ID number, we could match the students in the two datasets (about 200-300 cases or 0.03 percent of applicants could not be merged.)

[11] For the students who apply to higher education, we have additional information about the type of secondary school, high school results, an indicator for being from disadvantaged family background and whether the students obtained a foreign language exam certificate. However, we do not observe this information for students who do not apply to higher education. We therefore only use this information in the regressions that contain only the sample of applicants.

0.7% of applicants rank more than 6 options, we consider only the first 6 options to academic programs on the preference ranking in our analysis.

### 3.2 HIGH SCHOOL GRADUATES

Table 2 compares the sample of students who graduated from academic and vocational secondary schools before and after the policy reform. In 2012, fewer students graduated due to a demographic decline in Hungary (T-tudok, 2015). Proportionally more women than men graduate from high school. On average, students graduate from high school at the age of 19. This average age is slightly higher for men (19.2) compared with women (19.1). Graduation age at the high school has not changed after the reform.

To graduate from high school, all students have to take matriculation exams in the following three courses: Hungarian language, mathematics and history. In Table 2, we observe that women perform better on the Hungarian language, but worse on mathematics. Exam scores are similar before and after the reform but are slightly lower for history.[12] Students can choose for a normal matriculation exam or an advanced exam. Performing well on these advanced exams increases the probability of being admitted to higher education. However, only a small fraction of students choose an advanced exam. Women are more likely to choose for an advanced exam in the Hungarian language, but less likely to choose for an advanced exam in mathematics. After the reform, a slightly larger fraction of high school graduates choose for an advanced exam. The increased selectivity to higher education after the reform could have influenced the decision to choose for a matriculation exam of the normal level or the advanced level. Figure A1 in Appendix illustrates the distribution of the matriculation exam scores for the three courses. The distribution of exam scores looks similar before and after the policy reform and confirms the finding of Table 2 that scores of high school graduates on mathematics are slightly higher after the reform, and that the scores on Hungarian language and history are slightly lower after the reform.

[12] Note that the average matriculation exam score is slightly higher than 50% for mathematics and Hungarian language, implying that a substantial fraction of the students scores below 50%. These students can still apply to academic higher education as the threshold is at 25%. Nevertheless, the fact that they performed less well decreases their chances of being admitted to higher education.

*Table 2*

**High school graduates**

| | Men | | Women | |
|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 |
| Age | 19.2 | 19.2 | 19.1 | 19.1 |
| Exam scores | | | | |
| Math | 50.4 | 50.7 | 47.0 | 49.5 |
| Hungarian language | 54.9 | 53.4 | 63.5 | 61.1 |
| History | 63.5 | 59.8 | 64.2 | 59.6 |
| The fraction of students choosing for an advanced exam | | | | |
| Hungarian language | 0.3 | 0.4 | 1.9 | 2.3 |
| Math | 3.5 | 4.6 | 1.8 | 2.3 |
| History | 5.8 | 6.7 | 6.6 | 7.8 |
| Budapest | 23.7 | 23.0 | 21.5 | 21.2 |
| Total | 37522 | 36221 | 43055 | 41715 |

*Note:* Background characteristics of all students who graduate from academic and vocational secondary education. Exam scores are expressed as percentages. The fraction of students choosing for an advanced exam is expressed as a percentage of high school graduates.

Performing well on the different matriculation exams increases the probability of being admitted to higher education, but the weight attached to each exam differs between programs. Students who apply only to STEM programs might, therefore, study more for mathematics than students who apply only to language programs. The scores might, therefore, reflect both ability and study effort. Note that there is a positive weight for mathematics, Hungarian language and history for all programs in higher education. Students, therefore, have an incentive to score well on all three courses. Students who do not apply to higher education also have an incentive to perform well on the matriculation exams because matriculation exams are required by the employers in many positions. Finally, we also observe the location of the secondary school of students which is a proxy for the place of residence. Approximately 22% of students attended a high school in Budapest, the capital and economic center of Hungary.

### 3.3 APPLICANTS TO HIGHER EDUCATION

Table 3 compares the decision to apply to academic higher education before and after the policy reform. After the reform, less high school graduates applied to higher education. Women are more likely to apply to higher education than men but were more discouraged from applying by the reform. The fraction of women applying to higher education dropped from 61.8% to 54.8% (-7.0 %points), compared with a 4.6 %points decrease for men (a change from 54.4% to 49.8%). Students who are older than 19 when graduating from high school are less likely to apply to higher education. Both young and older students are less likely to apply after the reform.

*Table 3*

**Applying to higher education**

| | Men | | Women | |
|---|---|---|---|---|
| | 2011 | 2012 | 2011 | 2012 |
| Total | 54.4 | 49.8 | 61.8 | 54.8 |
| Student background | | | | |
| Age | | | | |
| ≤19 years | 56.3 | 51.8 | 64.2 | 57.0 |
| +19 years | 49.6 | 44.8 | 55.3 | 48.9 |
| Exam scores | | | | |
| Hungarian <50% | 28.9 | 24.3 | 27.1 | 22.0 |
| Hungarian ≥50% | 72.9 | 70.4 | 74.6 | 69.3 |
| Math <50% | 32.7 | 26.2 | 44.3 | 34.0 |
| Math ≥50% | 79.9 | 77.9 | 87.1 | 80.4 |
| History <50% | 24.0 | 21.7 | 27.3 | 25.4 |
| History ≥50% | 64.4 | 63.2 | 73.1 | 69.4 |
| Advanced exam | | | | |
| Hungarian language | 93.2 | 93.7 | 95.0 | 91.9 |
| Math | 97.2 | 97.0 | 97.4 | 96.2 |
| History | 94.8 | 92.4 | 96.2 | 94.6 |
| Residence | | | | |
| Budapest | 60.7 | 56.9 | 65.3 | 59.0 |
| Other region | 52.4 | 47.7 | 60.9 | 53.7 |

*Note:* Descriptive statistics are expressed as a percentage of the total number of male and female high school graduates before and after the reform.

The scores on the matriculation exams are an important factor of the decision to apply to higher education. Students who perform well, with scores above 50%, are more likely to apply for higher education. Students with low exam scores are more affected by the reform and less likely to apply to higher education. We observe a similar effect for the three courses. However, this effect differs between men and women. Men who perform well on their matriculation exams are almost not affected by the policy reform. Application decisions of men with high scores on mathematics or Hungarian language dropped by about 2 %points. However, women with high scores exhibit a larger decrease in the probability to apply to higher education of about 7 %points. We observe a similar pattern for the other two courses. Next, Table 3 shows that almost all students who choose for an advanced matriculation exam apply to higher education. However, these students are also affected by the reform as the fraction of students applying to higher education also decreases for these students. While there is almost no decrease in the probability to apply to higher education for men (except for the students who choose the advanced exam for history), women who choose the advanced exams were less likely to apply after the reform. Finally, we observe that students living in the area of Budapest are more likely to apply to higher education. Both students who live in Budapest and in the rest of Hungary are less likely to apply to higher education after the reform.

### 3.4 THE PREFERENCE RANKING OF STUDENTS

Table 4 studies the complete preference ranking and presents the first and the last option students apply to, and the total number of options students rank on their preference list.[13] We consider all high school graduates before and after the reform. We distinguish between STEM and non-STEM programs and state-funded and self-funded places. The numbers are expressed as a percentage of high school graduates. Tables A1 and A2 in Appendix provide more detailed information about the specific major students apply to. The first two panels of Table 4 consider the option that students ranked first on their application file. We immediately observe large differences between men and women. Before the reform, 25.2% of male high school graduates ranked a STEM program first, while this is only 7.1% for women. After the reform, a similar fraction of male high school graduates ranked a STEM program first, but a larger fraction of female high school graduates (8.2%) now prefers a STEM program.

Most students prefer a state-funded place, both before and after the reform. However, after the reform, a larger fraction of the students applied for a self-funded place. This effect is largest for programs in economics as shown in Table A1 in Appendix. This field of study was most affected by the reform. Proportionally more women apply for a self-funded place after the reform. This can be explained by the fact that the reform made applying for state funded non-STEM programs less attractive. In these programs, women are overrepresented. Note that ranking a self-funded program first is not a rational strategy for students if there are also state-funded places in the same program, which was less likely in non-STEM programs after the reform. Students can rank as many programs as they want, and they do not have to pay an additional contribution if they rank a self-funded program if they already ranked the same state-funded program. Shorrer and

[13] For students who apply to only 1 program in higher education, the last option on their preference list is the same option as the first ranked program.

