The STEM Major Gender Gap: Evidence from Coordinated College Application Platforms Across Five Continents†

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Abstract

This paper uses data from coordinated application and admissions systems in Australia, Brazil, Chile, China, Finland, Greece, Spain, Sweden, Uganda, and Taiwan to document differences in gender representation among talented students applying to STEM majors. These ten settings are very different in size, economic development, culture, gender norms, and geographic location. However, in all of them, university admission decisions rely on algorithms that allocate students to specific college-major combinations based on their academic performance when applying to university. We focus on students scoring in the top 10% of the university admission exam and show that female representation among STEM-major applicants varies from 22% in Taiwan to 46% in Sweden. In the contexts we study, these differences can be driven either by gender gaps in academic performance at the time of application or by gender gaps in the programs that these top-scoring students rank in their application lists. While we find some significant variation in female representation among top 10% scores—32.3% in Uganda to 65.6% in Sweden—we find a remarkably stable gender gap in applications to STEM across settings—between 22 and 29 percentage points in all education systems, but China and Australia, where it reaches 37% and 16% respectively. These results indicate that i.) closing gaps in academic performance is not enough to eliminate inequality in college trajectories across gender groups and ii.) the gender gap in major choices does not significantly vary with economic development.

***Keywords*:** gender inequality, STEM gender gap, centralized application platforms.
***JEL Codes*:** I23, I24, N30.

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1 Introduction

The field of study chosen in higher education significantly influences key life outcomes, including future occupation, earnings, fertility, and marriage (Altonji et al., 2016; Hastings et al., 2013; Kirkebøen et al., 2016). At the aggregate level, this choice also affects broader economic outcomes such as growth, inequality, and social mobility (Barrios-Fernández et al., 2024; Goldin and Katz, 2008; Hsieh et al., 2019). STEM programs, in particular, have been shown to yield high returns in the labor market, promote innovation and technological development, and to exhibit a smaller gender wage gap (Black et al., 2008; Blau and Kahn, 2017; Kirkebøen et al., 2016; Dahl et al., 2023; Beede et al., 2011). Yet, despite these benefits, female representation in STEM remains low. In OECD countries, women make up only 31% of those entering STEM programmes in 2024.

Understanding the causes of this phenomenon has become a growing area of research, not only because it may help in explaining the gender gaps observed later in the labor market but also due to the efficiency losses resulting from the underutilization of female talent in STEM fields (Hsieh et al., 2019). Disparities in gender representation in STEM have often been attributed to differences in academic preparedness, as well as to differences in major choices driven by tastes and preferences for non-pecuniary factors (Wiswall and Zafar, 2018; Bertrand, 2020; Patnaik et al., 2021; Card and Payne, 2021; Aucejo and James, 2021). However, disentangling the relative contribution of these factors to female underrepresentation in STEM is notoriously difficult.

This paper leverages detailed administrative data from centralized university application platforms in ten settings—Australia, Brazil, Chile, China, Finland, Greece, Spain, Sweden, Taiwan, and Uganda—to document disparities in female representation among STEM applicants and to quantify the contribution of differences in academic performance and program choices to these disparities. Despite significant differences in size, economic development, and gender norms, these educational systems share a common feature: a significant proportion of their university seats is allocated through a version of a deferred acceptance algorithm. Under these systems, university applicants submit a ranked ordered list of their preferred university programs via a centralized platform and are subsequently matched to the highest-ranked option for which they are eligible. Importantly, eligibility in these systems is predominantly determined by academic performance, typically assessed through a combination of university admission exams and high school grades. This centralized eligibility system based on academic performance implies that two students with the same academic performance would have similar probabilities of accessing the same college majors.

A unique feature of these admission systems is that they allow us to observe both the list of programs that students rank when applying to university and the primary determinant of admission—namely, their academic performance. Given that the number of programs applicants can list varies across settings, we concentrate on the program that they rank highest. This approach improves the comparability of our results and still provides a good reflection of students' academic and career interests. We define a student as a STEM applicant if the two-digit 2013 ISCED code of their top-ranked program classifies it within Engineering and Manufacturing, Information and Communication Technologies, or Natural Sciences and Mathematics. Our analyses focus on students in the top 10% of the academic performance distribution, as these students are the most likely to be admitted into and benefit from attending a selective STEM program.

We first show that female students are consistently underrepresented among talented students applying to STEM programs across all the educational systems in our study. However, the extent of this underrepresentation varies significantly. In half of the settings in our sample, the female share among STEM applicants is under 30%, while in Australia, Greece and Sweden, it approaches 45%. To shed some light on the potential drivers of these cross-setting differences and of female underrepresentation in STEM, we next study the contribution of gaps in academic performance and in program choices to these disparities.

Gender differences in academic performance might partially explain low female representation among students talented potential STEM applicant. To study whether this is indeed the case, we look at the gender composition of the top 10% students, independently of the programs that applicants rank in their list. We define the pipeline gap as the difference between the proportion of female and male students among all top 10% applicants. This is particularly relevant in the contexts we study, where strong academic performance is what enables admission to selective STEM programs.

We find large differences in the pipeline gap in the ten settings we study. While in Chile, the female share in the top 10% is 41.9%, in Sweden, it is close to 66%. These countries are also on the extremes of female representation among talented STEM applicants, which indicates that the pipeline gap explains some of the cross-setting differences discussed in the previous paragraph. However, the pipeline gap does not fully explain female underrepresentation among talented STEM applicants. Indeed, even in contexts where females are overrepresented among top-performing students, their share among STEM applicants remains low, suggesting that other factors also contribute to this underrepresentation. For instance, in countries such as China and Finland, where the female share in the top 10% is above 50%, female students represent less than one-third of talented STEM applicants.

Low female representation among talented STEM applicants may also stem from differences in the programs that female and male applicants prioritize in their lists. A nice feature of our data is that it allows us to analyze gender differences in the likelihood of ranking a STEM program at the top of the application list, conditioning on academic performance—the primary determinant of university admission in our settings. To investigate this "STEM choice gap," we focus on the top 10% students and compare the share of female and male applicants who rank a STEM program first.

We document a large and remarkably consistent STEM choice gap in all the settings we study. In eight out of ten settings, this gap fluctuates around 25 percentage points. The extremes of the distribution are Australia, with a STEM choice gap of 16 percentage points, and China, where the STEM choice gap reaches 36 percentage points. Although the stable STEM choice gap does not fully explain cross-setting differences in female representation among talented STEM applicants, it underscores that program choices are crucial to explaining why female applicants are underrepresented in STEM fields regardless of the territory's size, level of economic development, and gender norms.

