Gender differences in applying for STEM programs: evidence from a policy shift in Hungary

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Introduction

- Women have lower enrollment rates in STEM majors in higher education.
  - 44% of men and 11% of women preferred a STEM program in Hungary in 2011.

- Research questions:
  - How do preferences for STEM majors differ between men and women?
  - How did a policy reform affect application decisions in Hungary?
  - Can admission policies influence educational choices and decrease the gender gap?

Introduction

- We study a reform that limits the number of state funded places in non-STEM programs in Hungary.
- We investigate how the reform affected application decisions for men and women.
- We set up a discrete choice framework to estimate preferences for major choices in higher education.
- We simulate the impact of alternative admission policies designed to increase enrollment in STEM programs.

Overview

- Admission to higher education in Hungary
- The 2012 policy reform
- Evaluation of the reform
- Structural model of applying to higher education
- Model validation
- Counterfactual analysis
- Conclusion

Admission to higher education in Hungary

- There are tuition-free state funded places and cost-priced places where students have to pay the full market costs of their education.

- Students submit their preference ranking for specific programs in higher education.

- Students are admitted to at most 1 program: the first ranked option on their preference list for which they obtain the minimum admission score.
  - Admission thresholds are based on test scores and the number of available places.
  - Students rank programs in order of their preferences.

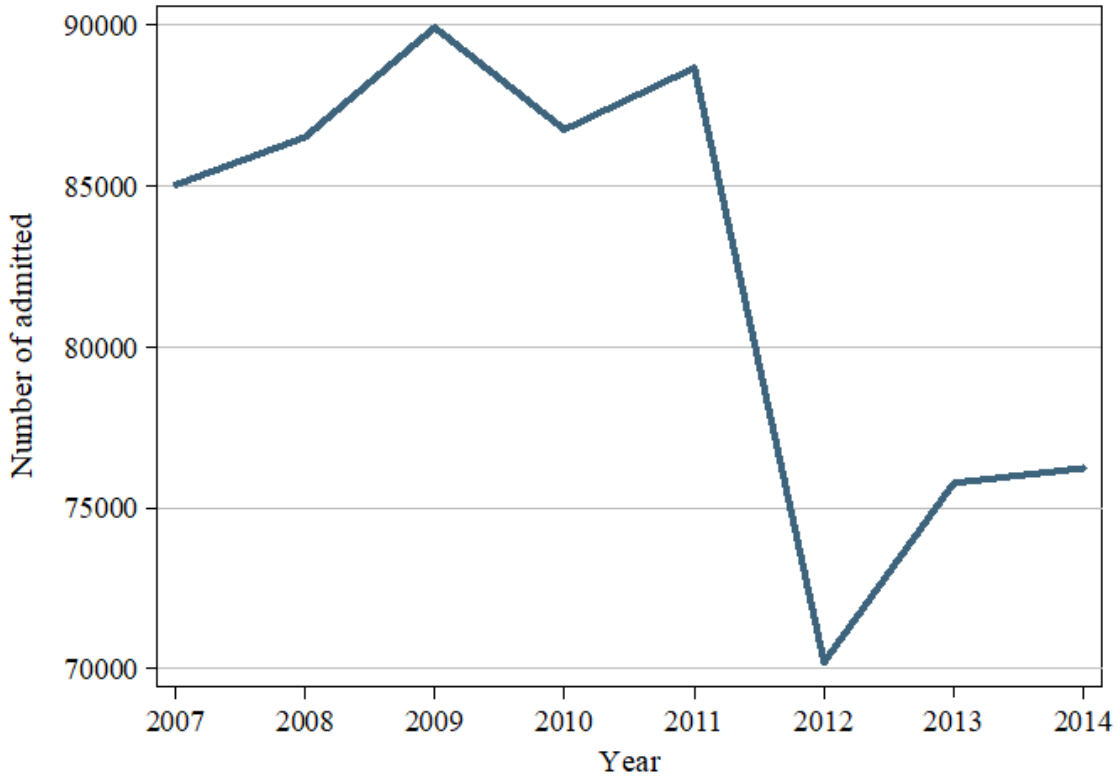
The 2012 policy reform

- From academic year 2012-2013, the Hungarian government reduced the number of state-financed places in non-STEM majors.