Sovago (2018) study these mistakes in rankings in Hungary and find that the fraction of students making such mistakes has increased after the reform.

*Table 4*

**Application decisions in higher education: ranking**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| *Panel A: First ranked option (2011)* | | | | | | |
| STEM | 25.1 | 0.1 | 25.2 | 7.1 | 0.0 | 7.1 |
| Non-STEM | 27.6 | 1.6 | 29.2 | 52.8 | 1.9 | 54.7 |
| Total | 52.7 | 1.7 | 54.4 | 60.0 | 1.9 | 61.8 |
| *Panel B: First ranked option (2012)* | | | | | | |
| STEM | 24.8 | 0.4 | 25.2 | 8.1 | 0.1 | 8.2 |
| Non-STEM | 18.3 | 6.3 | 24.6 | 36.5 | 10.1 | 46.6 |
| Total | 43.1 | 6.7 | 49.8 | 44.6 | 10.2 | 54.8 |
| *Panel C: Last ranked option (2011)* | | | | | | |
| STEM | 23.9 | 2.8 | 26.8 | 8.6 | 0.7 | 9.2 |
| Non-STEM | 19.3 | 8.4 | 27.7 | 40.3 | 12.3 | 52.6 |
| Total | 43.2 | 11.2 | 54.4 | 48.9 | 13.0 | 61.8 |
| *Panel D: Last ranked option (2012)* | | | | | | |
| STEM | 19.1 | 7.2 | 26.2 | 7.7 | 2.0 | 9.7 |
| Non-STEM | 11.0 | 12.5 | 23.6 | 24.2 | 20.9 | 45.1 |
| Total | 30.1 | 19.7 | 49.8 | 31.9 | 22.9 | 54.8 |
| *Panel E: Total number of options (2011)* | | | | | | |
| STEM | 1.5 | 0.1 | 1.6 | 0.4 | 0.0 | 0.4 |
| Non-STEM | 1.6 | 0.4 | 2.0 | 2.8 | 0.5 | 3.3 |
| Total | 3.1 | 0.5 | 3.6 | 3.2 | 0.5 | 3.6 |
| *Panel F: Total number of options (2012)* | | | | | | |
| STEM | 1.6 | 0.4 | 2.0 | 0.5 | 0.1 | 0.6 |
| Non-STEM | 1.1 | 0.8 | 1.9 | 2.1 | 1.2 | 3.3 |
| Total | 2.7 | 1.2 | 3.9 | 2.6 | 1.3 | 3.9 |

*Note:* The fraction of students applying to each option in panel A-D is expressed as a percentage of high school graduates of respectively 2011 and 2012. The total number of options students rank on their preference list in panel E and F is the average of all high school graduates who apply to higher education in 2001 and 2012.

The following two panels of Table 4 look at the last option ranked on the application list of students. We observe similar patterns as for the first ranked option when we look at the major decision. However, we observe that more students rank a self-funded place as their last option, especially after the reform. 11.2% of men and 13.0% of women ranked a self-funded program on the last place before the reform. This fraction increases to respectively 19.7% and 22.9% for men and women after the reform. In these self-funded places, students have a higher probability of being admitted. Varga (2006) shows that students are more sensitive to their expected admission probabilities for their last ranked option than for their most preferred option. Tables A1 and A2 in Appendix show that after the reform, more students applied to a self-funded program in economics than a similar state-funded option. This can be explained by the fact that after the reform the government reduced the number of state funded places to almost 0 in economics.

The final 2 panels of Table 4 illustrate how the reform affected the total number of study options, the number of self-funded options, and the number of STEM programs for which students apply. We consider only students who applied for at least one study option. Before the reform, students applied on average for 3.6 programs. After the reform, applicants ranked on average 3.9 options. This pattern is similar for men and women. Students could have decided to apply to more options in order to increase their probability of being admitted in the more selective post reform period. Alternatively, the reform could have discouraged applications from students who would otherwise have ranked few options and have now decided not to apply to higher education. We also observe that the reform affected the decision to apply to STEM and self-funded options which were less affected by the policy reform. Before the reform, applicants ranked on average 0.5 self-funded places. This number increased to 1.2 for men and 1.3 for women after the reform. Men rank more STEM programs than women before and after the reform. The increase in STEM options after the reform is larger for men.

## 4. EVALUATION OF THE REFORM

The descriptive statistics in the previous section already provide some first evidence about the potential effects of the reform on application decisions in higher education. In this section, we evaluate how the reform differently affected the decision to apply to higher education, the choice between STEM and non-STEM programs, and the choice between state-funded and self-funded programs of men and women after controlling for student background. To investigate the impact of the reform, we estimate the following regression equation:

$$Y_i = \alpha + \beta female_i + \gamma 2012 + \delta female_i * 2012 + \theta X_i + \varepsilon_i.$$

The coefficient of interest $\delta$ identifies how women responded differently to the reform than men. In all specifications, we control for matriculation exam scores. We also control for the level of the matriculation exams by including a dummy equal to one if a student took an advanced exam. We additionally control for age, socio-economic background of the students, and region fixed effects.[14] We estimate the probability of applying to higher education and the probability of choosing for STEM or self-funded places by logit, and we report marginal effects. We estimate the number of options students rank by OLS. Table 5 shows only the coefficients for gender, the period after the reform, and the interaction between both variables. Tables A3-A5 in Appendix show the full regression output.

*Table 5*

**Evaluation of the reform**

| | Apply | | Total options | |
|---|---|---|---|---|
| | Coef. | St. error | Coef. | St. error |
| Female | 0.080* | (0.004) | 0.096* | (0.014) |
| 2012 | -0.047* | (0.004) | 0.272* | (0.015) |
| Female*2012 | -0.049* | (0.006) | -0.111* | (0.020) |

| | STEM ranked first | | STEM ranked last | | At least one STEM | | Total STEM | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | St. error | Coef. | St. error | Coef. | St. error | Coef. | St. error |
| Female | -0.299* | (0.005) | -0.305* | (0.005) | -0.339* | (0.005) | -0.912* | (0.013) |
| 2012 | 0.018* | (0.004) | 0.016* | (0.004) | 0.014* | (0.005) | 0.302* | (0.017) |
| Female*2012 | -0.005 | (0.006) | -0.005 | (0.006) | 0.004 | (0.007) | -0.239* | (0.020) |
| | **Self ranked first** | | **Self ranked last** | | **At least one Self** | | **Total Self** | |
| | Coef. | St. error | Coef. | St. error | Coef. | St. error | Coef. | St. error |
| Female | 0.003 | (0.003) | 0.012* | (0.005) | 0.022* | (0.005) | 0.049 | (0.010) |
| 2012 | 0.105* | (0.003) | 0.200* | (0.005) | 0.245* | (0.005) | 0.660* | (0.013) |
| Female*2012 | 0.026* | (0.004) | 0.017* | (0.006) | 0.028* | (0.007) | 0.114* | (0.017) |

*Note:* Robust standard errors in parentheses; * p<0.05. The decision to apply for higher education and to rank a STEM or self-funded program is estimated by a logit regression. Results are reported as marginal effects. The regressions for the total number of options that students rank are estimated by OLS. The decision to apply to higher education is estimated on the sample of all high school graduates of 2011 and 2012 (158513 observations), while the other regressions are limited to the sample of high school graduates who rank at least one option (87939 observations). All regressions control for age, matriculation exam scores, and region fixed effects. The regressions that are estimated on the sample of applicants additionally control for socio-economic background. The complete output of the regressions is presented in Tables A3-A5 in Appendix.