Our findings contribute to two broad strands of research. Firstly, they add to the literature focusing on gender disparities in major choice. While the gender gap in college attendance and completion has reversed in women's favor over the last 50 years Goldin et al. (2006), women remain significantly less likely to major in quantitative and science fields (Bettinger and Long, 2005). Several studies have highlighted the role of high school preparedness in shaping college major choices and in explaining gender differences in the probability of majoring in STEM (Card and Payne, 2021; Aucejo and James, 2021; Humphries et al., 2023). However, the sorting of students into majors is primarily driven by non-pecuniary factors, often referred to as "tastes" for specific fields (Patnaik et al., 2021). In the context of gender gaps in selecting a college major, non-pecuniary factors may include marriage, fertility, or workplace characteristics (Zafar, 2013; Wiswall and Zafar, 2018; Buser et al., 2014; Reuben et al., 2017; Bertrand et al., 2010; Goldin and Katz, 2011; Goldin, 2014; Kleven et al., 2019). Furthermore, grading policies (Ahn et al., 2019; Exley et al., 2024) and anticipated discrimination (Lepage et al., 2024; Lavy and Megalokonomou, 2024) have also been shown to contribute to gender differences in major choices.[1]

Our findings also add to the literature studying gender gaps in academic performance and educational trajectories. The gender gap in science and math that precedes college entry has decreased over the past few decades and is now quantitatively smaller (Xie and Shauman, 2004; Goldin et al., 2006), yet male students continue to outperform female students in math in most settings (Guiso et al., 2008; Fryer Jr and Levitt, 2010; Pope and Sydnor, 2010; Ellison and Swanson, 2023). For instance, Fryer Jr and Levitt (2010) documents the emergence of a large gender gap in math test scores during primary education in the US and reports important gender gaps both in math and reading test scores among participants of the Program for International Student Assessment (PISA).[2] Ellison and Swanson (2023) also reports a substantial gender gap among high-achieving ninth-graders in math and finds that high-achieving girls show less year-on-year improvement compared to boys with similar initial performance, further widening the gender gap. Related to these studies, Barrios-Fernández and Riudavets-Barcons (2024) shows that math teachers are more effective at teaching male than female students and that these differences in teaching effectiveness significantly contribute to the gender gap in math test scores. Moreover, these gender differences in math performance could explain part of the underrepresentation of female students in STEM fields, both in college and in the labor market (Hedges and Nowell, 1995; Guiso et al., 2008; Hyde et al., 2008; Ellison and Swanson, 2023; Ginther and Kahn, 2004; Carrell et al., 2010).

We contribute to these literatures by examining the underrepresentation of women among STEM

[1]For a review of the recent literature on the determinants of college major choices see Patnaik et al. (2021).

[2]Muslim countries are an exception to this pattern. According to this study, there is little or no math gender gap in Muslim countries.

applicants across a diverse set of contexts and by decomposing this underrepresentation into the pipeline gap and the STEM choice gap. Our findings emphasize that closing gender gaps in academic performance alone is insufficient to address the underrepresentation of women in STEM. Tackling this inequality requires addressing the STEM choice gap, which remains strikingly consistent across the diverse educational systems we study. The consistency of the choice gap across different contexts suggests that its drivers must be common factors, ruling out influences unique to individual settings, such as population size, economic development, or gender norms. Our study underscores the importance of program choices in explaining the gender disparity in STEM representation.

The rest of the article is organized as follows. Section II describes the higher education systems we study and the data we use in each of them. Section III discusses some important definitions and presents our findings. Finally, Section IV concludes.

2 Institutions and Data

This section describes the institutional context and available data in the ten settings we study: Australia, Brazil, Chile, China, Finland, Greece, Spain, Sweden, Taiwan, and Uganda.[3]

As shown in Panel A of Table I, the ten settings in our sample significantly differ in size, GDP per capita, human development[4], inequality, and gender norms[5]. With 1.4 billion inhabitants, China is by far the largest country in our sample. It is followed by Brazil (209 million), Spain (47 million), and Uganda (40 million). Conversely, Sweden (10 million) and Finland (5.5 million) are the smallest countries in the study. Together with Australia and Taiwan, these four settings are among the wealthiest in the world. The GDP per capita of these four settings ranges between USD 55,000 and USD 65,000. They also exhibit high levels of human development. Indeed, all of them have human development indexes of 0.92 or above. In contrast, Uganda has a GDP per capita of USD 3,500 and a human development index of 0.53. Brazil, Chile, China, and Greece are in

[3]Online Appendix A provides additional details on each setting's university admission system and data.

[4]We measure the human development using the Human Development Index (HDI) developed and compiled by the United Nations. The range of the index is between 0 and 1.0, with 1.0 being the highest possible human development. Most developed countries have an HDI score of 0.8 or above, landing them in the very high human development tier. In contrast to this are the world's least-developed countries (LDCs), which tend to have HDI scores below 0.55, in the "low human development" category.

[5]We measure the gender norms using the Global Gender Gap Index developed by the World Economic Forum, The Global Gender Gap Index measures scores on a scale from 0 to 100, which can be read as the extent of progress made towards gender parity, indicating the proportion of the gender gap that has been closed.

the middle, with GDP per capita between USD 20,000 and USD 41,000 and human development indexes between 0.75 and 0.88. There are also considerable differences in terms of inequality. With Gini indexes above 0.42, Brazil, Chile, and Uganda are the most unequal countries in our sample. In Australia, Greece, Finland, Spain, and Sweden, the Gini index is under 0.35. Finally, to characterize these settings regarding their gender norms, we rely on the World Economic Forum gender parity index. This index measures gender differences in educational attainment, economic participation and opportunities, political empowerment, and health. It goes from zero to one, with zero meaning perfect inequality and one meaning perfect parity. Finland and Sweden have a gender parity index of 0.86 and 0.82, respectively. They are among the five countries with the highest levels of gender parity in the world. In contrast, China and Greece have a gender parity index under 0.7. They are in the bottom third of countries with the lowest levels of gender parity.

Despite all the differences discussed in the previous paragraphs, the university admission systems of the educational systems in this study share two key features. Firstly, they allocate all or a significant portion of their university seats through coordinated application and admission platforms. All these systems use some version of a deferred acceptance matching algorithm to pair students with college-major combinations. This means that to apply for college, students must submit a ranked list of their preferred university programs through a centralized platform. They are then allocated to the highest option for which they are eligible. Secondly, eligibility for these college-major combinations is determined by students' academic performance, typically measured by their high school grades and university admission exams. This paper uses administrative data from the agencies in charge of the university admission systems. These data contain both the application list that students submit when applying to university and information on their academic performance.

Panel B of Table I characterizes the university systems in the ten settings we study. All the universities of Australia, Finland, Greece, Sweden, Taiwan, and Uganda assign their seats through centralized admissions. In Chile, China, and Spain, at least half of the universities—including all the public institutions—use centralized admissions. In Brazil, 132 out of 230 public universities use centralized admissions.[6] Financial barriers to accessing higher education are relatively low in most of the settings in our sample. Public universities in China, Greece, Finland, Sweden, and

[6] None of Brazil's 2,152 private higher education institutions participate in the centralized admission system.

Brazil do not charge tuition fees. In Spain, as in other European countries such as France, Italy, and Belgium, universities charge tuition fees, but they are relatively low, and low-income students can access generous public funding. Universities in Australia and Chile charge high tuition fees. However, both countries offer income-contingent loans and scholarships that help students afford higher education.