- Aim of the reform:
  - Budget cuts
  - To alter the field of study composition of higher education

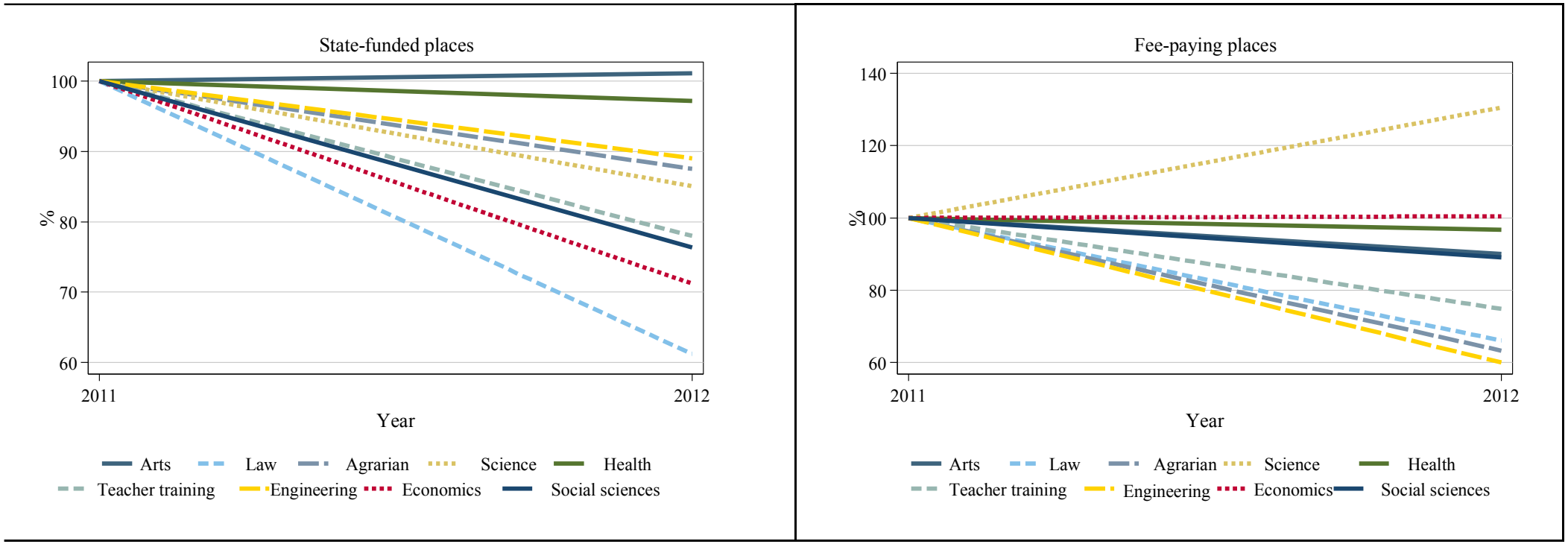
The 2012 policy reform

Figure 1: Number of admitted students in higher education



The 2012 policy reform

Figure 2: Change in admitted students by field of study to state funded and fee-paying courses between 2011 and 2012



The 2012 policy reform: descriptive evidence

Table 1: High school graduates

	Men		Women	
	2011	2012	2011	2012
Age	19.2	19.2	19.1	19.1
Exam scores				
Hungarian	54.9%	53.4%	63.5%	61.1%
Math	50.4%	50.7%	47.0%	49.5%
History	63.5%	59.8%	64.2%	59.6%
Advanced exam				
Hungarian	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%

- Less students participate in the matriculation exams in 2012 (demographic decline).
- After the reform, exam scores are lower for Hungarian language and history but higher for math.
- Women perform better on Hungarian language but worse on mathematics.
- More students choose for an advanced exam after the reform.

The 2012 policy reform: descriptive evidence

Table 2: Applying to higher education

	Men		Women	
	2011	2012	2011	2012
Total	54.4%	49.8%	61.8%	54.8%
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%

Note: Application decisions are expressed as a percentage of high school graduates.

- After the reform, less students applied to higher education.
- Proportionaly more women apply to higher education.
- Older high school graduates are less likely to apply for higher education.
- Students who perform well on the matriculation exams are more likely to apply.

