Unintended Consequences of Free College: Self-Selection into the Teaching Profession*

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Abstract

Teacher quality is one of the most relevant factors influencing student learning. However, attracting and retaining skilled people to the teaching profession is challenging. In this paper, we study how making college tuition free affects the pool of students pursuing a teaching career. We exploit the conjunction of two tuition-financing policies implemented in Chile: a scholarship introduced in 2011 for teaching majors, and a massive 2016 reform that made college tuition free for students from households in the bottom 50% of the income distribution. We use the programs' differences in timing and eligibility criteria to study the effects free college had on the self-selection of students into teaching majors. We find that free college decreased the relative returns to pursuing a teaching career, making it substantially less popular among relatively poor high-performing students who now self-select into degrees with higher returns. We find that the reform reduced the academic qualifications of the pool of students entering the teaching programs, which can negatively affect long-term teacher quality.

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1 Introduction

Teachers are a critical input in the formation of early human capital. Teacher quality is one of the most relevant external factors influencing academic achievement.[1] Effective teachers can create fruitful learning environments, inspire and motivate students, compensate for the lack of a favorable home environment, and help level the playing field for students who lag behind. A seminal study in the US shows that having a higher-quality teacher raises the probability of college attendance, the quality of the colleges to which students attend, and annual earnings (Chetty et al., 2014).

But, where do good teachers come from? There is convincing evidence that most high-quality teachers were once top- performing high school graduates.[2] Therefore, attracting high academically performing students to teaching majors is critical for the success of education systems. Thus, policies intended to attract, retain, and develop academically talented people for the teaching profession have become central to education policy (OECD, 2005; Bruns and Luque, 2015).[3] However, in most countries, colleges struggle to attract students to teaching majors, particularly high performers. For example in the US, teacher education enrollments dropped from 691,000 to 451,000 between 2009 and 2014, a 35% reduction (Sutcher et al., 2016); and for both, Latin America and the United States, there is robust evidence showing

[1]Several studies have found positive and meaningful impacts of teacher performance on student learning outcomes and academic achievement in kindergarten (Araujo et al., 2016), elementary school (Schacter and Thum, 2004; Bau and Das, 2019), and high school (Hanushek et al., 2018). Moreover, some evidence also suggests that teacher effects are persistent and matter not only in the current or following year but also in subsequent years (Konstantopoulos, 2011).

[2]Evidence from Teach for America (TFA), a program that recruits graduates from selective colleges in the US to teach in the most challenging K-12 schools, shows that students lectured by TFA teachers score higher on standardized tests despite the lack of experience of TFA teachers (Glazerman et al., 2005; Xu et al., 2011). Similarly, impact estimates of *Enseña Chile*, the Chilean adaptation of TFA, suggest that placing outstanding college graduates in the most vulnerable schools results in significant student gains in cognitive and non-cognitive abilities (Alfonso et al., 2010). Furthermore, highly successful education systems like Finland, Singapore, and South Korea rely on extremely competitive processes to select those allowed to become teachers before they enroll in teaching degrees (Auguste et al., 2010; Seng Tang, 2015).

[3]Such policies typically combine monetary and non-monetary incentives in order to increase the return of pursuing a teaching degree and to make it more appealing to students who may choose more rewarding degrees in other fields (OECD, 2005). These efforts include special scholarships, offering free study-abroad semesters, stipends, and allowances to cover living expenses (Santiago, 2002; Claro et al., 2013).

that students enrolling in teaching degrees are disproportionately drawn from the lower end of the academic proficiency distribution (Santiago, 2002; Eide et al., 2004; Balcázar and Ñopo, 2014), and tend to score lower on IQ tests than those who enroll in other fields (Lang and Palacios, 2018). This can result in a misallocation of talent if one considers the production of human capital of future generations.

Economic literature agrees that, to a large extent, this state of affairs is explained by a combination of low expected labor market returns and low social recognition of the teaching profession (Elacqua et al., 2018; OECD, 2018). Teachers are among the lowest paid college graduates.[4] Recent evidence shows that the economic returns to teaching degrees is relatively low or even negative, meaning that teacher earnings may not compensate the financial and opportunity costs of pursuing such degrees, and that high academically performing students systematically enroll in degrees with higher economic returns, such as STEM, business, and law (Gonzalez-Velosa et al., 2015; Espinoza and Urzua, 2016; Hastings et al., 2013).

Despite the consensus on the causes of the negative correlation between academic achievement and the likelihood of enrolling in teaching majors, economic literature has yet to explore how the problem could potentially be exacerbated by the increasing pressure citizens have put on governments and education systems to reduce or eliminate financial constraints affecting access to tertiary education. Policies aimed at making access to tertiary education more affordable and equitable will not only alleviate the financial burden of pursuing a college degree, but will also affect how students self-sort into different majors (Bucarey, 2018). In this paper, we study how tuition-free college affects the pool of students pursuing a teaching career. We exploit a major 2016 reform carried out in Chile that made college tuition free for students from households in the lower 50% of the income distribution. We leverage the fact that the introduction of free college affected the application behavior of distinct groups of students depending on their eligibility to the *Beca Vocacion de Profesor* (BVP) tuition

[4]In OECD countries, for example, primary teachers are paid 85% compared to other tertiary-educated workers (OECD, 2017a). Studies in middle-income countries find that this effect is still significant after controlling for observable characteristics typically linked to labor productivity (Mizala and Ñopo, 2016).

grant, a scholarship program implemented in 2011 that was successful in bringing high-quality students into teaching majors (Castro-Zarzur, 2018). The BVP granted full scholarships to students willing to enroll in teaching majors who scored in the top 30% of the college entrance exam. The free-college policy equalizes the relative prices of studying a wide range of different majors, potentially offsetting the incentives set out by the BVP.

Using a difference-in-difference strategy on a rich administrative dataset containing test scores, student applications, and enrollment, we compare the application and enrollment behavior of students in cohorts before and after the implementation of the reform. Thus, we identify the causal effect of eliminating tuition fees on student preferences for teaching degrees and the extent to which it affected the academic qualifications of students pursuing a teaching career. Our results suggest that granting tuition-free access to college decreased the demand for teaching programs of top-performing students. In consequence, students admitted to teaching degrees achieve, on average, lower academic performance than before the policy. The introduction of tuition-free access to college reduced the probability of applying to a teaching major among high-performing students who come from relatively poor backgrounds by about 15.8%, offsetting the gains obtained by the BVP scholarship during its first years of implementation. Furthermore, the average academic proficiency among those who applied to a teaching degree fell by 14% of a standard deviation in math and 8.8% of a standard deviation in language, while the average score of those who were accepted into other majors remained unchanged. The drop was concentrated on the relatively poor high school graduates whose score fell by around 16% of a standard deviation in both math and language.

Our paper highlights the potential unintended consequences of policies distorting equilibrium prices in markets such as higher education, and the potential long-term effects of such policies on teacher quality through a decrease in the qualifications of students pursuing teaching degree programs. Thus, we provide an important input to the ongoing international debate on free college as we present evidence of some negative—albeit unintended—consequences of such policy, going beyond the commonly used argument against the policy: its financial burden on governments.

Our findings are likely to be informative even in contexts lacking previous ability-based scholarships, such as the BVP. Teaching majors tend to be the least costly in many countries—including the United States, where differential tuitions are being increasingly used. Hence, in the absence of tuition-free college, the relatively cheap teaching majors are a pathway to higher education for low-income students. As free college equalizes the tuition cost across all majors, this allows high performers from poorer backgrounds to substitute relatively cheap majors with other—likely costlier—programs. In that sense, the BVP is just a vehicle for identification as it allows us to implement a difference-in-difference strategy while providing important insights on the potential impact of free college on self-selection into the teaching profession in more general settings like the US, where the college tuition-free policy is gaining momentum and several existing programs are already pushing in that direction (e.g., New Mexico state-wide free college policy and the Excelsior program in New York).

The paper is structured as follows. Section 2 gives an overview of the institutional background of the teaching profession in Chile and explains the recent reforms of the higher education system. Sections 3 and 4 present the data and empirical strategy. Section 5 presents the main results and section 7 discusses the results and concludes.