Finally, Panel C of Table I describes the centralized application systems we study. In all these settings, students apply to specific college-major combinations, which means that they typically have hundreds of options available. In Greece, the country with the fewest options in our sample, students can choose among 609 college-major combinations. In China, they can choose from more than 18,000 programs. The number of programs students can rank in their application lists also varies across settings. In Brazil, students only can include two programs in their list[7]. In contrast, in Greece, students can include as many programs as they wish. The number of university applicants that use the centralized admission platforms is proportional to the population of each setting. In China, more than 10 million students apply to university using the centralized admission system. Our data only covers one province of China: the Ningxia Autonomous Region. This is a relatively small province in which roughly 60 thousand students apply to university each year. Brazil is the country for which we observe the highest number of applicants. On average, 2.7 million students use the centralized admission platform each year. In Australia and Uganda, the countries with fewer applicants in our sample, we observe around 40 thousand individuals applying to university each year. In all settings, the number of students admitted to university through centralized admissions is significantly smaller than the number of applicants. With the exception of Taiwan and Uganda—where female students represent 48% and 43% of university applicants, respectively—female students are more likely to apply to university than male students. In Finland and Sweden, they represent roughly 60% of all university applicants. These results are well aligned with Goldin and Katz (2008) who show that currently female students are more likely to apply to college than male students in the United States.

[7] The system is an iterative DA that allows them to report over multiple days

3 Understanding the STEM Major Gender Gap

3.1 Definitions

This section introduces some definitions and describes the variables we use in our analyses. This paper studies differences in the representation of female and male students in STEM majors. As described in Section 2, the number of programs students can apply to varies significantly across settings. Thus, our analyses only look at the program that students rank at the very top of their application list. We rely on the 2013 two-digit ISCED code to define a program as STEM-Science, Technology, Engineering and Mathematics.[8] This system classifies higher education programs in ten fields of study. We group all programs in Engineering and Manufacturing, Information and Communication Technologies, and Natural Sciences and Mathematics to form the STEM category.

Although students from the whole academic performance distribution can apply and eventually be admitted to a STEM program, we focus on students in the top 10% of the academic performance distribution. This is a particularly interesting group of students as they are likely to be admitted and succeed in the most selective STEM programs in each educational system. To identify these talented students, we take an average of the sections of the admission exams that all applicants take.[9]

To document differences in the representation of female and male students among STEM applicants, we focus on this sample of talented students and identify those ranking a STEM program at the top of their list. In the contexts we study, admission to STEM programs depends on students' academic performance—typically measured by a weighted average of admission exams and high school GPA—and on whether students include a STEM program in their application list. Thus, differences in the representation of different genders in STEM programs can be driven by differences

[8] This classification distinguishes ten fields of study: Agriculture, Arts and Humanities, Business and Law, Education, Engineering and Manufacturing, Health, Information and Communication Technologies, Natural Sciences and Mathematics, Services, and Social Sciences. See the following link for further details.

[9] In all ten settings in our study, access to higher education requires a university admission exam, which all prospective university students must take. These exams typically consist of mandatory sections that all students complete, along with elective sections. With the exception of Australia, we use the scores from the mandatory sections to define our measure of academic performance. For Australia we use a combined score, which is used by universities to select their students. Students are then divided into deciles based on their performance within each setting and year. Our analysis focuses on students in the top decile of the academic performance distribution, identified as the most talented students.

in academic performance or in the programs students rank in their application lists. Our data allows us to decompose these two channels that we define as the *pipeline* and the *choice gap*. We measure the pipeline gap by computing the share of female and male students in the top 10% of the academic performance distribution. The pipeline gap captures gender differences in eligibility for selective STEM programs. We measure the choice gap as the difference in the probability that female and male applicants in the top 10% of the academic performance distribution rank a STEM program at the top of their application list. The choice gap captures gender differences in application for STEM programs.

3.2 Female and Male Representation among STEM Applicants

Figure I illustrates the share of female and male students among STEM applicants. As explained in Section 3.1, the sample behind this figure includes only students who are in the top 10% of the academic performance distribution in each setting and who rank a STEM program at the top of their application list.

In all settings, the female share is lower than the male share. However, there are some large differences between the educational systems we study. In five out of the ten settings in our sample, female students represent less than 30% of STEM applicants. Taiwan, whose STEM female share is 18.7%, has the lowest female representation among STEM applicants. In contrast, Spain, Australia, Greece, and Sweden—with STEM female shares ranging between 42.6% and 46.4%—are the countries with the highest female representation among STEM applicants. Next, we decompose these differences in the pipeline gap—i.e., gender differences in representation in the top 10%—and in the choice gap—i.e., gender differences in the probability of ranking a STEM degree at the top of the application list, conditional on belonging to the top 10%.

3.3 The Pipeline Gap

Figure II illustrates the pipeline gap. The bars represent the share of female students in the top 10% of the academic performance distribution in each educational system. As explained in Section 3.1, we rely on the sections of the admission exam that all applicants take to identify students in the top 10%. As women represent roughly 50% of the population, bars under 50% indicate that women are under-represented in the top 10% of the academic performance distribution.

In almost half of the settings we study—Brazil, Chile, Taiwan, and Uganda—the share of female students in the top 10% of the academic performance distribution is under 50%. Uganda has the lowest female share among top students, with only 40.4% of female students belonging to the top 10%. In the other half of the settings we study—China, Finland, Australia, Greece, Spain, and Sweden—female students represent more than 50% of students in the top 10% of the academic performance distribution. Sweden has the highest overrepresentation of female students among top students, with almost 66% of them being female.

When comparing Figures I and II, it becomes clear that the pipeline gap cannot fully explain differences in gender representation among STEM applicants. For instance, female students in China and Finland represent over half of the top students but only 30% of STEM applicants. Next, we study the choice gap.

3.4 The Choice Gap

Figure III illustrates the gender choice gap. The bars in panel (a) illustrate the share of female and male students in the top 10% ranking a STEM program at the top of the application list. The bars in panel (b) illustrate the differences between these shares, i.e., the choice gap.

In contrast to the significant cross-setting differences observed in the pipeline gap, the choice gap is remarkably similar across the settings in our sample. In all of them, female students are considerably less likely to rank a STEM program at the top of their list. In seven of the ten educational systems that we study, female students in the top 10% are between 22 and 26 percentage points less likely than their male counterparts to rank a STEM degree at the top of their list. On the extremes, we find that Australia has the smallest (16 pp) and China has the largest choice gap (36.7 pp). Next, we discuss some implications of these results and study whether the gaps we have documented so far correlate with the gender norms of the settings in our study.

3.5 Discussion

Female students are underrepresented among talented students applying to STEM in all the settings we study. The level of this underrepresentation, however, varies across settings. Indeed, while in

Taiwan only 19% of STEM applicants are female, in Sweden this figure is 46%. As shown in Sections 3.3 and 3.4, differences in female representation among STEM applicants are explained by a combination of the pipeline and the choice gap.

The pipeline gap does not always go against female applicants. Indeed, in half of the settings we study females represent more than half of top 10% students, suggesting that the pipeline gap cannot fully explain differences in gender representation among STEM applicants. The choice gap, however, is negative and big in all the settings in our sample. As discussed in Section 2, the settings we study differ in size, location, economic development, and gender norms. It is thus remarkable to find that the STEM choice gap is similar—it varies between 22 and 26 percentage points—in settings as different as Brazil, Chile, Finland, Greece, Spain, Sweden and Uganda. In Australia, the STEM choice gap is smaller—i.e., 16 percentage points—and in China and Taiwan it is larger—i.e., between 28 and 36 percentage points.