The 2012 policy reform: descriptive evidence

Table 3: Major choices (first choice)

	2011			2012		
	State-funded	Self-funded	Total	State-funded	Self-funded	Total
SSCI	9,93%	0,40%	10,33%	8,44%	1,09%	9,53%
ECON	11,71%	0,70%	12,40%	2,36%	5,52%	7,88%
ENG	12,81%	0,06%	12,86%	13,17%	0,21%	13,38%
TEACHING	2,72%	0,03%	2,75%	2,78%	0,08%	2,86%
HEALTH	4,89%	0,03%	4,92%	5,09%	0,06%	5,16%
SCI	2,69%	0,00%	2,70%	2,71%	0,02%	2,73%
AGRI	2,74%	0,04%	2,78%	2,86%	0,10%	2,95%
LAW	4,69%	0,43%	5,12%	3,30%	1,07%	4,37%
ARTS	4,41%	0,09%	4,50%	3,21%	0,42%	3,63%
TOTAL	56,59%	1,78%	58,37%	43,92%	8,57%	52,49%

Note: Application decisions are expressed as a percentage of high school graduates.

- Most students prefer a state funded place.
- After the reform, relatively more students prefer a self-funded place. This effect is largest for ECON.
- After the reform, more students apply to ENG, and less students apply to ECON and LAW.

Evaluation of the reform

- We analyze the impact of the reform on:
  - The decision to apply to higher education
  - Total number of options on the preference ranking
  - Applying for STEM programs
  - Applying for self-funded programs

- We estimate the following regression model

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

- X_i a vector that contains academic ability and place of residence

Evaluation of the reform

Table 4: Evaluation of the reform

	Apply		Total options	
	Coef.	St. error	Coef.	St. error
Female	0.306*	(0.018)	0.034*	(0.014)
2012	-0.163*	(0.018)	0.294*	(0.015)
Female*2012	-0.196*	(0.025)	-0.102*	(0.020)

Note: Standard errors in parentheses; * p<0.05. The binary logit regression for applying to higher education is estimated on the sample of all high school graduates of 2011 and 2012. The OLS regression for the total number of options is estimated on the sample of all students with at least one application to higher education in 2011 and 2012. All regressions control for matriculation exam scores, age and region fixed effects.

- Women are more likely to apply to higher education and apply to more study options.
- After the the reform:
  - Less students applied to higher education. This effect is larger for women.
  - Students applied to more options. The increase is smaller for women.

Evaluation of the reform

Table 4 (continued): Evaluation of the reform

	STEM ranked first		STEM ranked last		Total STEM options	
	Coef.	St. error	Coef.	St. error	Coef.	St. error
Female	-1.644*	(0.025)	-1.508*	(0.024)	-0.930*	(0.014)
2012	0.105*	(0.022)	0.079*	(0.022)	0.325*	(0.015)
Female*2012	0.013	(0.035)	-0.041	(0.033)	-0.271*	(0.020)

Note: Standard errors in parentheses; * p<0.05. Ranking a STEM option on the first or last place is estimated with a binary logit regression. The total number of STEM options on the preference ranking is estimated by OLS. These regressions are estimated on the sample of all students with at least one application to higher education in 2011 and 2012. All regressions control for matriculation exam scores, age and region fixed effects.

- Women are less likely to apply to STEM programs.
- After the the reform:
  - More students applied to STEM programs.
  - Students applied to more STEM options. The increase is smaller for women.

Evaluation of the reform

Table 4 (continued): Evaluation of the reform

	Self ranked first		Self ranked last		Total Self options	
	Coef.	St. error	Coef.	St. error	Coef.	St. error
Female	0.027	(0.055)	0.033	(0.024)	0.021	(0.012)
2012	1.642*	(0.047)	0.973*	(0.024)	0.661*	(0.013)
Female*2012	0.429*	(0.061)	0.091*	(0.031)	0.119*	(0.017)

Note: Standard errors in parentheses; * p<0.05. Ranking a self-funded option on the first or last place is estimated with a binary logit regression. The total number of self-funded options on the preference ranking is estimated by OLS. These regressions are estimated on the sample of all students with at least one application to higher education in 2011 and 2012. All regressions control for matriculation exam scores, age and region fixed effects.

- After the the reform:
  - More students applied to a self-funded program. This effect is larger for women.
  - Students applied to more self-funded options. The increase is larger for women.