2 Institutional Background

2.1 Access to Tertiary Education in Chile

Access to higher education has expanded considerably in Chile during the last 25 years (Espinoza and Urzua, 2016). The number of students enrolled in undergraduate degree programs has increased fourfold, from less than 250,000 in 1990 to 1.2 million in 2016 (Centro de Estudios MINEDUC, 2017). According to the World Bank Data, Chilean net enrollment rate is 90.3%, making it the fourth-highest rate in the world. Such a high degree of coverage is the product of a multi-tiered system that comprises three types of tertiary education institutions: Universities (*Universidades*) serving 42% of the enrolled population, Professional Institutes (PI, *Institutos Profesionales*) with 31% of the enrollees, and Technical Training Centers (TTC, *Centros de Formación Técnica*) enrolling the remaining 11% (Centro de Estudios MINEDUC, 2017). TTCs offer mostly two-year vocational programs and universities and PIs more often offer four to five-year majors. As opposed to PIs, universities are research-oriented institutions and have the exclusive right to offer certain degree programs such as medicine, law, and teaching degrees. Universities are further divided into two categories: 1) the 27 "traditional universities," which are part of the *Consejo de Rectores de Universidades Chilenas* (CRUCH)—a consortium that encompasses public and private universities founded before 1981; and 2) the remaining "non-traditional universities," all private and founded after 1981.

Student admissions to universities are determined based on merit within a dual system. First, a group of 41 universities, comprising all "traditional universities" and 14 private institutions, run a centralized matching system in which students apply by listing and ranking their preferred career choices, understood as a unique program-university pairs (e.g., teaching in university X, medicine in university Y, etc.). Each student can list up to 10 pairs. After the application process, students are matched with their choices using a deferred-acceptance matching algorithm determined upon the scores obtained in a nationwide standardized university entrance exam called *Prueba de Selección Universitaria* (PSU) and high school grades (Espinoza et al., 2017). The remaining universities run a decentralized process, although PSU scores are still required for admission. Because of the lack of a coordinated assignment in these remaining universities, students are not selected purely on merit. Some of these universities accept students on a first-come, first-served basis. Finally, PIs and TTCs also run

Table 1: Characteristics of the Teaching Degrees by Type of Institution

	Universities		Professional
	Centralized	Decentralized	Institutes (PI)
# of first-year students†	7,606	13,633	1,490
# of programs	295	702	112
Annual tuition (2015 USD)	2,971.0	2,427.9	1,712.5

Note: Unweighted average tuition across programs is shown. †Number of students calculated based on the number of non-zero vacancies opened by each program reported to SIES. PIs only offer assistant teacher diplomas. Source: SIES/CNED, 2015.

non-selective and decentralized admission processes.

2.2 The Teaching Profession in Chile

Chilean legislation requires that pre-primary and primary teachers hold a teaching degree granted by a state-recognized university. PIs and TTCs are allowed to offer only assistant teacher diplomas. There are two main ways students can enter the teaching profession. They can enroll in a teaching degree holding a high school diploma, in which case they obtain their degree in four to five years. Otherwise, students already holding a bachelor (or higher) degree can enroll in programs that train and certify professionals to teach in schools. These programs are shorter (one to two years) and give students pedagogical training.

In this paper, we focus on the incentives that delimit the pathway between high school graduation and teaching degrees. Hence, our analysis zeroes in on the undergraduate teaching majors and excludes postgraduate teaching degrees. In this context, Table 1 shows that in 2015 there were 1,109 four-to five-year undergraduate teaching programs, out of which around a fourth are provided by CRUCH universities.[5] These programs are the ones that enjoy greater prestige as evidenced by the fact that they charge on average substantially higher tuition than teaching programs in non-CRUCH universities.

[5]We define an undergraduate teaching program as one that grants a BA, that is deemed as education-related by the UNESCO classification, and requires at least 8 semesters for completion.

Table 2: Characteristics of Undergraduate Degrees Offered by Type of Degree

	Type of degree					
	Teaching		STEM		Others	
Number of programs	256		384		663	
Duration (years)	4.65	(0.03)	5.21	(0.04)	4.97	(0.02)
Annual tuition (2015 USD)	3,273.81	(43.83)	4,602.01	(48.85)	4,843.54	(56.16)
PSU score among enrollees						
Mean	567.61	(2.08)	588.44	(2.42)	581.65	(2.08)
Min	505.20	(1.80)	503.69	(2.31)	502.32	(2.15)
Max	660.31	(3.71)	697.79	(3.03)	685.15	(2.26)

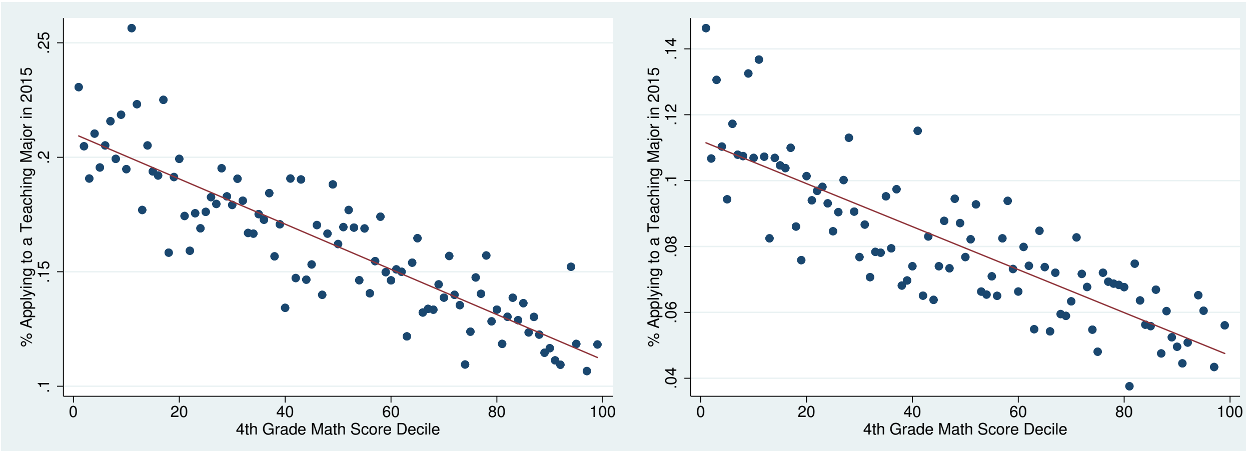
Note: The unit of observation is a degree-university pair. The sample includes all degrees offered in universities in centralized matching system. We exclude from the sample degrees offered by Professional Institutes and universities not in the centralized admission process. Standard deviation in parenthesis. Source: DEMRE and SIES, 2015.

Table 2, on the other hand, compares the four-to-five-year undergraduate teaching programs with programs in STEM and non-STEM fields granted by universities in the centralized admissions system. We see that teaching degree programs tend to be shorter than STEM degree programs, by about a semester, and their yearly tuition is on average 29% cheaper than STEM majors and 32% cheaper than non-STEM majors. Table 2 also shows that at the university-major level non-education majors are more selective in terms of PSU score requirements. Interestingly, the gap observed between the average teaching and non-teaching university majors comes from the high-achievers and not from the low-scorers. While there is virtually no difference between the typical minimum scores across types of majors, the typical maximum score in a STEM major is 37.48 points greater than in a teaching major. That is around a third of a standard deviation, as the PSU is designed to have a mean of 500 and a standard deviation of 110.

As in many other parts of the world including the US, Chile's teaching programs struggle to attract the most talented students (Eide et al., 2004; OECD, 2005; Alvarado et al., 2012; Balcázar and Ñopo, 2014; Castro-Zarzur, 2018; Gomez et al., 2019). Figure 1 shows a strong negative relation between early math proficiency—as measured by a nationwide assessment in

Figure 1: Fraction of Students Applying a Teaching Major by 4^{th} Grade Math Score, 2015 Graduating Cohort

(a) Listing a Teaching Major in the Choice Set (b) Listing a Teaching Major as Top Choice



Note: The left figure shows the share of students from the 2015 graduating cohort who listed a teaching major anywhere in their choice set by the 4^{th} grade math SIMCE decile. The right figure shows the share of students from the 2015 graduating cohort who listed a teaching major as their top choice by the 4^{th} grade math SIMCE decile. The lines in both figures represent a fitted regression line.

Table 3: Characteristics of Undergraduate Freshmen by Type of Degree

	Type of degree					
	Teaching		STEM		Others	
Overall PSU score	574.88	(0.571)	608.37	(0.474)	596.43	(0.332)
Language PSU score	587.43	(0.722)	586.59	(0.527)	601.65	(0.387)
Math PSU score	562.34	(0.700)	630.14	(0.530)	591.20	(0.373)
% From top 10% PSU score	12.32	(0.362)	32.83	(0.315)	26.89	(0.215)
% Female	62.98	(0.531)	27.47	(0.299)	59.10	(0.239)
Mother's years of schooling	5.99	(0.028)	6.56	(0.018)	6.74	(0.013)
% from public schools	29.32	(0.501)	24.43	(0.288)	22.79	(0.204)
% from voucher schools	58.87	(0.541)	55.10	(0.334)	50.12	(0.243)
% from private schools	11.26	(0.348)	20.02	(0.268)	26.44	(0.214)
% Teaching as 1st choice	20.16	(0.214)	0.09	(0.009)	0.21	(0.010)
% Teaching in top 3 choices	47.90	(0.267)	0.67	(0.025)	1.63	(0.028)
Number of students	8,233		22,187		42,358	

Note: The sample includes all students accepted in university degrees under the centralized matching system. Programs considered require at least 8 semesters for completion. We exclude from the sample students enrolling in Professional Institutes and universities running decentralized admission processes. Standard error in parenthesis. STEM programs include degrees in the fields of Sciences and Engineering according to the UNESCO classification of degrees. Source: DEMRE and SIES, 2015.