The first panel of Table 5 shows how the reform affected the decision to apply to higher education and the number of study programs students rank on their preference list. Before the reform, women were 8.0 %points more likely to apply to higher education than men. This finding confirms the higher application rates of women shown in Table 3. Next, we observe that the reform discouraged the decision to apply to higher education. After the reform, students are significantly less likely to apply to higher education. The interaction

[14] We observe socio-economic status only for the sample of applicants and not for the students who did not apply to higher education. Socio-economic status is measured by a dummy variable equal to one if the per capita household income is lower than 130% of the minimum pension.

effect between gender and the dummy for the period after the reform reveals that the reform mostly affected the application decisions of female students. The probability to apply to higher education decreased by 4.7 %points for men, but by 9.6 %points for women. This can be explained by the fact that the reform discouraged enrollment in non-STEM programs that are typically preferred by women as shown in Table 4. The second regression of Table 5 shows how the reform affected the total number of study options students rank on the preference ranking. Before the reform, women applied to 0.10 more study options than men. After the reform, both men and women applied to more options. However, the increase is larger for men (+0.27) than for women (+0.16), and male applicants now apply to more options than women.

The second panel of Table 5 assesses whether the reform affected the decision to apply to STEM programs. After the reform, there were less state-funded places in non-STEM programs. Students could therefore apply more to STEM programs in order to increase their chances to be admitted to higher education. We consider only the students who applied to at least one study program. The first two specifications estimate the probability of ranking a STEM program on the first and last place on the preference ranking. Before the reform, women are 29.9 %points less likely than men to rank a STEM program as their most preferred option. After the reform, both men and women are more likely to rank a STEM program (+1.8 %points). We do not find a significantly different effect of the reform between men and women. We obtain similar results when we consider the last option on the preference ranking in the second regression. The third column shows that before the reform women were 33.9 %points less likely than men to rank at least one STEM program. The reform increased the fraction of male and female applicants applying to at least one STEM program by 1.4 %points. The last column shows that female applicants ranked on average 0.91 STEM options less than men before the reform. After the reform, male applicants ranked on average 0.33 STEM options more than before the reform. The number of STEM options ranked by female applicants increased by a smaller amount of 0.06.

The last panel of Table 7 investigates whether students were more likely to apply for self-funded places after the reform. When accepted to a self-funded place, students must pay a tuition fee. Before the reform, men and women were equally likely to rank a self-funded option on the first place of their preference list. After the reform, the probability of ranking a self-funded program first increases by 10.5 %points for men, and by 13.1 %points for women. The second regression estimates the probability of ranking a self-funded program on the last position on the preference list. The increase in the probability of ranking a self-funded program is larger for men and women than for the previous outcome. The last two columns show that after the reform more men and women rank at least one self-funded program and they also rank more self-funded options than before the reform.

Tables A3-A5 in Appendix show the impact of the other control variables on application decisions. We find that matriculation exam scores significantly affect application decisions. Students who scored better on the exams or students who choose for an advanced exam are more likely to apply, rank more state-funded programs, but they are less likely to rank a self-funded program. Students who perform well on mathematics are more likely to apply to STEM programs. Finally, we find that disadvantaged students apply to less programs and are less likely to apply to self-funded programs.

## 5. STRUCTURAL MODEL OF APPLYING TO HIGHER EDUCATION

By decreasing the number of state-funded places in non-STEM programs, students had a lower probability of being admitted to these programs. To uncover the behavioral mechanisms that lead to the realized outcomes we found in the previous section, we estimate a structural model of program and institution choice, and we investigate whether students consider the probability of being admitted when applying. We assess whether this effect differs between men and women. We estimate the model on a cohort before the policy change and externally validate the model on the cohort that was affected by the reform.

### 5.1 DESCRIPTION OF THE MODEL

During the last year of secondary education, students can choose to apply for higher education in Hungary or not. A student $i$ applies to a study program $j \in J$ at an institution $k \in K$ to maximize the utility of studying. The utility of applying to a specific study option is given by

$$\begin{aligned} U_{ijk}\left(X_i,\lambda_{ijk},d_{ik}\right) &= \alpha_0^j + \alpha_1^j X_i + \alpha_2\lambda_{ijk} + \alpha_3\lambda_{ijk}X_i + \alpha_4 d_{ik} + \alpha_5 d_{ik}X_i + \varepsilon_{ijk} \\ &= V_{ijk}\left(X_i,\lambda_{ijk},d_{ik}\right) + \varepsilon_{ijk}, \end{aligned}$$

with $V_{ijk}(X_i, \lambda_{ijk}, d_{ik})$ the deterministic part of utility. Utilthe ity depends on an alternative specific constant $\alpha_0^j$, and personal characteristics such as gender and high school background $X_i$. Utility also depends on the admission probability $\lambda_{ijk}$. Students obtain a higher utility from programs for which they have a higher probability of being admitted.[15] We interact this probability with gender to assess whether women are more responsive to admission probabilities when making their application decisions. Admission probabilities differ between programs but also between institutions. Given that students have to pay a fee for each study program they rank after their third option, students might strategically apply to a less popular institution for which they have higher admission probabilities. Previous literature shows that travel distance is an important factor of participation in higher education and the decisions where and what to study. Students have a preference for study options located in their neighborhood.[16] We therefore include the travel distance $d_{ik}$ between the location of the high school of the student and the institution as a determinant of utility.[17] Finally, utility depends on an unobserved preference shock $\varepsilon_{ijk}$, which is iid type 1 extreme value distributed. The probability that student $i$ chooses for study program $j$ at institution $k$ is then given by the logit formula

$$P_{ijk} = \frac{\exp V_{ijk}(X_i, \lambda_{ijk}, d_{ik})}{\sum_{j' \in J, k' \in K} exp(V_{ij'k'}(X_i, \lambda_{ij'k'}, d_{ik'}))}.$$

In the model, students take into account the probability of being admitted when applying to higher education. The probability that student $i$ is admitted to study program $j$ at institution $k$ is given by

$$\lambda_{ijk}\left(M_i, cap_{jk}\right) = \beta_0^j + \beta_1^j M_i + \beta_2 cap_{jk} + \eta_{ijk},$$

and depends on a program alternative specific constant $\beta_0^j$, a vector of matriculation exam scores $M_i$, and a measure of the capacity of program $j$ at institution $k$: $cap_{jk}$.[18] Capacity of

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[15] Varga (2006) shows that students take into account the expected admission probabilities when applying to study programs in higher education in Hungary.

[16] See for example Frenette (2010) and Kelchtermans and Verboven (2010). This last study shows that travel distance has a small effect on the participation decision, but a strong impact on the decision where and what to study.

[17] As we do not observe the location of residence of the student, we use the location of the high school attended by the student as a proxy for the place of residence of the student.

[18] In the estimation of the probability of admission and the utility equation, we do not distinguish between matriculation exams of the normal and the advanced level. Only a small fraction of high school graduates chooses for an advanced exam (see Table 2). Students choosing for an advanced exam in mathematics almost never rank a non-STEM program first. Therefore, it is not possible to

the program is defined as the ratio of admitted students relative to the total applicants in the study option. The capacity of the program serves as an exclusion restriction. Capacity influences the utility of applying to an option only indirectly through the effect on the admission probability. We assume that there is no direct effect of capacity on the utility of applying to specific options. Finally, the admission probability depends on an iid type 1 extreme value distributed error term $\eta_{ijk}$.

We model the choice of all high school graduates in the year before the reform (2011). In the estimation of the model, we consider only the first option on the ranking of students. In 2011, high school graduates choose between 600 study options in academic higher education. They can choose not to apply to higher education or they can apply for a specific program at a specific institution. Finally, they decide between a state-funded or a self-funded place. Estimation of the model proceeds in two steps. We first estimate the probability of acceptance to the first option of the preference list with a binary logit regression. Next, we estimate the probability of choosing for option $j$ at institution $k$ with a conditional logit model. Given the size of our dataset, where 80577 students choose between 600 options, it is not computationally feasible to estimate the model with the full dataset. We therefore use a random subsample of 50 percent of the students.

## 5.2 EMPIRICAL RESULTS

In Table 8, we estimate a binary logit regression for the probability of being admitted to the program ranked first on the preference list. We include interaction effects between matriculation exam scores with the dummies for the specific majors. We find that math, Hungarian language, and history scores significantly affect the probability of being admitted. This effect differs between programs. Performing well on mathematics is most important for science and engineering programs while performing well on the Hungarian language is most important for teaching, law and social science programs. Students have a higher probability of being admitted to a self-funded place. Test scores are less important for being admitted to a self-funded place. Finally, it is easier to be admitted to a less popular program (capacity indicator).