Gender norms are often cited as a potential driver of differences in educational outcomes of female and male students (see for instance Akerlof and Kranton, 2000; Guiso et al., 2008; Bertrand, 2020). To explore whether this hypothesis has some support in the data, we study correlations between the pipeline and choice gaps and the World Economic Forum Gender Parity Index (explained in Section 2). Figure IV plots these relationships. Consistent with Guiso et al. (2008) and Fryer Jr and Levitt (2010), we find that in contexts with higher gender parity, the share of female students at the top of the academic performance distribution increases (panel a). We also find that the size of the STEM choice gap declines with gender parity (panel b). This relationship, however, is weaker than the relationship between the pipeline gap and gender parity, which is mostly driven by the extreme points of Australia and China. Although there is an association between gender norms and both the pipeline and choice gaps, the relationship is weak. Thus, differences in gender norms explain little of the gender gaps we document in academic performance and educational choices.

The large and consistent STEM choice gap we document in the ten educational systems we study indicates that reducing gender gaps in academic performance is not enough to eliminate gender differences in higher education trajectories. Understanding the factors behind these choices is thus essential for effectively addressing gender inequality in educational trajectories and, by extension, in other important outcomes.

4 Conclusion

This paper documents sizeable gender differences in the representation of talented students applying to STEM majors in Australia, Brazil, Chile, China, Finland, Greece, Spain, Sweden, Uganda, and Taiwan. We take advantage of a common feature of these settings' college centralized application systems: university admission decisions rely on algorithms that allocate students to specific college-major combinations based on their academic performance when applying to university. In the settings we study, female representation among STEM-major applicants can be driven either by gender gaps in academic performance at the time of application or by gender gaps in the programs that these top-scoring students rank in their application lists. While we find some significant variation in female representation among the top 10%, we see a remarkably stable gender gap in favor of men in applications to STEM across settings.

The inequalities that we document in college applications across gender groups have important equity and efficiency implications. Returns to higher education vary substantially by field of study. The gender differences we find in applications to STEM—a field associated with high returns—could therefore explain part of the inequality we observe in the labor market. From an efficiency perspective, improving the gender balance among applicants to different fields of study could result in a better allocation of talent and boost economic growth. As suggested by Hsieh et al. (2019), attracting talented women to high-skills fields in which they have been historically underrepresented could result in important gains in terms of economic growth and aggregate output. Moreover, due to the growing concerns about a shortage of STEM workers in advanced economies, the leveling off of the increase in women's participation in STEM in the last decade (National Science Foundation, 2017) likely exacerbates a loss of talent that may negatively impact overall productivity (Weinberger, 1999; Hoogendoorn et al., 2013).

Our findings suggest that closing the gap in academic performance is not enough to eliminate these differences. There are important differences in the fields of the programs to which similarly highly talented individuals apply depending on their gender. Our results indicate that beyond all the differential elements that all ten settings have, such as population size, economic development, or gender norms, there are still important factors that shape gender gaps in higher education trajectories. Identifying these factors and understanding their role in forming preferences for colleges and fields of study is key to tackling inequality and improving efficiency in educational pathways, and by extension, in the labor market.

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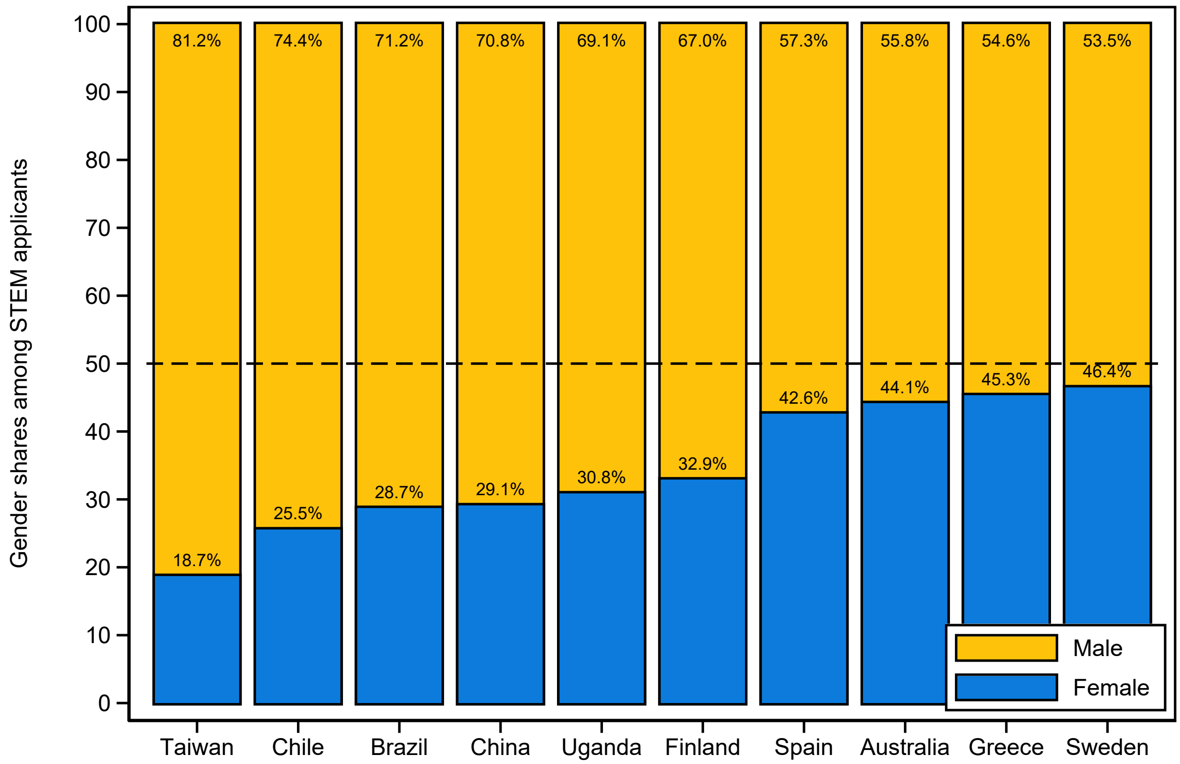
Table I: Institutional Characteristics

	Australia (1)	Brazil (2)	Chile (3)	China (4)	Finland (5)	Greece (6)	Spain (7)	Sweden (8)	Taiwan (9)	Uganda (10)
Panel A: Setting Characteristics										
Population	24,592,588	209,469,320	18,729,170	1,402,760,000	5,515,520	10,732,880	46,797,750	10,175,210	23,948,264	40,127,085
GDP per capita	$56,384	$20,625	$30,958	$23,643	$56,231	$41,443	$50,350	$61,977	$65,694	$3,514
Human Development Index	0.937	0.764	0.849	0.755	0.937	0.881	0.905	0.943	0.925	0.534
Gini index	33.7	53.9	44.4	38.5	27.3	32.9	34.7	30.0	34.2	42.8
Gender parity index	0.778	0.726	0.777	0.678	0.863	0.693	0.791	0.815	0.764	0.706
Panel B: University System Characteristics										
Institutions using centralized admissions	21/21	132/2448	34/60	1,252/2,663	36/38	41/41	50/86	41/41	67/67	8/8
Tuition fees	Yes	No	Yes	Yes	No	No	Yes	No	Yes	Yes
Financial aid for higher education	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel C: Admission System Characteristics										
Options available (yearly avg.)	1,078	6,310	1,423	18,671	1,458	609	2,169	15,374	1330	149
Max. number of preferences students can submit	12	2	10	90	6	No limit	12	20	100	6
N of applicants in a year (avg)	41,883	2,712,937	84,658	60,500	69,600	68,000	379,777	76,053	101,153	40,549
N of admitted students in a year (avg)		237,451	59,588	44,351	24,360	54,000	221,134	42,985		
Female share among applicants	55.6%	57.14%	56.16%	55.59%	60.0 %	55.8%	55%	59%	48.6%	43.92%
Data coverage	2009-2010	2016	2004-2018	2018	2016-2020	2003-2012	2018-2020	2008-2017	1996-2003	2011/2013-2018