4^{th} grade in elementary school, when they were 10 years old—and the probability of applying to a teaching major. Figure 1a indicates that around 22% of low-scoring children as measured at age 10 will list a teaching major when they apply to college eight years later. That figure drops to 11% for top-scoring students. In the same way, Figure 1b reveals that while 11% of low-scoring 10-year-olds will list a teaching major as their top choice when they reach college age, only 5% of top scoring students will do so. Table 3 compares the characteristics of students enrolled in teaching degrees with those enrolled in STEM and other disciplines. We find that the gap in the average PSU score between those enrolled in teaching and STEM majors is about 30% of a standard deviation in favor of the latter. The students who end up enrolled in teaching degrees even trail other non-STEM majors (e.g., liberal arts, social sciences) by more than a tenth of a standard deviation. The gaps come mainly from the difference in math proficiency. STEM major enrollees score on average 61.6% of a standard deviation more than teaching major enrollees on the math section of the test.[6] Furthermore, of those who pursue a teaching degree, only 12.3% come from the top 10% of the PSU distribution, while a third of those enrolled in STEM do. The gaps reflect substantial low desirability and competitiveness of enrolling in teaching majors relative to others. This is made evident by the fact that only a fifth of those who enrolled in teaching programs had teaching as their top career choice, while virtually none of those who ended up in majors other than teaching listed teaching as one of their top three choices. Table 3 also shows that teaching is overwhelmingly female dominated. Two-thirds of the entrants to teaching majors were females, while only 25.7% of those going into STEM majors were. Teaching major enrollees are relatively more disadvantaged high school graduates: more of them come from public schools, and their average mother's education is half a year and three-fourths of a year less than STEM and non-STEM majors enrollees, respectively.

[6]This relates to the fact that, when tested in the TEDS-M—an international study that quantifies the math proficiency of those who are studying to become math teachers—future Chilean high school math teachers ranked second to last, while those who would become elementary school teachers ranked last, behind countries that are vastly less developed, like Botswana and Philippines (Elacqua et al., 2018).

The reasons behind the low demand for teaching degrees among relatively skilled students and those coming from affluent backgrounds are multiple and intertwined. First, there is low social recognition of teaching as a profession (Elacqua et al., 2018). According to recent surveys, only a third of parents would like their children to be teachers, and two-thirds of teenagers consider the teaching profession to be among the least prestigious occupations, with dismal favorability numbers similar to those of music and theater (Cabezas and Claro, 2011). Second, teachers are underpaid (Mizala and Ñopo, 2016) and labor market returns are very low, even though tuition is also relatively low (see Table 2). Chilean teachers earn on average 56% of what comparable college graduates do (Elacqua et al., 2018). Thus, teachers' lifetime incomes are not very different from people without a college degree (Espinoza and Urzua, 2016). In fact, Gonzalez-Velosa et al. (2015) estimate that Chilean education majors have a lifetime rate of return of -1%. Third, career development and salary raises are based on seniority and not on merit. Despite these downsides, the teaching profession is still attractive to many individuals, particularly those who are relatively more risk averse (Lang and Palacios, 2018) and therefore value income and job stability, and also to those who prefer longer holiday periods.

As a response to this worrying picture, the Chilean government has deployed a number of attempts to reform the teaching profession and to make it more competitive and appealing to prospective students (OECD, 2017b; Santiago et al., 2013). These initiatives include offering higher remuneration to teachers, reforming and expanding professional development opportunities, and subsidizing or fully paying the tuition of teaching degrees. Probably the most well-know initiative, the "Teaching Calling Scholarship" (*Beca Vocacion de Profesor*) or BVP, was introduced in 2011. The BVP recruits students scoring within the top 30% of the PSU into accredited, high-quality teaching programs. It is a merit-based scholarship and does not select student based on their income. It is available to prospective college freshmen scoring 600 or more in the PSU exam enrolling in a teaching major that participates in the program.[7] The scholarship has different benefits depending on the student's score. For those scoring on or above 600, it covers full tuition fees for the duration of the degree. Those who score on or above 700 are also eligible for a monthly stipend of about USD$150. Finally, for those scoring 720, the BVP offers a one-semester exchange program in a university in a foreign country (Bonomelli, 2017).

Until the introduction of the free-college program, the BVP was the only public scholarship covering 100% of tuition fees and had shown to be an effective mechanism to increase the participation of top scoring students in teaching degrees. Alvarado et al. (2012) find that in the year of its introduction, the BVP increased the probability of applying to and enrolling in teaching programs for eligible students (i.e., relatively better students in terms of PSU), and the share of students coming from the top-third of the PSU distribution increased from 10.7% to 18.1%. Claro et al. (2013) analyze the effect of the BVP on the profile of the students admitted to education programs in 2011 at CRUCH universities. They find that with the introduction of the scholarship, the probability of applying and being admitted to teaching programs significantly increased for better-performing students who come from poorer households and have relatively undereducated mothers. Finally, Castro-Zarzur (2018) studies the impact of the BVP during 2011-2016, a period in which several older tuition scholarship programs were expanded and the free college reform was introduced. She finds that the scholarship had a positive local impact on both applications to and enrollment in teaching majors in the first years following its introduction; however, after 2013 the impact tends to diminish, and it is no longer significant by 2016 (year of the introduction of the free college reform). Consistent with these findings, Castro-Zarzur also reports that both eligible applications and accepted BVP scholarships decreased by 56% between 2011 and 2016, which suggests an important decline in the interest in this grant by students from newer cohorts, particularly those coming from public schools.

[7] BVP programs are teaching majors that are quality-accredited, require full-time dedication, and only admit students with $PSU \geq 500$.

2.3 The Tuition-Free College Policy

Starting in 2011, a series of countrywide student-led protests demanded more financial support from public sources.[8] Protestors demanded the repeal of the current market-based system in which universities compete with each other for funding and students. Based on the idea that education is a fundamental human right, their aim was to replace the prevailing structure with a publicly run system where the state provides free and universal higher education.[9] However, it was not until 2014 that the Chilean government pushed for major reforms, including one aimed at making college tuition-free. The main goal of the reforms was to make access more equitable so that all students, independent of their family income, had access to a high-quality and publicly funded higher education.

The complexity of the system, characterized by the coexistence of private and public universities (all charging tuition fees) and the high cost of the reform, made it difficult to implement (Espinoza and Urzua, 2015). In 2016, the government launched a partial version of a universal tuition-free program. From the universities' perspective, participation was non-mandatory. All 16 public universities automatically joined the program and 14 private institutions decided to participate.[10] Tuition was abolished for students from families from the bottom 50% of the income distribution enrolling in participating universities. Universities receive a

[8]The Chilean government funded the higher education system through three main mechanisms. First, it provides unconditional lump-sum transfers to CRUCH universities. Second, it finances research activities on a competitive basis. Most of these funds are available to all quality-accredited institutions. Finally, it funds students through scholarships and state-subsidized loans (see Beyer et al., 2015). These demand-side subsidies have increased dramatically over the past decade, especially after the introduction of a large state-guaranteed loan system in 2006 (see Figure AF1 in the Appendix).

[9]The government's first response was to expand the two largest college scholarship programs that existed by that time: the *Beca Bicentenario* (BBIC) available for those going to college at CRUCH universities, and the *Beca Juan Gomez Millas* (BJGM) available to students attending either CRUCH universities or any quality-accredited higher education institution. Between 2011 and 2014, these two tuition grants—which cover around 80% of the total tuition costs—gradually went from being available for students with PSU ≥ 550 who came from the first two income quintiles, to include students with PSU ≥ 500 coming from deciles one to seven of the income distribution. Tables A4 in the Appendix show that the expansion of these scholarships was finalized before the time period we explore in this paper.

[10]Professional Institutes (PIs) and Technical Training Centers (TTCs) were excluded from the tuition-free program.

regulated per-student fee.[11] And knowing that universities would have strong incentives to drastically change the number of places they made available in each program as a response to the elimination of tuition (Dynarski, 2003; Abraham and Clark, 2006), the government, by law, forbid it. Table A5 in the Appendix shows that universities complied, as we see no change in the number of programs offered, the number of places made available, or in the number of first year enrollees.