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include dummies for the level of the exam when we estimate the probability of admission or the utility of applying to specific majors.

Table 9 shows the output of the conditional logit model for applying to the first option on the preference list. We obtain the following main findings that are consistent with the regression results in the previous section. Gender significantly affects the application to the several majors in higher education. Men obtain a lower utility than women in applying for non-STEM programs. Students who are older than 19 years when graduating from high school are less likely to apply to higher education. The scores of the matriculation exams significantly affect the decision to apply for programs in higher education. Scores on the mathematics exam are most important for applying to engineering, economics and science programs. Performing well in the Hungarian language has the strongest effect on applying to law and social science programs. Regarding the choice between state-funded or self-funded programs, we find that students prefer to apply to state-funded places in which they do not have to pay tuition fees. Men, older students, and students living in Budapest are more likely to apply to a self-funded place. Students who perform well on the matriculation exams are less likely to apply for self-funded places.

*Table 8*

**Being admitted to the first ranked program**

| | ECON | ENG | TEACH | HEALTH | SCI | AGRI |
|---|---|---|---|---|---|---|
| Constant | -11.331* | -8.456* | -10.524* | -8.333* | -8.590* | -8.641* |
| | (0.333) | (0.228) | (0.566) | (0.378) | (0.493) | (0.494) |
| Mathematics | 3.638* | 5.722* | 0.912 | 1.383* | 4.835* | 3.518* |
| | (0.261) | (0.223) | (0.475) | (0.299) | (0.459) | (0.436) |
| Hungarian | 3.509* | 2.017* | 6.938* | 5.027* | 1.461* | 3.841* |
| language | (0.380) | (0.266) | (0.715) | (0.547) | (0.617) | (0.640) |
| History | 4.651* | 1.724* | 4.769* | 1.707* | 4.073* | 2.313* |
| | (0.425) | (0.300) | (0.680) | (0.531) | (0.681) | (0.719) |
| | **LAW** | **ARTS** | **SSCI** | | **State** | **Self** |
| Constant | -16.306* | -6.701* | -12.700* | | - | 4.874* |
| | (0.661) | (0.433) | (0.392) | | | (0.419) |
| Mathematics | 3.327* | 1.585* | 1.978* | | - | -1.902* |
| | (0.409) | (0.461) | (0.248) | | | (0.600) |
| Hungarian | 7.616* | 1.506* | 6.250* | | - | -2.896* |
| language | (0.665) | (0.611) | (0.421) | | | (0.614) |
| History | 6.978* | 2.869* | 4.476* | | - | -0.413 |
| | (0.694) | (0.689) | (0.433) | | | (0.679) |
| #admit/#applic | 8.424* | | | | | |
| | (0.311) | | | | | |

Note Standard errors in parentheses; * $p<0.05$. The probability of being admitted to the first ranked option is estimated with a binary logit regression. The regression is estimated on the sample of all high school graduates that apply to higher education in 2011.

Next, we find that students take into account admission probabilities when making their application decisions. Students are more likely to apply to programs in which they have a higher probability of being admitted. This effect is stronger for women. This finding is consistent with Gneezy et al. (2003), and Reuben et al. (2015) who found that women are more risk-averse when choosing their field of study. Students dislike travel distance. We do not find that this effect differs between men and women. Finally, we show that students living in the area of Budapest obtain lower utility from applying to state-funded programs in higher education. Students living in Budapest are more likely to apply to self-funded programs.

## 5.3 MODEL VALIDATION

Before simulating the impact of alternative policies, we assess how well the model performs in predicting actual application decisions of students. We perform both an in-sample and out-of-sample validation. The first two panels of Table 10 present the within-sample validation of the model for respectively men and women. We distinguish between STEM and non-STEM programs and state-funded and self-funded programs. The model performs very well in predicting the application decisions of both men and women. The following two panels show the results of the out-of-sample validation. The external validation assesses whether the model can predict choices of students under a different policy environment caused by the reform. We, therefore, use the parameter estimates of Table 9 to predict the study decisions of the high school graduates in the year after the reform. To compute the utility of each study option, we estimate the probability of being admitted to each option with a similar logit regression as in Table 8, but now on the cohort that was affected by the reform. The output of this logit regression is like the regression for 2011 and is shown in Table A6 in Appendix.

*Table 9*

**Application decisions of first ranked option**

| | ECON | ENG | TEACH | HEALTH | SCI | AGRI |
|---|---|---|---|---|---|---|
| Constant | -7.442* | -8.591* | -5.124* | -8.329* | -7.925* | -7.220* |
| | (0.085) | (0.099) | (0.129) | (0.141) | (0.173) | (0.148) |
| Male | -0.719* | 1.593* | -2.707* | -1.185* | 0.227* | 0.149* |
| | (0.043) | (0.058) | (0.140) | (0.068) | (0.084) | (0.072) |
| +19 years | 0.076 | -0.209* | -0.101 | -0.356* | -0.482* | -0.083 |
| | (0.041) | (0.045) | (0.073) | (0.065) | (0.085) | (0.074) |
| Mathematics | 4.123* | 5.413* | 0.503* | 3.270* | 3.545* | 2.267* |
| | (0.111) | (0.126) | (0.199) | (0.152) | (0.192) | (0.186) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Hungarian language | 2.181* | 1.224* | 1.444* | 2.921* | 1.330* | 1.338* |
| | (0.137) | (0.139) | (0.241) | (0.215) | (0.246) | (0.238) |
| History | 1.718* | 0.570* | 0.913* | 2.663* | 2.120* | 2.028* |
| | (0.150) | (0.154) | (0.256) | (0.229) | (0.281) | (0.263) |
| Budapest | -0.805* | -1.080* | -0.689* | -0.613* | -0.841* | -1.152* |
| | (0.044) | (0.047) | (0.081) | (0.067) | (0.084) | (0.082) |
| Self | -0.838* | -3.074* | -2.881* | -2.007* | -4.026* | -2.370* |
| | (0.172) | (0.257) | (0.300) | (0.303) | (1.013) | (0.281) |

| | LAW | ARTS | SSCI | Self | Prob admit | Distance |
|---|---|---|---|---|---|---|
| Constant | -7.283* | -6.426* | -7.551* | - | 1.756* | -0.015* |
| | (0.125) | (0.108) | (0.092) | | (0.065) | (0.000) |
| Male | 0.057 | -0.121* | -0.853* | 0.519* | -0.673* | 0.000 |
| | (0.055) | (0.056) | (0.046) | (0.098) | (0.085) | (0.000) |
| +19 years | -0.084 | -0.121* | 0.077* | 0.179* | - | - |
| | (0.058) | (0.057) | (0.043) | (0.085) | | |
| Mathematics | 1.000* | 1.055* | 0.453* | -1.708* | - | - |
| | (0.146) | (0.151) | (0.148) | (0.239) | | |
| Hungarian language | 5.053* | 2.229* | 4.553* | -2.967* | - | - |
| | (0.200) | (0.182) | (0.148) | (0.276) | | |
| History | 1.371* | 1.408* | 1.922* | -1.456* | - | - |
| | (0.208) | (0.197) | (0.156) | (0.301) | | |
| Budapest | -1.279* | -0.304* | -0.572* | 0.968* | - | - |
| | (0.062) | (0.056) | (0.046) | (0.082) | | |
| Self | -0.148 | -2.530* | -1.277* | - | | |
| | (0.185) | (0.222) | (0.182) | | | |

*Note* Standard errors in parentheses; * $p<0.05$. The probability of ranking an option first is estimated with a conditional logit model. The model is estimated on the sample of all high school graduates of 2011. Results have to be interpreted relative to the base category of not applying to higher education.