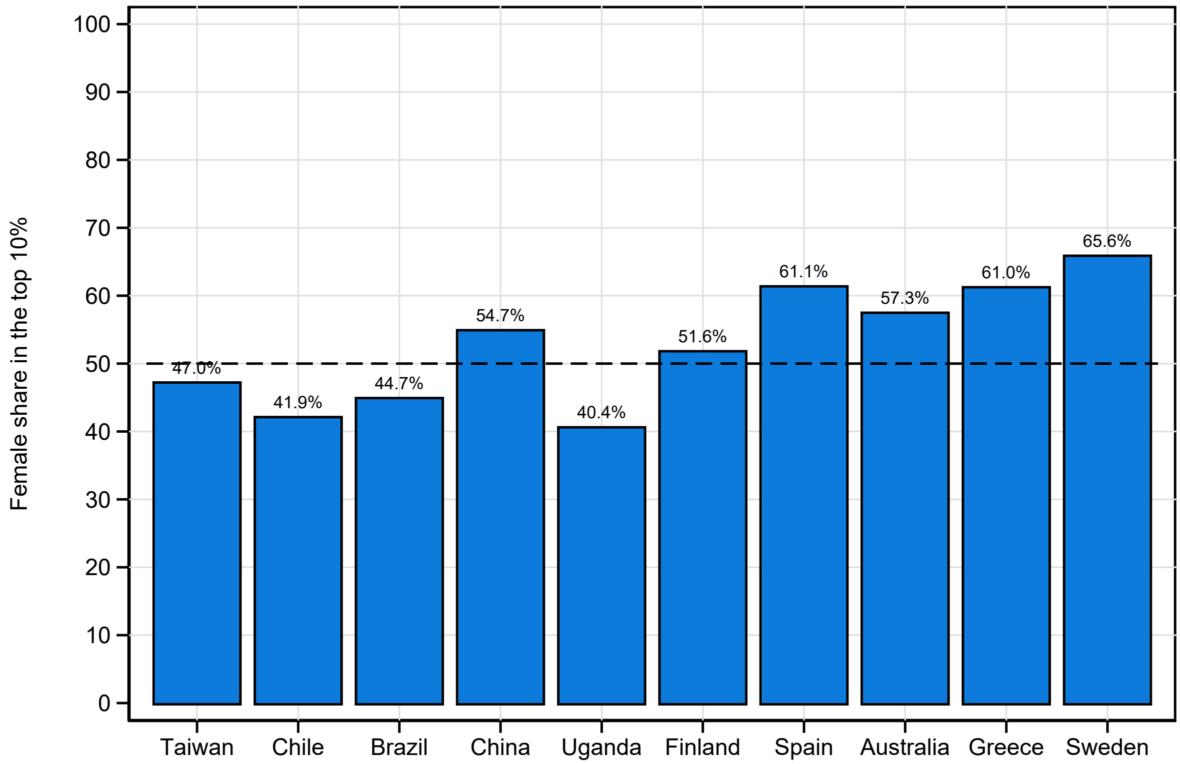
The table provides summary statistics characterizing the settings in our sample and their university admission systems. Panel A provides general information on each setting, panel B characterizes their university systems, and panel C describes their university admission systems. The statistics presented in Panel A come from World Economics (https://www.worldeconomics.com/GDP-Per-Capita), United Nations Development Programme (https://hdr.undp.org/data-center), and the World Economic Forum (https://www3.weforum.org/docs/WEF_GGGR_2023.pdf). The Gender Parity Index of Taiwan come from Gender at a Glance in R.O.C. (Taiwan) report (https://gec.ey.gov.tw/en/44A64D84C166AE4A), since the World Economic Forum does not have that index for Taiwan. However, the government of Taiwan uses the same methodology to calculate the index.

Figure I: Gender Shares among STEM applicants (top 10% students)



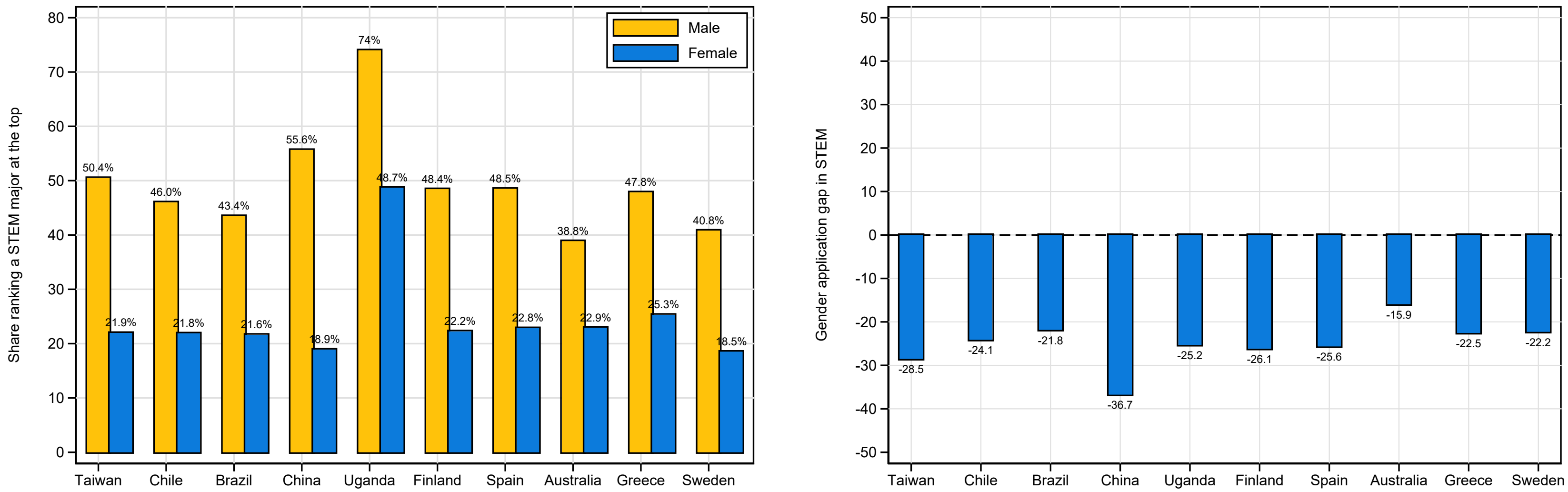
Notes: This figure illustrates the gender composition of applicants ranking a STEM degree at the top of their application list. As described in Section 3.1, we focus exclusively on students in the top 10% of the academic performance distribution for this exercise. Each bar illustrates female and male shares for different contexts. Settings are ordered from lower to higher female representation among STEM applicants.