3 Data

We use three different administrative datasets in this study. First, we use data on student applications to universities in the centralized admission system. These data are managed and maintained by the Departamento de Evaluación, Medición y Registro Educacional (DEMRE), an entity that is part of Universidad de Chile, the main public university and one of the 33 higher education institutions affiliated to the centralized admission system as of 2016. The DEMRE designs the PSU test and administers it nationwide. The PSU evaluates students in four subjects: math, language, science, and social sciences. Scores range from 150 to 850 with a mean of 500 and standard deviation of 110. The PSU dataset contains individual information on PSU score, as well as demographics such as gender and age, and self-reported socioeconomic characteristics such as family income (discrete categories), household size, and parental education. It also contains students' high school GPA, their year of graduation and the school they graduated from and its nature (i.e., public, voucher, private). Students take the PSU at the end of high school but it is relatively common for individuals to retake the exam. We restrict our sample to students who graduated from high school the year before entering higher education.

For those who apply to the centralized admissions system after taking the PSU exam, we

[11] The per-student transfer is defined by a technical body, and is calculated using a complex formula that takes into account quality and efficiency indicators. See Gobierno de Chile (2017) for more details.

also observe the ranking list of up to 10 major-university pairs submitted by each student in each year. Students and programs are matched using a deferred-acceptance algorithm, which takes into account student rankings, programs' preferences (students with higher scores are preferred to student with lower scores), and quotas. Therefore, students may not be matched with their most preferred option. The dataset reports the outcome of the application process. Specifically, we observe the acceptance/rejection decision to each program students applied to.

Second, we use information on the supply of higher education programs, provided by the National Education Council (*Consejo Nacional de Educación*, CNED) and the Ministry of Education. The dataset includes a comprehensive list of programs offered by all higher education institutions in each academic year. The program-level data contain information on tuition fees, field of study, length, geographical location, and application requirements, among others.

Third, we obtain measures of academic proficiency from the SIMCE (*Sistema de Medicion de Calidad de la Educacion*, Education Quality Measurement System), a yearly national test that is part of an information system established by the Chilean government to periodically evaluate learning outcomes across the country. The SIMCE tests are taken by elementary (2nd, 4th, and 6th grades), middle school (8th grade), and high school (10th and 11th grades) students. Their main goal is to provide information about the learning achievements of students in a wide range of knowledge areas that are part of the national curriculum. Currently, the tests measure numeracy and language and communication skills, as well as knowledge of natural sciences, history, geography, social sciences, and English. Since its introduction (1980s) the SIMCE has undergone changes regarding the subjects tested as well as the grades in which the examinations are administered. Each year, the National Agency for the Quality of Education decides which grades will take the SIMCE tests as well as the corresponding areas of knowledge that will be evaluated. It is common for students to take the SIMCE two or three times during their school years. We choose to focus on the 4^{th} grade SIMCE, as it is the first SIMCE the class of 2016 took and was also taken by the previous cohort of students.

4 Empirical Strategy

The college choice literature has systematically found that students' preferences are sensitive to tuition fees and that changes in relative prices may affect the way students apply to and enroll in different colleges and programs (for evidence from Chile, see Alvarado et al., 2012; Hastings et al., 2016; Espinoza, 2017; Bucarey, 2018; Solis, 2017). The tuition-free policy changed the relative price of different majors for a subpopulation of prospective students. The value that student i gives program j is a function of price (tuition) $p_{i,j}$ and the expected lifetime earnings that she may obtain with such a degree. If student i qualifies for the tuition free program, then $p_{i,j} = 0$ for any j offered by a participating university. Therefore, the value derived from the different programs j will not be the same with and without the policy, and student application behavior will change accordingly.

As Table 2 shows, teaching degree programs have the lowest tuition fees in Chile. Equalizing their price to more expensive majors in other fields may affect the pool of students applying and pursuing a teaching programs. Lowering to zero the tuition fees charged by programs in other fields may have made them more attractive to students who would have chosen teaching programs in the absence of the free-college policy, and whose preferences for a teaching degree may have been influenced by the relatively low price. Therefore, tuition-free college has the potential to change students' choices by equalizing the cost of pursuing more expensive degrees in other fields with the cost of attending teaching programs. The impact of such change on the pool of students pursuing a degree and the extent to which students may switch from teaching majors to majors in other fields is the empirical question we address in this paper.

We use the introduction of tuition-free college as a natural experiment to analyze the sorting of students into majors. Especially, how it alters the pool of applicants who choose to pursue teaching programs, given that such a pool had already been responding to the incentives provided by the BVP scholarship. As explained above, eligibility for the BVP scholarship required scoring more than 600 points in the college entrance exam PSU. Hence, the base of our empirical strategy throughout the paper will entail the comparison of application behavior before and after the introduction of tuition-free college among those who score above and below 600 points in the PSU. In that sense, ours is a difference-in-difference strategy, where one difference comes from the introduction of the policy and the second difference comes from the BVP scholarship eligibility criterium.[12]

Our typical estimation strategy can be described by the following:

$$P_{i,t} = \beta Post_t + \gamma \mathbf{1}[PSU_{i,t} \geq 600] + \delta Post_t \mathbf{1}[PSU_{i,t} \geq 600] + X_{i,t}\theta + \mu_s + \varepsilon_{i,t} \quad (1)$$

where $P_{i,t}$ is the outcome of interest (e.g., applying to a teaching program or not) of student i at time t, $Post_t$ takes the value of 1 if $t \geq 2016$ the year of the introduction of the tuition-free college and 0 otherwise, $\mathbf{1}[PSU_{i,t} \geq 600]$ is an indicator variable that takes the value of 1 when student i scores more that 600 points in the college entrance exam, $X_{i,t}$ are individual level controls like gender and contains a constant, and μ_s is a school-level or *comuna*-level fixed-effect. Hence, the parameter δ corresponds to the effect that the introduction of tuition-free college had among those that would have been eligible for the BVP scholarship.[13]

[12] We assume that the distribution of college preferences and income are equal in the 2015 and 2016 high school cohorts. Nonetheless, our results are robust if we take into account that the free-tuition policy could have brought "new entrants" into higher education, as we show in Appendix G. We also need to assume that the effect of the BVP is stable across years, which Castro-Zarzur (2018) shows in her paper.

[13] Despite the existence of other scholarships applicable to any field of study, in 2015, the BVP grant was the only tuition scholarship covering full tuition costs. In particular, while the BBIC and the BJGM were available for students coming from income deciles 1-7 and did not limit the field of study, they only covered up to 80% of the full tuition costs. This 20% difference corresponds to approximately 150% of the legal minimum wage, which is an economically significant figure if we take into account the per-capita income bounds of the

We extend strategy (1) to incorporate the fact that college was made tuition free for only those who come from the bottom half of the income distribution. Incidentally, that subgroup is the one that has responded the most to the incentives provided by the BVP scholarship (Castro-Zarzur, 2018). To do so, we use $Y_{i,t}^g$ as an indicator variable that takes the value of 1 if student i's income belongs to category g and 0 otherwise. By convention, we use $Y^0 = 1$ to account for the base terms that have no income-group interaction (i.e., $\beta_0 Post_t + \gamma_0 \mathbf{1}[PSU_{i,t} \geq 600] + \delta_g Post_t \mathbf{1}[PSU_{i,t} \geq 600]$). Thus we can write our estimating equation as:

$$P_{i,t} = \sum_{g=0}^{G-1} \left(\beta_g Y_{i,t}^g Post_t + \gamma_g Y_{i,t}^g \mathbf{1}[PSU_{i,t} \geq 600] + \delta_g Y_{i,t}^g Post_t \mathbf{1}[PSU_{i,t} \geq 600]\right) + X_{i,t}\theta + \mu_s + \varepsilon_{i,t} \quad (2)$$