We observe that the model performs reasonably well in the out-of-sample predictions of the total number of students applying to the several majors. For example, while the observed fraction of male high school graduates applying to higher education decreased from 54.4% to 49.8% after the reform, our model predicts a similar decrease from 54.2% to 50.2%. The model slightly under predicts the negative effect on the total participation of women. While the observed fraction of women applying to higher education decreased from 61.8% to 54.8% after the reform, our model predicts a slightly lower decrease from 61.9% to 56.6%. While our model performs well in predicting the choice between the several majors (which is further illustrated in Tables A7 and A8 in Appendix), our model is not able to explain the observed increase in the number of students applying to self-funded programs. A possible explanation for this limitation of our model is that after the reform, more students prefer a self-funded program although there also some state-funded places available in the same program. Given that there is no cost of applying to a state-funded place if a student has already ranked a self-funded place in the same program, it is not rational for students to not rank a state-funded option before a self-funded option in the same program. Shorrer and Sovago (2018) show that the fraction of students making these mistakes has increased after the reform.

*Table 10*

**Model validation**

| | Observed choices | | | Predicted choices | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| *Panel A: In sample validation: men (2011)* | | | | | | |
| STEM | 25.1 | 0.1 | 25.2 | 25.1 | 0.1 | 25.2 |
| Non-STEM | 27.6 | 1.6 | 29.2 | 27.6 | 1.5 | 29.0 |
| Total | 52.7 | 1.7 | 54.4 | 52.6 | 1.6 | 54.2 |
| *Panel B: In sample validation: women (2011)* | | | | | | |
| STEM | 7.1 | 0.0 | 7.1 | 7.0 | 0.1 | 7.1 |
| Non-STEM | 52.8 | 1.9 | 54.7 | 53.0 | 1.8 | 54.8 |
| Total | 60.0 | 1.9 | 61.8 | 60.0 | 1.8 | 61.9 |
| *Panel C: Out-of-sample validation: men (2012)* | | | | | | |
| STEM | 24.8 | 0.4 | 25.2 | 28.8 | 0.1 | 28.9 |
| Non-STEM | 18.3 | 6.3 | 24.6 | 20.1 | 1.5 | 21.7 |
| Total | 43.1 | 6.7 | 49.8 | 48.9 | 1.6 | 50.5 |
| *Panel D: Out-of-sample validation: women (2012)* | | | | | | |
| STEM | 8.1 | 0.1 | 8.2 | 10.3 | 0.0 | 10.3 |
| Non-STEM | 36.5 | 10.1 | 46.6 | 44.3 | 2.0 | 46.3 |
| Total | 44.6 | 10.2 | 54.8 | 54.6 | 2.0 | 56.6 |

*Note:* Observed and predicted outcomes are expressed as percentages of high school graduates of respectively 2011 and 2012.

## 6. COUNTERFACTUAL ANALYSIS

We use the model to simulate the impact of alternative policies to further investigate how admission policies differently affect application decisions of men and women. The policy that was implemented in Hungary in 2012 aimed at increasing the share of students in STEM programs. The government, therefore, reduced the number of state-funded places in non-STEM programs and expected students to switch to STEM programs. This policy decreased the probability of being admitted to non-STEM programs and therefore made applying to these non-STEM programs less attractive. Instead of discouraging students to apply to non-STEM programs, alternative policies could also encourage enrollment in STEM programs by making applying to STEM programs more attractive without decreasing the utility of applying to other programs.

We use the model to simulate such a policy that increases the utility of applying to STEM programs by setting the probability of admission to these programs to one for all students. This policy corresponds to an open access policy in which all high school graduates, irrespective of high school background, can start at all STEM options. This policy might maybe not be preferred from a cost minimizing government because higher education systems without admission standards lead to unsuccessful drop out and reorientation to other programs during higher education (Declercq and Verboven, 2018). However, the policy simulations will us give further insights into how admission policies affect application decisions.

*Table 11*

**Counterfactual analysis: the impact of open access to STEM programs**

| | Status quo | | | Counterfactual policy | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| *Panel A: First ranked option (men)* | | | | | | |
| STEM | 25.1 | 0.1 | 25.2 | +10.1 | 0.0 | +10.0 |
| Non-STEM | 27.6 | 1.5 | 29.0 | -4.0 | -0.2 | -4.1 |
| Total | 52.6 | 1.6 | 54.2 | +6.2 | -0.2 | +6.0 |
| *Panel B: First ranked option (women)* | | | | | | |
| STEM | 7.0 | 0.1 | 7.1 | +6.9 | -0.1 | +6.8 |
| Non-STEM | 53.0 | 1.8 | 54.8 | -3.9 | -0.1 | -4.0 |
| Total | 60.0 | 1.8 | 61.9 | +3.0 | -0.1 | +2.7 |

*Note:* Predicted outcomes are expressed as percentages of 2011 high school graduates. Outcomes of the counterfactual policy are expressed as percentage point changes relative to the status quo.

Table 11 shows the results of the counterfactual analysis for men and women. We again distinguish between applications for STEM and non-STEM programs and state-funded and self-funded places. Table A9 in Appendix shows the results for the specific majors. Under the counterfactual scenario of an open access policy in state-funded STEM programs, more men and women would apply to higher education, but there is also substitution from non-STEM to STEM programs. The fraction of high school graduates applying to higher education would increase by respectively 6.0 %points for men, and by a smaller amount of 2.7 %points for women. More men and women would apply to STEM programs (+10.0 %points for men, and +6.8 %points for women). While the relative increase in applications for STEM programs is larger for women, the increase in the total number of students applying for STEM programs is larger for men. This counterfactual policy will, therefore, further increase the gender gap in STEM programs.

## 7. CONCLUSION

We have studied how admission policies differently affect the enrollment decisions of men and women, and how admission policies can increase enrollment of women in STEM programs. We evaluated how a policy reform that decreased the number of admitted students in state-funded non-STEM programs affected application decisions in higher education in Hungary. After the reform, fewer students applied to higher education. The impact was larger for women because the reform mainly reduced the number of state-funded places in study fields that are preferred by women. Both men and women were more likely to apply to a STEM program and more students applied to a self-funded program after the reform. The latter effect is larger for women.

To uncover the behavioral mechanisms that lead to the realized outcomes, we estimated a structural model of program and institution choice in higher education. We assessed how responsive students are to the odds of being admitted to a program when making their application decisions. We estimated the model on a cohort before the policy change and found that women were more sensitive to admission probabilities when making their application decisions. We externally validated the model on the cohort that was affected by the reform. Finally, we used the model to simulate how an alternative policy that stimulates enrollment in STEM programs would affect application decisions of men and women. We simulated how an open access policy in STEM programs would affect application decisions. We found that more students would apply to higher education and more students would apply to a STEM program. These effects are smaller for women and an open access policy in STEM programs would further increase the gender gap.

Our findings have several implications for policy. First, governments can use admission policies to influence the decision to apply to higher education. We showed that when it becomes harder to be admitted to higher education, fewer students apply to higher education. If the aim of the government is to increase enrollment in higher education, increasing the number of places will lead to a higher number of applicants. Second, we find that increasing the selectivity in particular fields of study implied substitution to other programs that were not affected by the reform. This implies that students perceive the different study programs as substitutes. Governments can, therefore, increase enrollment in STEM programs by increasing the number of places in these programs or decreasing the number of places in other fields of study. Finally, we also find that many students apply to self-funded programs after the reform. This shows that many students are willing to pay the contribution. This effect is most outspoken for programs in economics. Although the number of students admitted to state-funded places in economics almost decreased to zero, the total number of students admitted to programs in economics was not affected by the reform.