Structural model of applying to higher education

- After graduating from high school, a student i prefers the study option j in institution k that maximizes utility.

$$U_{ijk}(X_i, \lambda_{ijk}, d_{ik}) = \alpha_j^0 + \alpha_j^1 X_i + \alpha^2 \lambda_{ijk} + \alpha^3 \lambda_{ijk} X_i + \alpha^4 d_{ik} + \alpha^5 d_{ik} X_i + \varepsilon_{ijk}$$

  - X_i a vector of personal characteristics: gender, academic ability and place of residence
  - λ_{ijk} the probability of being admitted to program j in institution k
  - d_{ik} travel distance to institution k
  - ε_{ijk} an i.i.d. type 1 extreme value distributed error term

Structural model of applying to higher education

- The probability of being admitted to program j in institution k:

$$\lambda_{ijk}(X_i, cap_{jk}) = \beta_j^0 + \beta_j^1 X_i + \beta^2 cap_{jk} + \eta_{ijk}$$

  - X_i a vector of personal characteristics: gender, academic ability, place of residence
  - cap_{jk} a measure of the capacity of the program: the ratio of admitted students relative to total applicants in option j
  - η_{ijk} an i.i.d. type 1 extreme value distributed error term

Estimation

- We model the choice of all high school graduates in the year before the reform (2011).
- We use the cohort of students affected by the reform (2012) to validate the model.
- We only consider the first option on the ranking of students.
- All high school graduates choose between 600 options in 2011:
  - Not applying to higher education
  - Specific institution and location
  - Specific program
  - State-funded or self-funded place
- Estimation proceeds in two steps:
  - We estimate the probability of acceptance to the first option of the preference list with a binary logit regression.
  - We estimate the probability of choosing for option j at institution k with a conditional logit model.

Empirical results

Table 5: Being admitted to first ranked program (2011)

	ECON	ENG	TEACH	HEALTH	SCI	AGRI
Constant	-11.901* (0.245)	-9.063* (0.185)	-11.233* (0.429)	-8.878* (0.281)	-9.434* (0.366)	-9.984* (0.399)
Male	0.258* (0.065)	0.360* (0.067)	0.967* (0.272)	0.212* (0.095)	0.469* (0.123)	0.705* (0.122)
+ 19 years	0.416* (0.068)	0.236* (0.063)	0.109 (0.138)	0.124* (0.100)	0.176 (0.155)	0.390* (0.132)
Mathematics	3.634* (0.187)	5.983* (0.162)	1.098* (0.138)	2.009* (0.223)	5.676* (0.353)	3.637* (0.328)
Hungarian language	3.806* (0.283)	2.329* (0.203)	7.864* (0.531)	5.177* (0.392)	2.520* (0.456)	4.207* (0.504)
History	4.938* (0.308)	1.605* (0.218)	4.134* (0.491)	1.710* (0.391)	3.395* (0.470)	2.994* (0.532)
Budapest	-0.649* (0.071)	-0.869* (0.062)	-0.915* (0.153)	-0.965* (0.104)	-1.130* (0.153)	-0.373* (0.141)

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. Results have to be interpreted relative to the base category of not applying to higher education

Empirical results

Table 5 (continued): Being admitted to first ranked program (2011)

	LAW	ARTS	SSCI	State	Self	#admit/#applic
Constant	-15.759* (0.456)	-7.641* (0.346)	-13.136* (0.285)	-	9.182* (0.304)	8.967* (0.250)
Male	0.358* (0.104)	0.407* (0.124)	0.268* (0.075)	-	-0.351* (0.135)	
+ 19 years	0.122 (0.114)	-0.131 (0.136)	0.256* (0.071)		-0.195 (0.140)	
Mathematics	3.094* (0.288)	1.342* (0.326)	2.332* (0.179)	-	-2.006* (0.364)	
Hungarian language	7.619* (0.466)	2.237* (0.466)	5.762* (0.300)	-	-3.588* (0.426)	
History	6.425* (0.491)	3.348* (0.510)	6.085* (0.316)	-	-1.261* (0.473)	
Budapest	-0.914* (0.128)	-0.115 (0.127)	-0.511* (0.074)		0.219 (0.134)	

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.

Empirical results

Summary: admission to higher education

- The probability to be admitted to a state funded program is lower than in self funded programs.
- Men and older students are more likely to be admitted to most programs.
  - This effect is smaller for self funded programs
- Exam scores have an important impact on admission
  - Math scores are most important for ENG and SCI.
- The capacity of a program has a significantly positive effect on the probability of being admitted.