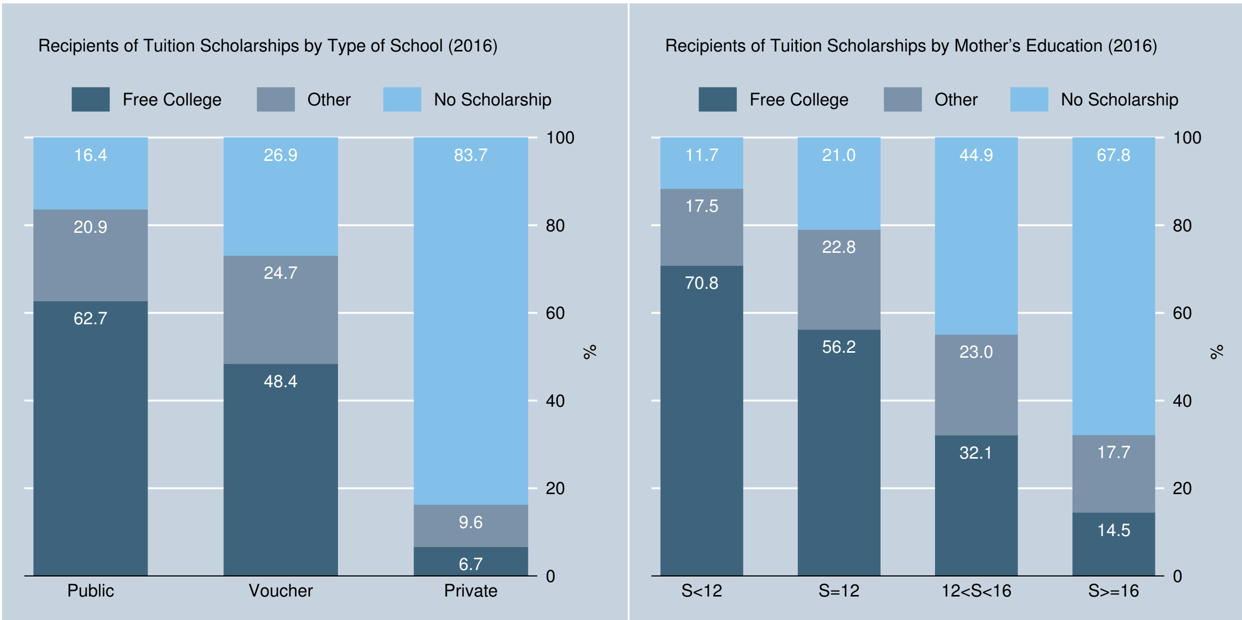
By providing an estimate of δ_g for each income group, we can see if the policy affected more students from poorer families than wealthier ones, as we anticipate.

We proxy Y^g with two measures that are known to closely correlate with family income: the education level of the student's mother and the type of high school in which the student finished. We do so because we do not perfectly observe per-capita family income at the time of application. But also, by proxying income with indicators of long term socio-economic status, we isolate our estimates from possible strategic behaviors in which families at the margin could reduce their labor supply in order to become eligible for the big financial relief of not having to pay college tuition. In particular, we split mother education into four categories: high school dropouts (19.4%), high school graduates (36.9%), some tertiary education (22.4%), and college graduates (21.3%). Regarding school type, we use the fact that primary and secondary schools in Chile are classified in three main categories: private, public, and voucher. School types exhibit significant differences between them and are highly

income deciles used in the 2015 scholarship assignment process. For instance, per-capita incomes in the fifth decile ranged between 56% and 69% of the legal minimum wage (see Table A1 in the Appendix). Therefore, the BVP was effectively enabling an important portion of low-income students' access to higher education. Changes in the application behavior of precisely this population of students allows us to identify δ.

Figure 2: Recipients of Tuition Scholarships in 2016

(a) By Type of School (b) By Mother's Education



Note: Both figures show the share of students from the 2016 graduating cohort who apply to college and obtain (or not) tuition scholarships. The left panel shows those fractions by school type. The right panel does so by mother's education. $S < 12$: high school dropout, $S = 12$: high school graduate, $12 < S < 16$: technical education or incomplete college, and $S >= 16$: complete college or above.

correlated with students' socioeconomic background (Correa et al., 2014). Public schools are run by municipalities and publicly funded. Voucher schools, which can be for-profit or not-for-profit, are privately owned and receive a per-student subsidy (voucher) from the state.[14] Finally private schools do not receive any public funds. Wealthier students typically attend private schools, voucher schools are highly demanded by the middle class, and poorer students typically attend public schools (Elacqua and Santos, 2013; Sánchez, 2018).

Figure 2 shows that school type and mother's education are good predictors of access to need-based college scholarships, thus reflecting the incidence of long-term credit constraints.[15] For instance, while 83.6% of applicants coming from public schools have access to a scholarship,

[14]The fraction of the cost covered by the voucher varies from family to family depending on its socio-economic status and the monthly cost of the school.

[15]Tables A2 and A3 in Appendix C present descriptive evidence further supporting the use of mother's education and school type as proxies of family income.

only 16.3% of applicants coming from private schools do so. That is almost an exact reversal in the likelihood of need-based accessing scholarships. In that domain, we see that the incidence of access to scholarships among applicants graduating from voucher schools is closer to that of public schools than to that of private schools. Figure 2b shows that 88.3% of applicants whose mothers were high school dropouts required some kind of scholarship, while less than a third of students whose mothers completed a college degree applied to college with a scholarship at hand.

We are interested in evaluating the effect of the tuition-free college policy not only on the application behavior and preferences between majors of the incoming students, but also on how that sorting changed the distribution of academic quality of the students across majors. This stems from the extensive evidence showing that high-achieving students are more likely to become better teachers (Auguste et al., 2010; Seng Tang, 2015). To do so, we implement the following specification that relies on the introduction of the policy and its differential effects across income groups due to its eligibility criterium:

$$Score_{i,t} = \sum_{g=0}^{G-1} \left(\beta_g Y_{i,t}^{g} Post_t Teach_{i,t}\right) + X_{i,t}\theta + \mu_s + \varepsilon_{i,t} \quad (3)$$

where $Teach_{i,t}$ is an indicator variable that takes the value of 1 if student i lists a teaching program as one of her choices when applying to college. That way, we will compare the change in the average academic proficiency after the introduction of free college among those who pursue a teaching degree and those who do not, at different levels of family income.

As measures of academic proficiency, we use scores from SIMCE standardized tests measured when the students were in 4^{th} grade of elementary school, around 10 years old. that is, eight years before they consider their tertiary education decision. We refer to those past scores instead of using the PSU for this particular estimation because application decisions may depend on the PSU score obtained. Therefore, there is a feedback process between scores and application behavior that would bias the results. Instead, the 4^{th} grade SIMCE scores,

Table 4: Change in Application Behavior by PSU range

Panel A: PSU<600	Before	After	Diff. (%)	p-value
Business	0.102	0.108	6.05	0.001
Education	0.111	0.109	-1.85	0.293
Health	0.288	0.299	3.54	0.000
Social Sciences/Humanities	0.139	0.145	3.83	0.015
STEM	0.220	0.199	-9.44	0.000
Others	0.140	0.141	0.77	0.621

Panel B: PSU≥600	Before	After	Diff. (%)	p-value
Business	0.105	0.105	0.68	0.792
Education	0.044	0.036	-17.78	0.000
Health	0.249	0.279	12.13	0.000
Social Sciences/Humanities	0.105	0.108	2.54	0.325
STEM	0.350	0.319	-8.69	0.000
Others	0.148	0.153	3.10	0.144

Note: For students applying to degrees in the centralized matching system, we compare the probability of applying to a degree (in each of the fields) as top choice, before and after the implementation of the tuition-free policy. We restrict the sample to students who graduated from high school the year before entering higher education. The last two columns test the statistical significance of these differences.

having no bearing on the college acceptance decisions, do not influence students' application behavior.

5 Results

5.1 Application Behavior

We first show that the introduction of free college had an immediate effect on student application behavior. Table 4 compares the field of study of the students' most preferred choice before and after free college. It presents simple mean comparisons between application frequencies to different fields. We split the sample in two. The top panel shows the frequency of applications among students scoring below the 600-point threshold that defines the eligibility to the BVP scholarship. Panel B replicates these statistics for students who are eligible for the BVP, those who score above 600 points. The last two columns show the before-after difference and its statistical significance. The table shows a statistically significant drop in the fraction of students applying to teaching degrees as their most preferred choice among top performers. In the year before the introduction of free college, 4.4% of students scoring more than 600 points applied to a teaching degree as their most preferred choice. After the policy the fraction dropped to 3.6%. That is, among those that are eligible for the BVP scholarship, the introduction of free college causes a decline in the probability of applying a teaching degree as top choice of about 17.8%. The drop is largest across all fields of study. Such behavior supports the hypothesis that the introduction of free college decreased the return of pursuing a teaching degree *vis-a-vis* degrees in other degrees that compete for similar students. In contrast, such behavior is not mirrored by students scoring below the 600-point threshold. There is only a slight and non-significant decline from 11.1% to 10.9%.[16]

Next, we use the regression framework detailed in Section 4 to estimate the effect of free college on student application behavior. We estimate the model using two alternative dependent variables. The first takes the value of 1 if the student applied to a teaching degree, independent of the order in which she listed it (*Teaching as a choice*). In the second one, the dependent variable takes the value of 1 if the student applied to a teaching degree as her top choice (*Teaching as top choice*). As indicated in Section 4, we do not use precise households income data to exactly pin down each student's eligibility for free college. Instead, we proxy household income with two variables that are well known to closely correlate with it: type of school (i.e., public, voucher or private) and student mothers' education. Results are presented in Tables 5 and 6. We report the marginal effects for students scoring above and below BVP scholarship's eligibility criteria.