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## APPENDIX: ADDITIONAL FIGURES AND TABLES

*Figure A1*

**Distribution of matriculation exam scores**

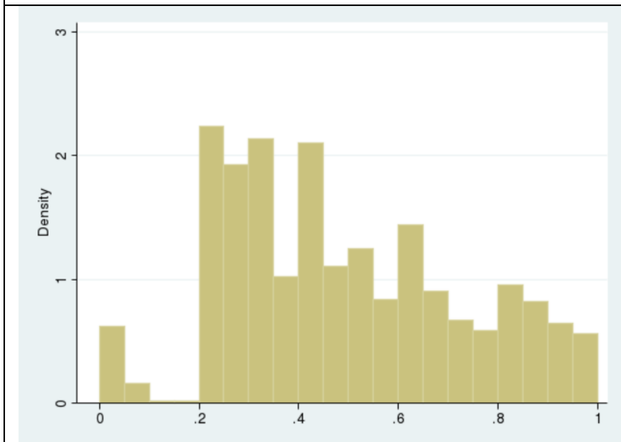
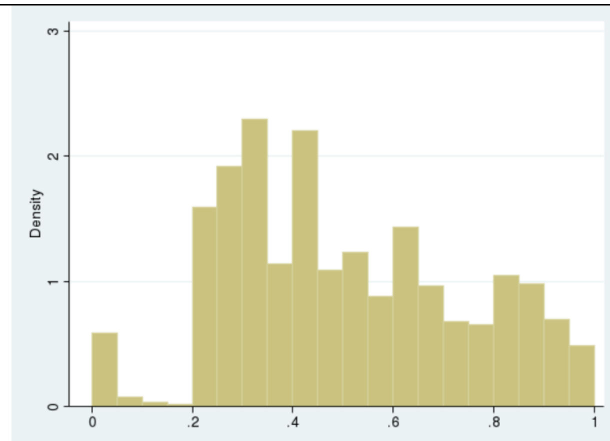
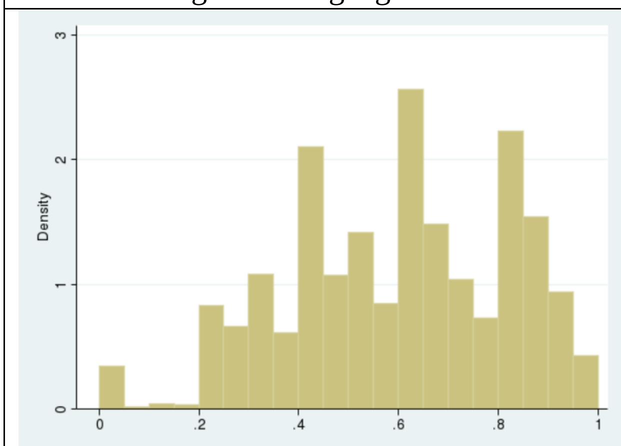
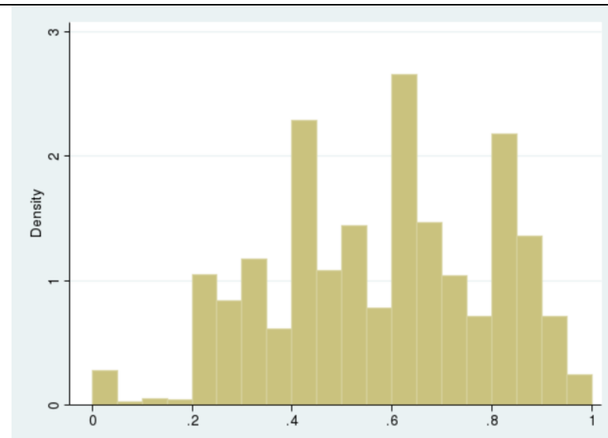
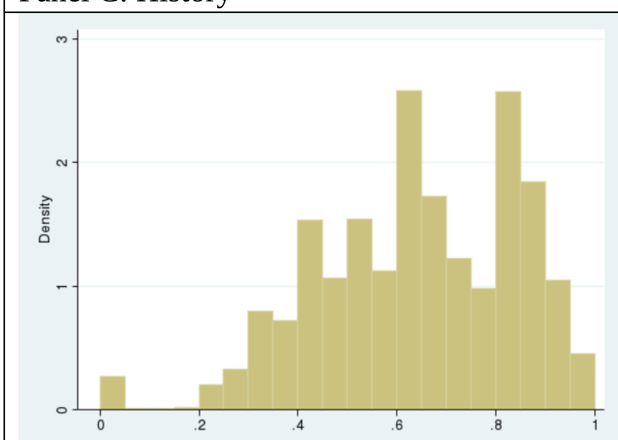
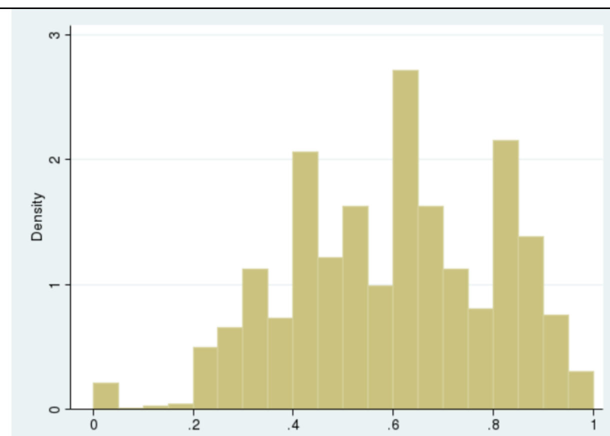
| 2011 | 2012 |
|---|---|
| Panel A: Mathematics | |
|   |   |
| Panel B: Hungarian Language | |
|   |   |
| Panel C: History | |
|   |   |

*Table A1*

**Application decisions in higher education (first ranked option)**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| *Panel A: 2011* | | | | | | |
| SSCI | 5.2 | 0.3 | 5.5 | 14.1 | 0.5 | 14.6 |
| ECON | 8.5 | 0.7 | 9.2 | 14.5 | 0.7 | 15.2 |
| ENG | 22.3 | 0.1 | 22.4 | 4.6 | 0.0 | 4.6 |
| TEACHING | 0.3 | 0.0 | 0.3 | 4.9 | 0.1 | 4.9 |
| HEALTH | 2.2 | 0.0 | 2.2 | 7.3 | 0.0 | 7.3 |
| SCI | 2.9 | 0.0 | 2.9 | 2.5 | 0.0 | 2.6 |
| AGRI | 2.9 | 0.1 | 3.0 | 2.6 | 0.0 | 2.6 |
| LAW | 4.4 | 0.5 | 4.9 | 4.9 | 0.4 | 5.3 |
| ARTS | 4.2 | 0.1 | 4.2 | 4.6 | 0.1 | 4.7 |
| TOTAL | 52.7 | 1.7 | 54.4 | 60.0 | 1.9 | 61.8 |
| *Panel B: 2012* | | | | | | |
| SSCI | 4.3 | 0.7 | 5.0 | 12.0 | 1.5 | 13.5 |
| ECON | 2.0 | 4.2 | 6.2 | 2.6 | 6.7 | 9.3 |
| ENG | 22.0 | 0.4 | 22.4 | 5.5 | 0.1 | 5.6 |
| TEACHING | 0.2 | 0.0 | 0.2 | 5.0 | 0.2 | 5.1 |
| HEALTH | 2.4 | 0.0 | 2.4 | 7.4 | 0.1 | 7.5 |
| SCI | 2.8 | 0.0 | 2.9 | 2.6 | 0.0 | 2.6 |
| AGRI | 2.8 | 0.1 | 3.0 | 2.9 | 0.1 | 3.0 |
| LAW | 3.4 | 0.9 | 4.3 | 3.2 | 1.2 | 4.4 |
| ARTS | 3.1 | 0.4 | 3.5 | 3.4 | 0.4 | 3.8 |
| TOTAL | 43.1 | 6.7 | 49.8 | 44.6 | 10.2 | 54.8 |

*Note:* The fraction of students applying to each option is expressed as a percentage of high school graduates of respectively 2011 and 2012.