Figure II: Share of Female Students in the Top 10% of the Academic Performance Distribution



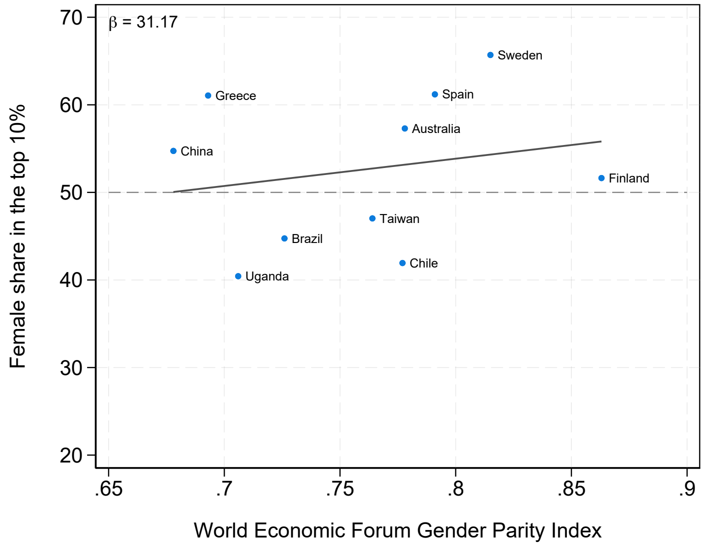
Notes: This figure illustrates the shares that female students represent among students in the top 10% of the academic performance distribution in all the settings we study. As explained in Section 3.1, we rely on sections of admission exams taken by all applicants to identify students in the top 10%. The bars are ordered from lower to higher representation of female students among STEM applicants.

Figure III: The Gender Choice Gap in STEM (Top 10% Students)

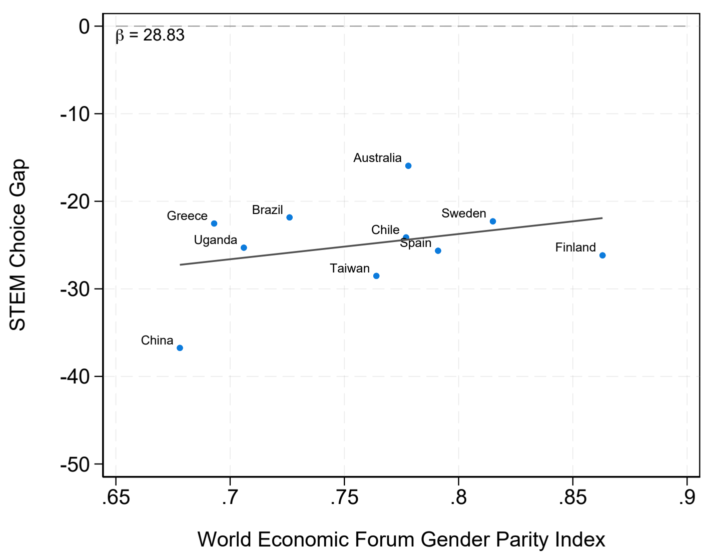


Notes: This figure illustrates differences in the likelihood that female and male applicants in the top 10% of the academic performance distribution rank a STEM degree at the top of their application list. Panel (a) illustrates levels, while panel (b) focuses on differences between female and male applicants.

Figure IV: Female Representation in the Top 10% and the Gender Application Gap in STEM vs the World Economic Forum's Gender Gap Index



(a) Female share in the top 10%



(b) STEM Choice Gap

Notes: Panel (a) in the figure illustrates the relationship between the share that female students represent among students scoring in the top 10% of the college admission and the World Economic Forum's Gender Gap Index. Similarly, panel (b) illustrates the relationship between the gap in the share of female and male students who, conditional on scoring in the top 10% of the college admission exam, rank a STEM major at the top of their application list and the World Economic Forum's Gender Gap Index. For more details on the World Economic Forum's Gender Gap Index, visit https://www3.weforum.org/docs/WEF_GGGR_2023.pdf.

The Choice Gap Problem in Access to Higher Education: Evidence from Centralized College Admissions in Five Continents

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Contents

A Institutional Details

This section provides additional details on the admission systems through which colleges select their students in the educational systems that we study. It also provides information on the data sources we use in this project.

A.1 Australia

Australian states use separate clearinghouses that operate using similar rules. Our study focuses on the clearinghouse in the state of Victoria. Each student submits a ranked ordered list of up to 12 college-major combinations to the clearinghouse, which allocate them to the highest-ranked combination to which they are eligible based on the student rank in the applicants' cohort (an "Australian Tertiary Admissions Rank", ATAR). ATAR uses a combination of scores for a variety of subjects with a possible small adjustment based on the student's affirmative action status. As two students may have zero subjects in common, we use ATAR as the measure of academic performance. A high school subject result combines an end-of-academic-year exam, administered in November, and the results of the tests throughout the last year of high school. Students finalize their ranked list once they receive their ATAR in December, are offered admission in January, and have a few weeks to enroll.

Our data for Australia comes from the Victorian Tertiary Admissions Centre, a clearinghouse that processes the applications. It includes individual-level information on all students applying to tertiary institutions in 2009 and 2010. The variables include performance in English and math subjects, applicants' ranked choices, gender, and parental education, which we use to proxy socioeconomic status. We classify students whose parents at most completed high school as low-SES, and those who have a parent with a bachelor's degree as high-SES.

A.2 Brazil

All public tertiary institutions in Brazil can opt to participate in a centralized digital platform that matches students to degree programs (SISU).[10] The students are assigned to degree programs using an iterative deferred acceptance algorithm that takes into account performance in the national university entrance exam (ENEM), student preferences, and affirmative action status.[11] The ENEM takes place at the end of the Brazilian academic year in December. Students submit their preferences in the first week of January, receive their results the third week of January and have until the last week of January to accept or reject an offer. Students can submit up to 2 choices in their application form. Private universities use decentralized admissions right after the assignment by SISU.

Our data for Brazil cover the year 2016 and are made up of two datasets in which we observe

[10] Centralized matching for public universities was introduced in 2010. By 2016 - the year of our data - 57% of the 4.8 million university entrance exam takers applied to a degree program using the SISU platform.

[11] To implement affirmative action, each degree sets aside quotas reserved for students from public high schools. As a result, targeted students face lower admission cutoffs than non-targeted students.

all applications submitted to the centralized admission system and students' test scores. The data include students' overall and subject-level scores, students' ranked preferences for specific college-major combinations, demographic characteristics—i.e., gender and age—and self-reported household income.

A.3 Chile

Chile uses a nationwide centralized admissions system that covers all public universities and 17 out of the 43 private universities.[12] As in the case of Brazil, students are allocated to specific college-major combinations through a deferred acceptance admission algorithm. Students submit a list of up to 10 preferences and are then allocated the highest one for which they are eligible based on their high school GPA, their performance in a national level college admission exam (PSU), and affirmative action status.[13] In contrast to Brazil, less than 4% of the seats offered by the universities that participate of centralized admissions are reserved for low-ses students. Students take the PSU in early December, at the end of the Chilean academic year, but register for the examination in mid-August. Students receive their scores and apply for college using an online platform by the end of December. In early January they learn where they were admitted and have a couple of weeks to decide whether to take or reject the offer.