Empirical results

Table 6: Application to higher education

	ECON	ENG	TEACH	HEALTH	SCI	AGRI
Constant	-7.381* (0.061)	-8.327* (0.069)	-4.966* (0.091)	-8.344* (0.100)	-8.071* (0.124)	-6.905* (0.103)
Male	-0.701* (0.030)	1.490* (0.040)	-2.944* (0.106)	-1.122* (0.048)	0.219* (0.059)	-0.017 (0.050)
+19 years	-0.007 (0.029)	-0.239* (0.031)	-0.179* (0.053)	-0.379* (0.046)	-0.429* (0.059)	-0.201* (0.053)
Mathematic	3.980* (0.079)	5.223* (0.088)	0.655* (0.140)	3.253* (0.107)	3.347* (0.136)	2.232* (0.132)
Hungarian language	2.166* (0.097)	0.867* (0.098)	1.502* (0.171)	2.565* (0.152)	1.405* (0.176)	1.156* (0.169)
History	1.736* (0.105)	0.657* (0.107)	0.409* (0.181)	2.874* (0.161)	2.174* (0.199)	1.893* (0.185)
Budapest	-0.759* (0.031)	-0.933* (0.033)	-0.571* (0.058)	-0.417* (0.048)	-0.555* (0.057)	-1.087* (0.057)
Self funded	0.364* (0.076)	-2.299* (0.165)	-1.795* (0.209)	-1.415* (0.203)	-3.377* (0.711)	-1.372* (0.183)

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.

Empirical results

Table 6 (continued): Application to higher education

	LAW	ARTS	SSCI	State	Self		λ_{ijt}	d_{ijk}
Constant	-7.217* (0.087)	-6.330* (0.078)	-0.898* (0.065)		-1.147* (0.125)		1.992* (0.047)	-0.150* (0.003)
Male	-0.021 (0.039)	-0.175* (0.040)	-0.898* (0.033)		0.582* (0.066)		-0.730* (0.060)	0.003* (0.001)
+19 years	-0.053 (0.040)	-0.127* (0.041)	0.041 (0.030)		0.092* (0.059)			
Mathematics	0.918* (0.102)	0.971* (0.107)	0.549* (0.081)		-1.740* (0.165)			
Hungarian language	4.715* (0.140)	2.233* (0.131)	4.362* (0.106)		-2.483* (0.189)			
History	1.682* (0.146)	1.260* (0.141)	1.876* (0.110)		-1.652* (0.206)			
Budapest	-1.176* (0.043)	-0.290* (0.040)	-0.527* (0.032)					
Self funded	1.002* (0.083)	-1.760* (0.138)	-					

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

Empirical results

Summary: application to higher education

- Students prefer to apply for state funded places.
- Men have a higher preference for ENG programs.
- Exam scores have an important impact on application decisions:
  - Math scores are most important for ENG, ECON and SCI.
  - Hungarian language is most important for LAW and SSCI.
- Men are more likely than women to apply for a self-funded place.
- Students with higher exam scores are less likely to apply for a self-funded place.
- The probability of being accepted in a program has a positive effect on applying for this program. This effect is lower for men.
- Students are responsive to travel distance. This effect is smaller for men.

Model validation

Table 7: In sample validation of the model (2011)

	Observed choices			Model predictions		
	State-funded	Self-funded	Total	State-funded	Self-funded	Total
SSCI	9,93%	0,40%	10,33%	9,93%	0,40%	10,33%
ECON	11,71%	0,70%	12,40%	11,71%	0,70%	12,41%
ENG	12,81%	0,06%	12,86%	12,81%	0,06%	12,87%
TEACHING	2,72%	0,03%	2,75%	2,72%	0,03%	2,75%
HEALTH	4,89%	0,03%	4,92%	4,89%	0,03%	4,92%
SCI	2,69%	0,00%	2,70%	2,69%	0,00%	2,69%
AGRI	2,74%	0,04%	2,78%	2,74%	0,04%	2,78%
LAW	4,69%	0,43%	5,12%	4,69%	0,43%	5,12%
ARTS	4,41%	0,09%	4,50%	4,41%	0,09%	4,50%
TOTAL	56,59%	1,78%	58,37%	56,59%	1,78%	58,37%

Note: Observed and predicted outcomes are expressed as a percentage of 2011 high school graduates.

- The model performs well in predicting choices of students within-sample.