*Table A2*

**Number of students applying in higher education (last ranked option)**

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| *Panel A: 2011* | | | | | | |
| SSCI | 4.4 | 1.8 | 6.2 | 12.6 | 3.9 | 16.6 |
| ECON | 5.6 | 3.4 | 9.0 | 10.6 | 4.5 | 15.1 |
| ENG | 20.1 | 2.6 | 22.6 | 4.6 | 0.4 | 5.0 |
| TEACHING | 0.4 | 0.1 | 0.5 | 4.3 | 0.8 | 5.0 |
| HEALTH | 1.3 | 0.2 | 1.4 | 5.3 | 0.5 | 5.8 |
| SCI | 3.9 | 0.3 | 4.2 | 4.0 | 0.3 | 4.2 |
| AGRI | 2.5 | 0.8 | 3.3 | 2.2 | 0.5 | 2.6 |
| LAW | 2.2 | 1.2 | 3.4 | 2.1 | 1.4 | 3.5 |
| ARTS | 2.9 | 0.9 | 3.8 | 3.3 | 0.8 | 4.1 |
| TOTAL | 43.2 | 11.2 | 54.4 | 48.9 | 13.0 | 61.8 |
| *Panel B: 2012* | | | | | | |
| SSCI | 3.3 | 3.0 | 6.2 | 8.5 | 6.6 | 15.2 |
| ECON | 0.6 | 5.5 | 6.1 | 0.9 | 8.4 | 9.4 |
| ENG | 15.8 | 6.4 | 22.1 | 4.4 | 1.3 | 5.7 |
| TEACHING | 0.2 | 0.1 | 0.3 | 3.9 | 1.4 | 5.3 |
| HEALTH | 1.3 | 0.4 | 1.6 | 5.3 | 1.0 | 6.3 |
| SCI | 3.3 | 0.8 | 4.1 | 3.3 | 0.7 | 4.0 |
| AGRI | 2.0 | 1.2 | 3.3 | 2.0 | 0.9 | 2.9 |
| LAW | 1.8 | 1.1 | 2.9 | 1.5 | 1.4 | 3.0 |
| ARTS | 1.9 | 1.3 | 3.2 | 2.1 | 1.1 | 3.1 |
| TOTAL | 30.1 | 19.7 | 49.8 | 31.9 | 22.9 | 54.8 |

*Note:* The fraction of students applying to each option is expressed as a percentage of high school graduates of respectively 2011 and 2012.

*Table A3*

**Evaluation of the reform (applicants and the number of ranked study options)**

| | Apply | | Total options | |
|---|---|---|---|---|
| | Coef. | St. error | Coef. | St. error |
| Female | 0.080* | (0.004) | 0.096* | (0.014) |
| 2012 | -0.047* | (0.004) | 0.272* | (0.015) |
| Female*2012 | -0.049* | (0.006) | -0.111* | (0.020) |
| +19 years | -0.009* | (0.003) | 0.071* | (0.012) |
| Disadvantaged | - | - | -0.227* | (0.016) |
| Matriculation exam scores | | | | |
| Math | 0.798* | (0.009) | 0.364* | (0.027) |
| Hungarian | 0.541* | (0.011) | 0.108* | (0.040) |
| History | 0.457* | (0.012) | 0.657* | (0.041) |
| Advanced exam | | | | |
| Math | 0.328* | (0.007) | 0.186* | (0.021) |
| Hungarian | 0.317* | (0.007) | 0.379* | (0.033) |
| History | 0.336* | (0.004) | 0.763* | (0.015) |

*Note:* Robust standard errors in parentheses; * p<0.05. The decision to apply for higher education is estimated by a logit regression on the sample of all high school graduates of 2011 and 2012 (158513 observations). Results are reported as marginal effects. The second regression is estimated by OLS on the sample of applicants to higher education (87939 observations). Both regressions include region fixed effects.

*Table A4*

**Evaluation of the reform (ranking a STEM program)**

| | STEM ranked first | | STEM ranked last | | At least 1 STEM | | Total STEM | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | St. error | Coef. | St. error | Coef. | St. error | Coef. | St. error |
| Female | -0.299* | (0.005) | -0.305* | (0.005) | -0.339* | (0.005) | -0.912* | (0.013) |
| 2012 | 0.018* | (0.004) | 0.016* | (0.004) | 0.014* | (0.005) | 0.302* | (0.017) |
| Female*2012 | -0.005 | (0.006) | -0.005 | (0.006) | 0.004 | (0.007) | -0.239* | (0.020) |
| +19 years | -0.030* | (0.003) | -0.039* | (0.004) | -0.046* | (0.004) | -0.102* | (0.011) |
| Disadvantaged | 0.000 | (0.005) | 0.017* | (0.006) | 0.026* | (0.007) | -0.043* | (0.015) |
| Matriculation exam scores | | | | | | | | |
| Math | 0.634* | (0.009) | 0.715* | (0.009) | 0.888* | (0.011) | 2.287* | (0.026) |
| Hungarian | -0.256* | (0.012) | -0.223* | (0.013) | -0.314* | (0.015) | -0.797* | (0.039) |
| History | -0.236* | (0.012) | -0.206* | (0.013) | -0.198* | (0.016) | -0.664* | (0.040) |
| Advanced exam | | | | | | | | |
| Math | 0.382* | (0.011) | 0.338* | (0.010) | 0.391* | (0.009) | 1.263* | (0.028) |
| Hungarian | -0.203* | (0.003) | -0.231* | (0.005) | -0.310* | (0.006) | -0.652* | (0.016) |
| History | -0.224* | (0.002) | -0.206* | (0.013) | -0.287* | (0.004) | -0.922* | (0.012) |

*Note:* Robust standard errors in parentheses; * p<0.05. The first three regressions are estimated by a logit regression and results are reported as marginal effects. The last regression is estimated by OLS. All regressions are estimated on the sample of applicants to higher education in the year before and after the reform (87939 observations). All regressions include region fixed effects.

*Table A5*

**Evaluation of the reform (ranking a self-funded program)**

| | Self ranked first | | Self ranked last | | At least 1 Self | | Total Self | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | St. error | Coef. | St. error | Coef. | St. error | Coef. | St. error |
| Female | 0.003 | (0.003) | 0.012* | (0.005) | 0.022* | (0.005) | 0.049 | (0.010) |
| 2012 | 0.105* | (0.003) | 0.200* | (0.005) | 0.245* | (0.005) | 0.660* | (0.013) |
| Female*2012 | 0.026* | (0.004) | 0.017* | (0.006) | 0.028* | (0.007) | 0.114* | (0.017) |
| +19 years | 0.013* | (0.002) | 0.030* | (0.004) | 0.040* | (0.004) | 0.113* | (0.010) |
| Disadvantaged | -0.032* | (0.002) | -0.124* | (0.005) | -0.160* | (0.005) | -0.356* | (0.012) |
| Matriculation exam scores | | | | | | | | |
| Math | -0.067* | (0.004) | -0.177* | (0.009) | -0.221* | (0.010) | -0.461* | (0.023) |
| Hungarian | -0.060* | (0.006) | -0.113* | (0.013) | -0.118* | (0.014) | -0.385* | (0.035) |
| History | 0.010 | (0.006) | 0.025 | (0.013) | 0.064 | (0.014) | 0.157* | (0.036) |
| Advanced exam | | | | | | | | |
| Math | -0.030* | (0.002) | -0.054* | (0.007) | -0.058* | (0.007) | -0.117* | (0.018) |
| Hungarian | -0.033 | (0.003) | -0.037* | (0.011) | 0.001 | (0.012) | -0.118* | (0.027) |
| History | 0.031* | (0.003) | 0.085* | (0.006) | 0.161* | (0.006) | 0.418* | (0.015) |

*Note* Robust standard errors in parentheses; * p<0.05. The first three regressions are estimated by a logit regression and results are reported as marginal effects. The last regression is estimated by OLS. All regressions are estimated on the sample of applicants to higher education in the year before and after the reform (87939 observations). All regressions include region fixed effects.

*Table A6*

**Being admitted to the first ranked program**

| | ECON | ENG | TEACH | HEALTH | SCI | AGRI |
|---|---|---|---|---|---|---|
| Constant | -8.455* | -8.353* | -11.312* | -9.515* | -9.061* | -9.563* |
| | (0.396) | (0.212) | (0.562) | (0.360) | (0.466) | (0.462) |
| Mathematics | 1.439* | 5.302* | 0.981 | 1.524* | 3.399* | 3.793* |
| | (0.458) | (0.222) | (0.478) | (0.345) | (0.477) | (0.437) |
| Hungarian | 1.552* | 1.712* | 7.959* | 4.078* | 1.806* | 2.206* |
| language | (0.621) | (0.268) | (0.786) | (0.542) | (0.611) | (0.608) |
| History | 4.263* | 1.426* | 3.534* | 3.339* | 4.452* | 4.401* |
| | (0.631) | (0.285) | (0.688) | (0.552) | (0.638) | (0.660) |

| | LAW | ARTS | SSCI | | State | Self |
|---|---|---|---|---|---|---|
| Constant | -13.041* | -7.546* | -10.928* | | - | 1.101* |
| | (0.551) | (0.396) | (0.364) | | | (0.366) |
| Mathematics | 2.111* | 0.520 | 1.482* | | - | 0.732 |
| | (0.466) | (0.434) | (0.272) | | | (0.410) |
| Hungarian | 7.430* | 1.430* | 4.766* | | - | -0.148 |
| language | (0.713) | (0.569) | (0.452) | | | (0.552) |
| History | 3.821* | 4.767* | 4.814* | | - | 0.200 |
| | (0.621) | (0.632) | (0.410) | | | (0.562) |
| #admit/#applic | 12.026* | | | | | |
| | (0.330) | | | | | |

Note Standard errors in parentheses; * p<0.05. The probability of being admitted to the first ranked option is estimated with a binary logit regression. The regression is estimated on the sample of all high school graduates that apply to higher education in 2012.