[16]Table 4 shows that STEM majors also experienced a decline in the fraction of applicants. We analyze this interesting phenomenon in a separate paper (Castro-Zarzur et al., 2018). Importantly for the purpose of the this paper, the drop in STEM applications is common to both sides of the 600-point threshold. Therefore, it is not a confounding factor in the margin we are interested in.

Table 5: Effect of Free College on Application Behavior to Teaching Majors by School Type

	Teaching as a Choice		Teaching as Top Choice	
	Coef.	Std.Err.	Coef.	Std.Err.
Public				
$PSU < 600$	0.002	(0.006)	-0.006	(0.004)
$PSU \geq 600$	-0.023***	(0.008)	-0.016***	(0.004)
Diff	-0.025***		-0.010*	
Voucher				
$PSU < 600$	-0.004	(0.003)	-0.008***	(0.003)
$PSU \geq 600$	-0.014***	(0.005)	-0.012***	(0.003)
Diff	-0.010*		-0.004	
Private				
$PSU < 600$	0.000	(0.007)	0.003	(0.005)
$PSU \geq 600$	-0.001	(0.003)	-0.001	(0.002)
Diff	-0.001		-0.003	
Obs.	154,277		154,277	
Avg. dep. variable	0.171		0.086	

Note: We present the size of the effect for each category calculated based on the regression results presented in Table A12 in the Appendix. All regressions include *comuna* fixed-effects, gender, and linear PSU score controls. The 600 threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. Standard errors clustered at the school level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.05$.

Table 5 proxies household income with school type. Its first column shows that the probability of listing a teaching major as a choice falls significantly only among those coming from public and voucher schools that scored above the 600-point threshold. That is, with the introduction of the free-college policy, the probability of considering a teaching major falls for relatively poor BVP-eligible students. The drops are not only statistically significant but economically meaningful. The likelihood of listing a teaching major among these students falls by 2.7 (public) and 1.5 (voucher) percentage points. These drops correspond to a 16% and 9% decrease, respectively. Furthermore, these results are even larger among those who listed a teaching major as their top choice. The likelihood for relatively poor BVP-eligible students of doing so decreased by 18.6% and 14% for students from public and voucher schools, respectively. In contrast, we find no significant changes in the probability of applying to teaching programs among the relatively wealthy students (i.e., those graduating from private schools) who are not eligible for free college.

Interestingly, we find a response, albeit smaller, on the number of students listing an education major as their top choice among voucher school students scoring below the BVP eligibility threshold. We argue that this decline results from the fact that some voucher school students are eligible for free college, and some of them, who now consider other majors as their top choice, would have found in teaching the only pathway to a college degree when college was not free for them, as teaching majors were usually the cheapest ones.

Our findings remain overall consistent when we proxy household income with mother's years of education in Table 6.[17] BVP-eligible students from relatively poor socioeconomic backgrounds (i.e. with relatively less educated mothers) respond to the introduction of free college by opting out of the teaching profession. The first column of Table 6 shows that the probability of applying to a teaching program decreases significantly for BVP-eligible students with high school dropout mothers (18%), high school graduate mothers (14.3%), and to some extent to those whose mothers had technical degrees or incomplete college who decreased their teaching major applications by 10%. Additionally, in line with our previous finding, the probability of applying to a teaching program as top choice drops for poorer students who score below the 600-point threshold, possibly reflecting the substitution of a relatively cheap major with others that they can now afford due to the free-college policy.

The introduction of free college increased the number of applications by 3.4 percentage points, mostly coming from outside the top three deciles of the PSU distribution (Castro-Zarzur et al., 2018). Thus, some of the effect found so far could be due, in part, to "new entrants"—people who would not have applied in the absence of the policy—rather than to a "reshuffle" across

[17] Results in Tables 5 and 6 are not strictly comparable because the ones collected in the former use *comuna*-level fixed-effects, while the ones presented in the latter come from estimations using school-level fixed-effects. The use of school-level fixed-effects may be more desirable as they capture any unobserved school traits that may correlate with college application. However, being the school type a time invariant school characteristics, its effect on a given outcome is not identified in a school-level fixed-effects specification. We consider that the results coming from the models with school types provide relevant insights and thus are worth reporting despite their lack of school-level fixed-effects.

Table 6: Effect of Free College on Application Behavior to Teaching Majors by Mother's Schooling

	Teaching as a Choice		Teaching as Top Choice	
	Coef.	Std.Err.	Coef.	Std.Err.
$S < 12$ (19.4%)				
$PSU < 600$	-0.005	(0.006)	-0.016***	(0.004)
$PSU \geq 600$	-0.027**	(0.012)	-0.011	(0.007)
Diff	-0.022*		0.005	
$S = 12$ (36.9%)				
$PSU < 600$	-0.004	(0.004)	-0.006*	(0.003)
$PSU \geq 600$	-0.019***	(0.006)	-0.016***	(0.004)
Diff	-0.014**		-0.010*	
$12 < S < 16$ (22.4%)				
$PSU < 600$	-0.003	(0.006)	-0.004	(0.004)
$PSU \geq 600$	-0.010*	(0.005)	-0.008**	(0.004)
Diff	-0.007		-0.004	
$S \geq 16$ (21.3%)				
$PSU < 600$	0.005	(0.007)	0.002	(0.005)
$PSU \geq 600$	-0.007*	(0.004)	-0.004	(0.002)
Diff	-0.012		-0.006	
Obs.	140,984		140,984	
Avg. dep. variable	0.173		0.086	

Note: We present the size of the effect for each category calculated based on the regression results presented in Table A13 in the Appendix. All regressions include school fixed-effects, gender, and linear PSU score controls. The 600 threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. Standard errors clustered at the school level. $*p < 0.1$, $**p < 0.05$, $***p < 0.05$.

majors of people who would have applied anyway. To address that, we rerun our estimations on a 2016 subsample that is most likely to have applied without the implementation of free college. We define that subsample based on a propensity score estimated from observed characteristics of students and their application decisions in 2015. That is, we model college application decisions with gender, mother's education, 4^{th} grade math and language SIMCE scores and the school students come from. The model reports an R^2 of 0.91; details can be found in Appendix G. We take the estimated parameters and predict the propensity of having applied to college based on their observable characteristics for the 2016 sample. Thus, we drop from the 2016 sample those who applied but were less likely to do so according to the propensity score. We drop around 9,000 applicants from 2016 in order to match the number of applicants in 2015.

The results of the estimations on the subsamples without "new entrants" are reported in Tables A8 and A9 in Appendix G. They are very similar to the ones obtained using the whole sample, indicating that most, if not all, the effects on applications to education majors found so far are due to changes in major preferences of students who would have applied to college even if the tuition-free policy had not been implemented.

Changes in application behavior due to the introduction of free college may be evident in the extensive margin (i.e., whether the student applied to a teaching program or not) but in the intensive margin as well. To explore that, we exploit the information contained in the application list submitted to the clearinghouse, in which students rank in order of desire the programs (i.e., university-major pairs) they consider pursuing.

Tables 7 and 8 present changes in the probability of applying to a teaching major before and after the introduction of the free college reform for four different ranking positions. These tables confirm our previous findings: first, the observed drops in applications to education majors are driven by the application behavior changes among relatively poor BVP-eligible students; and second, these drops are driven by students no longer listing educations majors as their top choice. These declines are consistent with the fact that financially constrained, high-performing individuals who before the free-tuition reform could only access higher education with the BVP grant can now choose from a wide range of majors besides teaching, many of which have higher expected returns. Indeed, the introduction of the free-college policy not only resulted in less application to education majors from academically better individuals, but also in a deterioration of the relative attractiveness of the teaching career,even for those top-performing students who consider it as an option.

Our results also shows that for students with PSU scores below 600, the probability of choosing a teaching major as their fourth or higher most preferred choice increased by 8.4%.