Our data for Chile comes from the Chilean agency in charge of college admissions, DEMRE, and includes individual-level information on all students who registered to take the PSU between 2004 and 2018. The data include students' performance in high school and on each section of the PSU; students' ranked application choices; demographic characteristics (gender and age); and parental education, which we use as a proxy for socioeconomic status. We classify students whose parents at most completed high school as low-ses, and students whose parents had some university education as high-ses.

A.4 China (Ningxia Hui Autonomous Region)

China, including the Ningxia province, uses a college admissions system centralized at the province-track level. Students only compete for college-major vacancies with peers within the same province. All Chinese provinces match students to tertiary education places using the Chinese Parallel mechanism, which is similar to deferred acceptance, and takes into account students' choices and their academic performance in a national entrance exam (College Entrance Examination, CEE).[14] The process begins with the administration of the CEE in early June. In mid-June, all Chinese colleges

[12] In total there are 60 universities in Chile. Before 2012 only 9 private universities participated in the centralized admission system. In 2012, eight new institutions joined the system. Since 2020, most universities use the centralized admission system. Admissions to two-year colleges are fully decentralized.

[13] In 2018—the last year we observe for Chile—the registration fee for the PSU was around USD 47. As of 2006, all public and voucher school graduates (93% of high school students) are eligible for a fee waiver that makes the PSU free for them. The entire registration process operates through an online platform that automatically detects the students' eligibility for the fee waiver.

[14] See discussion in Chen and Kesten, 2017 on the Chinese Parallel mechanism.

publish their college-major allocation quotas for each province and their tuition fees. After learning their CEE score and the college-major quotas and fees, students submit their applications with up to 90 ranked choices at the end of June.[15] Students who choose not to pursue tertiary education do not submit applications.

Following the matching process, each student receives a single take-it-or-leave-it offer. If a student declines the offer or does not get any offers must wait until the following year to retake the CEE. The alternative is to enter the labor market with only a high school degree or to enroll at a tertiary institution abroad.[16]

We use data for the province of Ningxia for the year 2018, which is supplied by the Ningxia Department of Education. The data includes students' performance on the CEE; their ranked application choices; demographic characteristics (gender and age); and parental education that we use as a proxy for socio-economic status. As in the case of Chile, we classify students whose parents at most completed high school as low SES, and students whose parents had some university education as high SES. Ningxia is among the poorest provinces in China, yet application choices of students remain representative of those seen in the rest of the country (see for example Ding et al., 2021; Loyalka et al., 2021).

A.5 Finland

Most tertiary education institutions in Finland participate in a centralized college admissions system.[17] To assign students to seats, the system takes into account students' preferences, their high school exit examination, and/or a university entrance examination.[18] The assignment algorithm goes through queues in a pre-specified order and students are allocated to places by applying a deferred acceptance algorithm. The main application round takes place in spring. Finnish students submit their applications with their ranked choices a few months before sitting their university entrance exam and before knowing their final high school GPA.[19] Individuals submit applications through an online platform that is open for around two weeks in March. Students can rank up to six college-major combinations in their application.[20] The online platform also contains information on how different college-major combinations weight high school exit exams, program-specific

[15] In 2018, 42% of students from Ningxia remained in Ningxia. This number ranges from 15%-19% in all provinces. Of all students attending tertiary education in Ningxia, 35% are from other provinces. This number ranges from 10-80% in all provinces.

[16] Few students choose to go overseas after having taken the CEE. Those who aim to study abroad usually do not take the CEE and most of them have enrolled in foreign institutions before the CEE in June.

[17] 36 out of the total 38 tertiary education institutions are part of the centralized admissions system.

[18] Before 2020, most of the programs admitted students through three queues: the first queue considered only exit exams, the second queue ranked individuals based on a joint score of high school exit and university admission exams, and finally, some individuals were admitted only based on the university admission exams. In 2020, the joint score queue was abolished, and currently, individuals are admitted based on their high school exit exams or university admission exams only.

[19] Applications take place twice a year, once in the fall and once in spring, but in this paper, we focus on the spring period since the number of programs offered during the fall round is very limited.

[20] In earlier years, students were able to list more courses.

queues, and whether there exist any special requirements. Once an offer is made, students can decide whether to accept the offer and enroll in that college-major or not.

Our data for Finland come from two registers maintained by the Ministry of Education—HAREK and AMKOREK—for the years 2016 to 2020. In these data, we observe the full set of applications, whether a student took the college entrance examination, high school GPA, and high school exit examination grades. We augment this dataset with information from Statistics Finland on the student's age and parental education. As in the case of Chile and China, we classify students whose parents' highest level of education is high school as low-SES. Students with at least one parent completing university and a master's degree are classified as high-SES.

A.6 Greece

Most tertiary education institutions in Greece are public and use a centralized admissions system.[21] Students are assigned to tertiary education places using a deferred acceptance admissions algorithm that takes into account performance in a college admissions examination (Panhellenic Examinations, PE), student preferences, and affirmative action status.[22] Well in advance of the PE, the Ministry of Education publishes the number of places for each college-major and the subject weights assigned to different parts of the PE.[23] Students sit the Panhellenic Examinations in May-June and after getting their results submit their application forms with their ranked preferences in early August. There is no limit to the number of choices. However, students can only apply to at most 2 out of the 5 general subject categories into which college majors are divided into. In practice, this translates to about 350 choices out of 600 available.

Each student receives a take-it-or-leave-it offer and if a student declines the offer they can retake the exam the following year at no financial cost.[24] Some students do not receive any offers and can also retake the following year. In our analyses, we focus on first-time applicants.

Our data for Greece are supplied and maintained by the Ministry of Education and include the universe of applicants. For each student, we observe their full set of choice lists, their final PE score, their gender, and the high school they attended for the years 2003-2012. From the Ministry of Finance, we obtained a measure of average household income at the postcode level for the year 2009, which we match to the location of students' high school. We use the latter information as a proxy for socioeconomic background. We define low-SES students as those coming from the bottom third of the income distribution and high-SES those coming from the top third.

[21]There are a number of private universities using a fully decentralized admissions system. However, graduates of private institutions do not yet have equal degree recognition rights as graduates of public institutions within Greece.

[22]Affirmative action works by reserving a pre-specified proportion of college places for specific sub-groups, and affects around 5% of applicants. Thus students from a specific sub-group that benefits from affirmative action compete only with other students with the same status.

[23]The PE consists of 6-9 papers that are centrally set and graded.

[24]Students can also retain their first PE score and re-use the following year. However, they will not be competing with the main cohort, only with other students who also chose to defer their entrance.