*Table A7*

**Model validation (men)**

| | Observed choices | | | Model predictions | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| Panel A: In-sample validation (2011) | | | | | | |
| SSCI | 5.2 | 0.3 | 5.5 | 5.4 | 0.2 | 5.6 |
| ECON | 8.5 | 0.7 | 9.2 | 8.3 | 0.6 | 8.9 |
| ENG | 22.3 | 0.1 | 22.4 | 22.3 | 0.1 | 22.4 |
| TEACHING | 0.3 | 0.0 | 0.3 | 0.3 | 0.0 | 0.3 |
| HEALTH | 2.2 | 0.0 | 2.2 | 2.0 | 0.0 | 2.1 |
| SCI | 2.9 | 0.0 | 2.9 | 2.8 | 0.0 | 2.8 |
| AGRI | 2.9 | 0.1 | 3.0 | 2.9 | 0.1 | 3.0 |
| LAW | 4.4 | 0.5 | 4.9 | 4.3 | 0.5 | 4.8 |
| ARTS | 4.2 | 0.1 | 4.2 | 4.3 | 0.1 | 4.4 |
| TOTAL | 52.7 | 1.7 | 54.4 | 52.6 | 1.6 | 54.2 |
| | | | | | | |
| Panel B: Out-of-sample validation (2012) | | | | | | |
| SSCI | 4.3 | 0.7 | 5.0 | 4.6 | 0.3 | 4.9 |
| ECON | 2.0 | 4.2 | 6.2 | 2.2 | 0.6 | 2.9 |
| ENG | 22.0 | 0.4 | 22.4 | 25.8 | 0.1 | 25.9 |
| TEACHING | 0.2 | 0.0 | 0.2 | 0.3 | 0.0 | 0.3 |
| HEALTH | 2.4 | 0.0 | 2.4 | 2.2 | 0.0 | 2.2 |
| SCI | 2.8 | 0.0 | 2.9 | 3.0 | 0.0 | 3.0 |
| AGRI | 2.8 | 0.1 | 3.0 | 3.4 | 0.0 | 3.4 |
| LAW | 3.4 | 0.9 | 4.3 | 3.0 | 0.5 | 3.5 |
| ARTS | 3.1 | 0.4 | 3.5 | 4.5 | 0.1 | 4.6 |
| TOTAL | 43.1 | 6.7 | 49.8 | 48.9 | 1.6 | 50.5 |

*Note:* Observed and predicted outcomes are expressed as percentages of high school graduates of respectively 2011 and 2012.

*Table A8*

## Model validation (women)

| | Observed choices | | | Model predictions | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| Panel A: In-sample validation (2011) | | | | | | |
| SSCI | 14.1 | 0.5 | 14.6 | 14.2 | 0.5 | 14.6 |
| ECON | 14.5 | 0.7 | 15.2 | 14.6 | 0.8 | 15.4 |
| ENG | 4.6 | 0.0 | 4.6 | 4.4 | 0.0 | 4.4 |
| TEACHING | 4.9 | 0.1 | 4.9 | 4.8 | 0.1 | 4.9 |
| HEALTH | 7.3 | 0.0 | 7.3 | 7.3 | 0.1 | 7.4 |
| SCI | 2.5 | 0.0 | 2.6 | 2.6 | 0.0 | 2.6 |
| AGRI | 2.6 | 0.0 | 2.6 | 2.6 | 0.0 | 2.6 |
| LAW | 4.9 | 0.4 | 5.3 | 4.8 | 0.4 | 5.2 |
| ARTS | 4.6 | 0.1 | 4.7 | 4.7 | 0.1 | 4.8 |
| TOTAL | 60.0 | 1.9 | 61.8 | 60.0 | 1.8 | 61.9 |
| Panel B: Out-of-sample validation (2012) | | | | | | |
| SSCI | 12.0 | 1.5 | 13.5 | 12.5 | 0.5 | 13.1 |
| ECON | 2.6 | 6.7 | 9.3 | 4.5 | 0.9 | 5.4 |
| ENG | 5.5 | 0.1 | 5.6 | 7.1 | 0.0 | 7.1 |
| TEACHING | 5.0 | 0.2 | 5.1 | 5.0 | 0.0 | 5.0 |
| HEALTH | 7.4 | 0.1 | 7.5 | 9.1 | 0.0 | 9.1 |
| SCI | 2.6 | 0.0 | 2.6 | 3.3 | 0.0 | 3.3 |
| AGRI | 2.9 | 0.1 | 3.0 | 3.5 | 0.0 | 3.5 |
| LAW | 3.2 | 1.2 | 4.4 | 3.8 | 0.4 | 4.3 |
| ARTS | 3.4 | 0.4 | 3.8 | 5.8 | 0.1 | 5.9 |
| TOTAL | 44.6 | 10.2 | 54.8 | 54.6 | 2.0 | 56.6 |

*Note:* Observed and predicted outcomes are expressed as percentages of high school graduates of respectively 2011 and 2012.

*Table A9*

**Counterfactual analysis**

| | Model predictions | | | Counterfactuals | | |
|---|---|---|---|---|---|---|
| | State-funded | Self-funded | Total | State-funded | Self-funded | Total |
| Panel A: Men | | | | | | |
| SSCI | 5.4 | 0.2 | 5.6 | -0.8 | -0.0 | -0.8 |
| ECON | 8.3 | 0.6 | 8.9 | -1.2 | -0.1 | -1.3 |
| ENG | 22.3 | 0.1 | 22.4 | +9.4 | -0.0 | +9.4 |
| TEACHING | 0.3 | 0.0 | 0.3 | -0.0 | -0.0 | -0.0 |
| HEALTH | 2.0 | 0.0 | 2.1 | -0.2 | -0.0 | -0.3 |
| SCI | 2.8 | 0.0 | 2.8 | +0.8 | -0.0 | +0.8 |
| AGRI | 2.9 | 0.1 | 3.0 | -0.4 | -0.0 | -0.5 |
| LAW | 4.3 | 0.5 | 4.8 | -0.6 | -0.1 | -0.6 |
| ARTS | 4.3 | 0.1 | 4.4 | -0.7 | -0.0 | -0.7 |
| TOTAL | 52.6 | 1.6 | 54.2 | +6.2 | -0.2 | +6.0 |
| | | | | | | |
| Panel B: Women | | | | | | |
| SSCI | 14.2 | 0.5 | 14.6 | -1.0 | -0.1 | -1.0 |
| ECON | 14.6 | 0.8 | 15.4 | -1.1 | -0.1 | -1.2 |
| ENG | 4.4 | 0.0 | 4.4 | +5.1 | -0.0 | +5.1 |
| TEACHING | 4.8 | 0.1 | 4.9 | -0.3 | -0.0 | -0.4 |
| HEALTH | 7.3 | 0.1 | 7.4 | -0.5 | -0.0 | -0.6 |
| SCI | 2.6 | 0.0 | 2.6 | +1.8 | -0.0 | +1.8 |
| AGRI | 2.6 | 0.0 | 2.6 | -0.3 | -0.0 | -0.2 |
| LAW | 4.8 | 0.4 | 5.2 | -0.3 | -0.1 | -0.4 |
| ARTS | 4.7 | 0.1 | 4.8 | -0.4 | -0.0 | -0.4 |
| TOTAL | 60.0 | 1.8 | 61.9 | +3.0 | -0.1 | +2.7 |

*Note:* Predicted outcomes are expressed as percentages of 2011 high school graduates. Outcomes of the counterfactual policy are expressed as percentage point changes relative to the status quo.