Table 7: Preference Order of Education Programs Before and After Free College (by School Type)

Education as	$PSU < 600$ Before	After	Dif.(%)	$PSU \geq 600$ Before	After	Dif.(%)
Panel A: Public						
First choice	0.123	0.122	-0.908	0.059	0.044	-24.088**
Second choice	0.033	0.032	-0.566	0.014	0.015	2.681
Third choice	0.028	0.029	5.573	0.018	0.020	12.615
≥ Fourth choice	0.054	0.059	10.728**	0.053	0.045	-14.910*
Panel B: Voucher						
First choice	0.113	0.108	-4.201*	0.056	0.044	-21.766***
Second choice	0.027	0.026	-6.292	0.015	0.013	-11.076
Third choice	0.023	0.024	3.288	0.016	0.015	-5.398
≥ Fourth choice	0.045	0.048	8.829**	0.038	0.038	-0.697
Panel C: Private						
First choice	0.067	0.070	4.690	0.021	0.021	-0.067
Second choice	0.015	0.017	17.792	0.006	0.006	7.479
Third choice	0.017	0.016	-6.866	0.010	0.009	-6.020
≥ Fourth choice	0.032	0.028	-12.616	0.018	0.018	-2.364

Note: The average student lists five programs. In case the student listed more than one teaching program among her preferences, we chose for the regressions the minimum rank among them. The 600-point threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

Likewise, such an increase is limited to relatively poor individuals (i.e., those coming from public and voucher schools or less-educated mothers), as reported in Tables 7 and 8.

Interestingly, Table 8 shows that students with PSU scores below 600 who have high school dropout mothers decreased their likelihood of choosing teaching as their top choice and, at the same time, increased their likelihood of listing teaching as their third choice or as their fourth of higher choice. These results suggest a reordering of the preference for teaching among relatively low-performing students from the poorest backgrounds, by which education majors lose their appeal and are downgraded to less-preferred options. This is again consistent with the fact that free college allows the relatively low performers to switch away from the comparatively cheaper teaching programs to majors that are costlier and generally tend to have higher expected returns.

Table 8: Preference Order of Education Programs Before and After Free College (by Mother's Education)

	$PSU < 600$			$PSU \geq 600$		
Education as	Before	After	Dif.(%)	Before	After	Dif.(%)
Panel A: $S < 12$						
First choice	0.130	0.119	-8.749**	0.061	0.051	-15.342
Second choice	0.032	0.031	-2.059	0.018	0.017	-1.865
Third choice	0.024	0.028	20.266**	0.021	0.021	3.342
≥ Fourth choice	0.047	0.055	17.781**	0.050	0.037	-26.770**
Panel B: $S = 12$						
First choice	0.117	0.115	-1.758	0.060	0.046	-23.242***
Second choice	0.027	0.028	0.532	0.014	0.013	-10.189
Third choice	0.025	0.025	-0.773	0.016	0.016	-0.834
≥ Fourth choice	0.049	0.051	3.892	0.042	0.042	-0.518
Panel C: $12 < S < 16$						
First choice	0.099	0.099	-0.554	0.045	0.036	-18.679**
Second choice	0.025	0.025	-3.081	0.013	0.010	-16.407
Third choice	0.023	0.024	4.560	0.013	0.014	4.787
≥ Fourth choice	0.042	0.044	4.101	0.030	0.030	-0.807
Panel D: $S \geq 16$						
First choice	0.079	0.081	3.580	0.028	0.026	-8.460
Second choice	0.022	0.022	-0.307	0.008	0.009	18.235
Third choice	0.021	0.019	-10.249	0.013	0.011	-11.441
≥ Fourth choice	0.040	0.045	11.211	0.027	0.024	-8.582

Note: The average student lists five programs. In case the student listed more than one teaching program among her preferences, we chose for the regressions the minimum rank among them. The 600-point threshold for the PSU score was chosen based on the minimum score required to apply to the BVP scholarship. $*p < 0.1$, $**p < 0.05$, $***p < 0.05$.

Hence, in conjunction with our previous results, we find that the introduction of free college had effects in both the extensive and the intensive margin of teaching majors application behavior. However, the effect is heterogeneous across different groups of students. Free college reduced the probability of considering a teaching profession as an option among those who would have been eligible for the BVP scholarship. In addition, for those who did consider a teaching profession among their choices, the introduction of free college made teaching majors less attractive: they were less likely to put them as their first choice and more likely to list them as a latter, less preferred option.

Table 9: Effect of Free College on PSU Score of Accepted Applicants

Panel A: Overall					
N=110935	Other		Education		Diff.
Post	-0.362	(0.482)	-2.671***	(0.784)	-2.309**
Panel B: School Type					
N=110719	Other		Education		Diff.
Post#Public	-2.710**	(1.268)	-4.724***	(1.429)	-2.014
Post#Voucher	-0.104	(0.655)	-2.709***	(1.018)	-2.605**
Post#Private	3.198***	(1.059)	2.789	(2.598)	-0.409
Panel C: Mother's Education					
N=100814	Other		Education		Diff.
Post#$S < 12$	-2.524***	(0.960)	-5.754***	(1.555)	-3.230*
Post#S=12	-1.389*	(0.744)	-3.689***	(1.201)	-2.300
Post#$12 < S < 16$	1.803**	(0.902)	-1.189	(1.644)	-2.992
Post#$S \geq 16$	0.445	(0.916)	2.214	(2.082)	1.769

Note: All regressions include gender controls. Regressions in Panel A and C include school fixed-effects. Regressions in Panel B include *comuna* fixed-effects. Column *Diff* presents the difference between the point estimates of *Education* and *Other* and tests for whether they are statistically different from each other or not. Standard errors clustered at the school level in parentheses. $*p < 0.1$, $**p < 0.05$, $***p < 0.05$.

5.2 Effect on Enrollment

The change in application behavior due to the introduction of free college translated to a change in the relative academic proficiency of the students that were offered admission in different programs as measured by the PSU score. In Table 9, we present the changes in PSU scores due to the introduction of free college for education majors and non-education majors separately. In Panel A, we show that while the introduction of free college did not change the average score of the students accepted to non-education majors, the scores among the accepted to education ones did deteriorate. We find an overall drop of 2.67 percentage points. That amounts to a decrease in the score of the new entrants to the teaching majors of almost 4% of a standard deviation.[18]

Panels B and C of Table 9 include the interactions with income proxies. Panel B reports the

[18]While the standard deviation of the PSU among the entire population that took the exam is 110, when we limit the sample to those who ended up being accepted in traditional universities, the standard deviation of the score becomes 68.5.

results by school type, while Panel C does so by mother's education level. Both cases provide the same insights. The deterioration in the quality of the students admitted is limited to those relatively poor. The average score among those admitted to education programs that came from the poorest backgrounds fell by 9.1% of a standard deviation. Interestingly, while the quality of those from voucher schools and high school graduate mothers that were accepted in non-education majors remains mostly unchanged, the performance of those who were offered admission to education majors after the implementation of free college is significantly lower.[19] These findings provide evidence in favor of a mechanism in which the BVP scholarship had brought relatively high-quality students who could not afford college. Once the relative profitability of the teaching programs changed again due to the free tuition policy that covered the other majors, that subpopulation of high-scoring low-income students shifted to other disciplines, as they no longer saw the teaching majors as the only pathway to a college degree.

In Table 10, we further explore the deterioration of the academic proficiency of applicants to the teaching majors caused by the introduction of the tuition-free college policy. We regress measures of academic proficiency on a dummy indicating the introduction of the policy in samples that consist of those who listed the education major within their 10 preferred degrees (*Any*) and those who did so as their top choice (*Top*). As indicated in the empirical strategy, we use the math and language SIMCE scores measured when the students were in 4^{th} grade of elementary school as measures of academic proficiency, that is, eight years before they consider their tertiary education decision. This way we avoid the feedback process between PSU scores and application behavior that would bias the results.

We find that the introduction of free college changed the pool of applicants to teaching majors in such a way that it ended up being comprised by students who were on average 14% of a

[19] In Table A11 in the Appendix, we show the estimations using data on enrolled students instead of accepted students. Our findings remain the same, albeit sightly smaller point estimates. Differences are not statistically significant. In Appendix H, on the other hand, we perform the same estimations using math scores in 4^{th} grade of elementary school. The results hold.