A.7 Spain

Spain has 86 universities, 50 public and 36 private. Private universities have a fully decentralized admission system, while public universities select their students using a centralized deferred acceptance admission system that takes into account a weighted average of the high-school GPA and a college entrance exam (EBAU).[25] Most students enroll in a public university program (83%). The students take the entrance exam at the beginning of June, which corresponds to the end of the Spanish academic year. Students apply to their majors of interest using an online platform open between mid-June and the beginning of July and can submit a rank-ordered list of up to 12 college-majors combinations. Colleges publish the list of majors and vacancies offered for the next academic year before the application starts. The results of the first round of admissions are published in mid-July. Students can either accept their initial offer and pre-register or reject it. If they reject this initial offer, they could end with no offer or with an offer for an option far down in their priority list.[26]

Our data for Spain cover students who take the EBAU to access university (81% of an average cohort) between 2018 and 2020 and come from the Spanish Ministry of Universities.[27] We observe students' GPA in high school, their score in the EBAU, and their list of preferences. We also observe their age and gender. As in other countries, we approximate socioeconomic status with parental education: students whose parents at most completed high school are classified as low-SES, while students whose parents completed a higher education degree are classified as high-SES.

A.8 Sweden

In Sweden, postsecondary education is tuition-free and all students are eligible for a monthly stipend as well as a subsidized loan. Admission to tertiary education in Sweden is centrally managed by Universitets och Högskolrådet (UHR). Students are matched to tertiary education places using a deferred acceptance algorithm that takes into account students' ranked preferences, their high school GPA, and/or their university entrance examination (Högskoleprovet). As in Finland, but unlike the college admission exams of the other countries in the study, the university entrance exam is voluntary. The system contemplates multiple *admissions queues* and students can participate in all of them simultaneously. For each program, at least a third of the vacancies are reserved for a group that only competes based on high school GPA. At least another third is allocated based only

[25] The final grade for each student is computed as a weighted average of two-year high school GPA (60% of the total score) and the entrance exam (40% of total score). Students can gain extra points by taking elective subjects in the entrance exam. The final score ranges between 0 and 14 points, where the threshold of passing is established at 5 points.

[26] If a student rejects the offer, she can apply to a different program. If the program is over-subscribed the student is placed on the waiting list even if she has a higher score than others currently admitted because she modified her order of preference after the deadline of the first applications.

[27] Students not entering university through the standardized entrance exam represent a 19% of first-year students. 53% of them come from the vocational track of tertiary education. The other 47% of them already completed a university degree, come from foreign universities, or took special exams designed for students older than 25, 40, and 45 years old.

on the university admission exam. The remaining third of vacancies are also mostly assigned by high school GPA, but can sometimes be used for special admission paths.[28]

Applicants' best ranking determines their admission status. Two rounds of applications are organized each year, a larger one in April for programs and courses starting in August and one in October for those starting in January.[29] As in Finland, most students submit their rank of preferences before knowing their high school GPA. Students may rank up to 20 alternatives in each application round. After an initial round of allocations, applicants can choose to accept any offer they receive or participate in the second round for admission to higher-ranked alternatives.[30] If a first-round offer is declined, it cannot be recovered.

The data for Sweden come from the Swedish Council for Higher Education (UHR) and cover the years 2008 to 2017. The data contain information on students' high school GPA, their scores on the college admission exam, and their rank of applications. We match individual records to data from Statistics Sweden to obtain information on their gender, age, and parental education. As in previous cases, we classify students whose parents' highest level of education is high school as low-SES and students whose parents attended university as high-SES.

A.9 Taiwan

In Taiwan, all the public and private universities participate in a centralized clearinghouse operated by the Joint Board of College Recruitment Commission (JBCRC). The admission unit is a university-major combination (termed as a "program"). Students need to take two exams, General Scholastic Ability Test (GSAT) in January/February and Advanced Subjects Test (AST) in July. After knowing their scores, students submit their rank-ordered lists (ROLs) to the clearinghouse. The maximum number of choices that each student can rank is 100 in the most recent academic year. University programs rank students by evaluating students' exam performance mainly in AST. Students are assigned to programs via a program-proposing Deferred Acceptance (DA) algorithm. The final placement results are announced in August. Students can only enroll in the program to which they are assigned (or opt out of the system) as there is full compliance strictly executed (with very few exceptions applied to top-scoring students).

Our data for Taiwan come from JBCRC's administrative registers and cover years 1996-2003. We observe students' exam scores of all the subjects in both GSAT and AST, their reported ROLs, and final admission outcomes. Augmented with various insurance records from Taiwan's Ministry of Labor, we also observe rich information on students' demographics and family background, such as age, gender, residential location, parental income and education level. Furthermore, attributes

[28]This is the case in some highly selective majors, where an additional test or an interview is sometimes used to allocate this last third of vacancies. We do not include admissions through such groups in our analysis.

[29]Students can apply to full-time programs and short courses in the same application. A student can never be admitted to multiple programs in the same semester, but could be admitted to both a course and a program, or multiple courses.

[30]Their scores and lists of preferences do not change between the two rounds, but the admission cutoffs might.

of high schools from which students graduated are observed supplied by the Ministry of Education. We define a student to be low-SES if her parents at most completed high school, and high-SES if her parents had some university education.

A.10 Uganda

As of 2018, Uganda had eight public universities and 44 private universities. According to the National Commission on Higher Education, more than half of university enrollments are in public universities. Students can be admitted to public universities through two schemes: the national merit scholarship, which covers both living expenses and tuition, and the self-funding scheme, where students pay for both tuition and living expenses. The national scholarship scheme is centralized, while the self-funding scheme and admissions to private universities are decentralized. Admission to universities under either scheme is based on test scores, specifically the ”weighted score” of national exams, which are similar to subject-based SATs in the U.S.[31] Students apply to the centralized scheme before knowing their test scores, typically between December and January, with some even applying before taking their national exams in early December. Offers are usually announced around March or April. Unlike in many other countries, students in Uganda take exams in three subjects, known locally as the ”subject combination,” when leaving secondary school. This combination may vary by student. For example, one student might take exams in biology, chemistry, and math, while another might take physics, economics, and math exams. Thus, students' tracks (STEM or non-STEM) are determined early during upper secondary school. A student who takes a non-STEM subject combination cannot apply for STEM majors at university, but the reverse is possible—a student with a STEM subject combination can apply to both STEM and non-STEM programs. However, before selecting their "A-level" secondary subject combination, students must take national exams in at least eight subjects at the end of "O-level" (similar to junior high school). These exams can qualify students for specific subject combinations and influence their future career paths in STEM, social sciences, humanities, or business. Our data from Uganda covers university applicants through the centralized platform, the Public University Joint Admissions Board (PUJAB), spanning at least seven years. This dataset includes each student's preference list, ranking six majors in order of preference, along with their test scores in the subject combinations and scores in the O-level national exams. We also have information on each applicant's age, gender, high school, and district of origin. Most importantly, we observe universal test scores from O-level school exams, which allow us to determine the cut-off scores for the students in top 10% of the score distribution. We then use this cutoff to observe if applicant scores in O-level English and Math were in the top 10% of the score distribution.

[31]There are additional schemes of admissions, such as district quota, disabled quota, sports, international students, mature age, and diploma or degree holders. Still these categories depend on test in national exams and make up a very small portion of the total admissions and are mostly self-funded, except for the district and disabled quotas. Also, more recently, the largest public university has implemented a gender affirmative action policy that sets quotas for either gender to utmost 60% of the slots in each major.