Model validation

Table 8: Out of sample validation of the model (2012)

	Observed choices			Model predictions		
	State-funded	Self-funded	Total	State-funded	Self-funded	Total
SSCI	8,44%	1,09%	9,53%	8,47%	0,46%	8,93%
ECON	2,36%	5,52%	7,88%	3,41%	0,90%	4,31%
ENG	13,17%	0,21%	13,38%	15,78%	0,05%	15,83%
TEACHING	2,78%	0,08%	2,86%	2,82%	0,02%	2,84%
HEALTH	5,09%	0,06%	5,16%	5,66%	0,03%	5,69%
SCI	2,71%	0,02%	2,73%	3,04%	0,00%	3,04%
AGRI	2,86%	0,10%	2,95%	3,62%	0,03%	3,65%
LAW	3,30%	1,07%	4,37%	3,74%	0,48%	4,22%
ARTS	3,21%	0,42%	3,63%	5,27%	0,06%	5,33%
TOTAL	43,92%	8,57%	52,49%	51,81%	2,03%	53,84%

Note: Observed and predicted outcomes are expressed as a percentage of 2012 high school graduates.

- The model performs well in predicting choices of students.
- It under predicts the fraction of students preferring a self-funded place in economics after the reform.

Counterfactual analysis

- We can use the model to predict the impact of a hypothetical policy.
- If the government wants to increase enrollment in STEM programs, it could increase its capacity in state funded STEM programs.
- We simulate the impact of an open access policy in these programs.
- The probability of being accepted to a state funded STEM program (ENG and SCI) is 1 for all students.
- The model predicts how application decisions would change.

Counterfactual analysis

Table 9: Counterfactual analysis (men)

	Status quo			Counterfactual		
	State-funded	Self-funded	Total	State-funded	Self-funded	Total
SSCI	5,18%	0,27%	5,45%	4,35%	0,22%	4,57%
ECON	8,54%	0,63%	9,17%	7,07%	0,50%	7,57%
ENG	22,25%	0,11%	22,36%	33,69%	0,01%	33,70%
TEACHING	0,26%	0,00%	0,26%	0,22%	0,00%	0,22%
HEALTH	2,18%	0,02%	2,20%	1,84%	0,02%	1,86%
SCI	2,87%	0,00%	2,87%	3,69%	0,00%	3,69%
AGRI	2,91%	0,05%	2,96%	2,40%	0,04%	2,44%
LAW	4,38%	0,50%	4,88%	3,67%	0,41%	4,08%
ARTS	4,14%	0,09%	4,23%	3,40%	0,07%	3,47%
TOTAL	52,71%	1,67%	54,38%	60,33%	1,27%	61,60%

Note: Predicted outcomes are expressed as a percentage of 2011 male high school graduates.

- More men would apply to higher education.
- In the counterfactual scenario, more men would prefer a STEM program.

Counterfactual analysis

Table 10: Counterfactual analysis (women)

	Status quo			Counterfactual		
	State-funded	Self-funded	Total	State-funded	Self-funded	Total
SSCI	14,06%	0,52%	14,58%	12,69%	0,47%	13,16%
ECON	14,46%	0,75%	15,21%	12,90%	0,65%	13,55%
ENG	4,58%	0,01%	4,59%	11,65%	0,01%	11,66%
TEACHING	4,87%	0,06%	4,93%	4,35%	0,05%	4,40%
HEALTH	7,25%	0,05%	7,30%	6,55%	0,04%	6,59%
SCI	2,54%	0,00%	2,54%	4,96%	0,00%	4,96%
AGRI	2,58%	0,03%	2,61%	2,30%	0,03%	2,33%
LAW	5,00%	0,37%	5,37%	4,48%	0,33%	4,81%
ARTS	4,65%	0,08%	4,73%	4,12%	0,08%	4,20%
TOTAL	59,99%	1,87%	61,86%	64,00%	1,66%	65,66%

Note: Predicted outcomes are expressed as a percentage of 2011 female high school graduates.

- Increase in enrollment for women would be smaller than for men.
- More women would prefer a STEM program.

Conclusion

- We assess the impact of gender on applying for STEM majors in higher education in Hungary.

- We assess the impact of a reform that decreased the number of state-funded places in non-STEM programs
  - Less students applied for higher education (larger effect for women)
  - A larger share of applicants applied for STEM (smaller effect for women)
  - Students applied to more self-funded programs (larger effect for women)

- Students take into account the probability of admission when applying to higher education.

- Admission policies affect application decisions.