Table 10: Effect of Free College on SIMCE Scores of Applicants to Education Programs

	Overall			School Type			Mother's Education	
	Any	Top		Any	Top		Any	Top
Panel A: Math								
Post	-6.259***	-7.112***	$Post\#Publ$	-9.459***	-8.082***	$Post\#\ S<12$	-7.469***	-6.736***
	(0.664)	(0.725)		(1.157)	(1.235)		(1.419)	(1.560)
			$Post\#Vou$	-7.637***	-9.029***	$Post\#\ S{=}12$	-7.870***	-8.639***
				(0.827)	(0.896)		(1.080)	(1.153)
			$Post\#Priv$	-0.933	-2.132	$Post\#\ S^{16}_{12}$	-4.803***	-7.277***
				(1.987)	(2.293)		(1.444)	(1.652)
						$Post\#\ S\geq 16$	-1.272	-2.364
							(1.747)	(1.903)
Obs.	114679	51031		114368	50897		105819	47079
Panel B: Language								
Post	-3.810***	-4.439***	$Post\#Publ$	-5.629***	-5.168***	$Post\#\ S<12$	-6.855***	-5.915***
	(0.654)	(0.706)		(1.114)	(1.235)		(1.433)	(1.576)
			$Post\#Vou$	-5.496***	-6.557***	$Post\#\ S{=}12$	-5.291***	-6.088***
				(0.796)	(0.851)		(1.058)	(1.127)
			$Post\#Priv$	0.721	-0.991	$Post\#\ S^{16}_{12}$	-1.287	-2.270
				(2.188)	(2.404)		(1.512)	(1.613)
						$Post\#\ S\geq 16$	1.600	0.709
							(1.736)	(1.912)
Obs.	114454	50953		114146	50819		105633	47021

Note: All regressions include gender controls. All regressions include school fixed-effects, except for school type regressions, which include *comuna* fixed-effects. Standard deviation of the scores in the subsamples are as follows. Math (Any): 44.45, Math (Top): 45.24, Language (Any): 43.31, and Language (Top): 43.77. Standard errors clustered at the school level in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

standard deviation less proficient in math and 8.8% of a standard deviation less proficient in language, as measured by their 4^{th} grade scores. As expected, we see a stronger effect among relatively poor students. In fact, we observe drops of 20.5% of a standard deviation in the math scores and 12.8% of a standard deviation in the language scores among students from public schools, and 16.24% of a standard deviation in the math scores and 15.8% of a standard deviation in the language scores among students whose mothers were high school dropouts. These figures contrast with those reported for students from affluent backgrounds in which no statistically significant effects were found. All these results provide evidence in favor of the argument, indicating that the large declines of the scores of applicants to teaching majors is the result of two forces: the introduction of relatively poor low-scoring students to the tertiary education system as college became affordable, and a substitution effect among relatively poor high-scoring students who leave the education majors for other disciplines, as the BVP scholarship is no longer giving education majors an advantage in terms of profitability.

6 Beyond the Difference-in-Difference

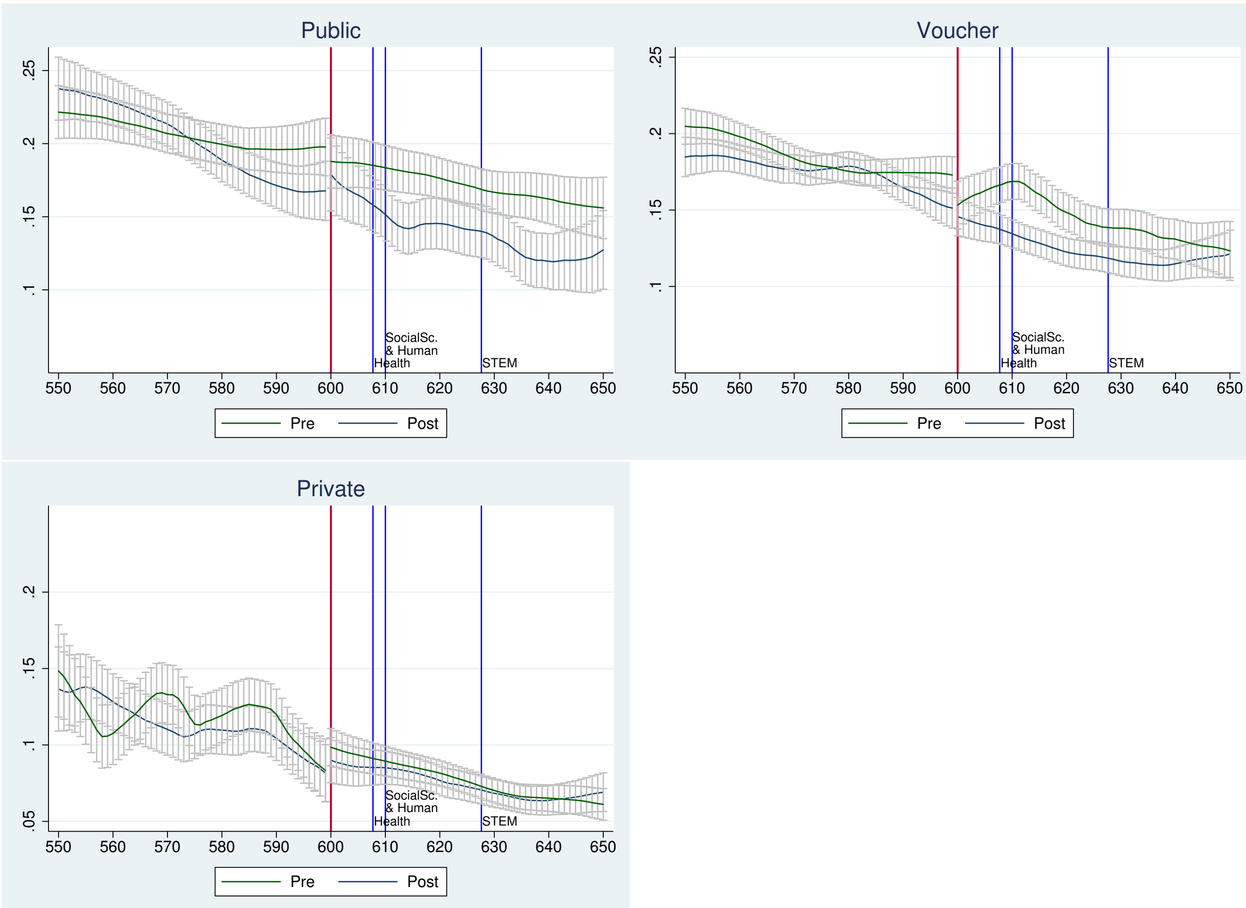
We further use BVP's score eligibility cutoff (i.e., $PSU \geq 600$) to estimate the effects of the introduction of free college on applications to teaching majors. To that effect, we compare the differences in application behavior before and after the introduction of free college. We unpack our difference-in-difference results by identifying heterogeneous effects in application behavior to teaching majors at different PSU levels. We estimate non-parametric functions of PSU scores on application behavior to the left and to the right of the $PSU = 600$ cutoff and before and after the introduction of the free-college policy.

Figures 3 and 4 present our results. In each figure, we present the non-parametric results by each type of school. Figure 3 considers the probability of listing a teaching major anywhere in the preference list, while Figure 4 considers the probability of listing a teaching major as their top choice. As expected, we consistently find no differences in application behavior for those whose PSU scores were less than 600. They simply had the same incentives before and after the introduction of free college as they were never eligible for the BVP scholarship. The interesting results come from the right of the cutoff. First, in line with our parametric difference-in-difference results, we find significant differences in the application behavior of students in public and voucher schools who scored more than 600 and were or would have been eligible for the BVP scholarship. We do not find those gaps among students coming from private schools. Second, our findings suggest that by 2015 the BVP was not adding (bringing in) extra students to the teaching profession, but avoiding larger shortages of qualified applicants to teaching majors.[20] With the introduction of the tuition-free policy, those shortages deepened as it made the BVP scholarship innocuous. Third, Figures 3 and 4 show that the gaps in application behavior do not open right at the $PSU = 600$ BVP eligibility cutoff. Instead, they open 5 to 10 PSU points to the right of that threshold. This may seem puzzling, since the elimination of the BVP incentive should in principle affect all those that would have been eligible. However as we have established, the introduction of free college made teaching majors less attractive to BVP-eligible high school graduates relative to other majors. Then, the reference score for those students is not $PSU = 600$ but the scores required to get into the majors in which they intend to enroll. The vertical lines in Figures 3 and 4 represent those scores, namely, the average scores of applicants accepted to health, social sciences and humanities, and STEM programs in 2015.[21] Those scores are to the right of the $PSU = 600$ threshold and in the case of health, social sciences and humanities majors—which were the ones with the greatest inflow of $PSU > 600$ students after the introduction of the free tuition policy—overlay remarkably well with the PSU scores

[20]This is consistent with findings reported in Castro-Zarzur (2018) where, using a regression discontinuity approach, finds that the positive impacts of the BVP diminished with each incoming cohort.

[21]The scores of accepted applicants from past cohorts to each program are publicly available in `www.psu.demre.cl` and in specific university websites like `www.admision.uai.cl` and `http://www.admisionyregistros.uc.cl`. They are made public intentionally year after year in order to inform prospective applicants about the scores they require to maximize their chances of getting into a given program.

Figure 3: Probability of Listing a Teaching Major Within Choice Set and PSU Score by School Type



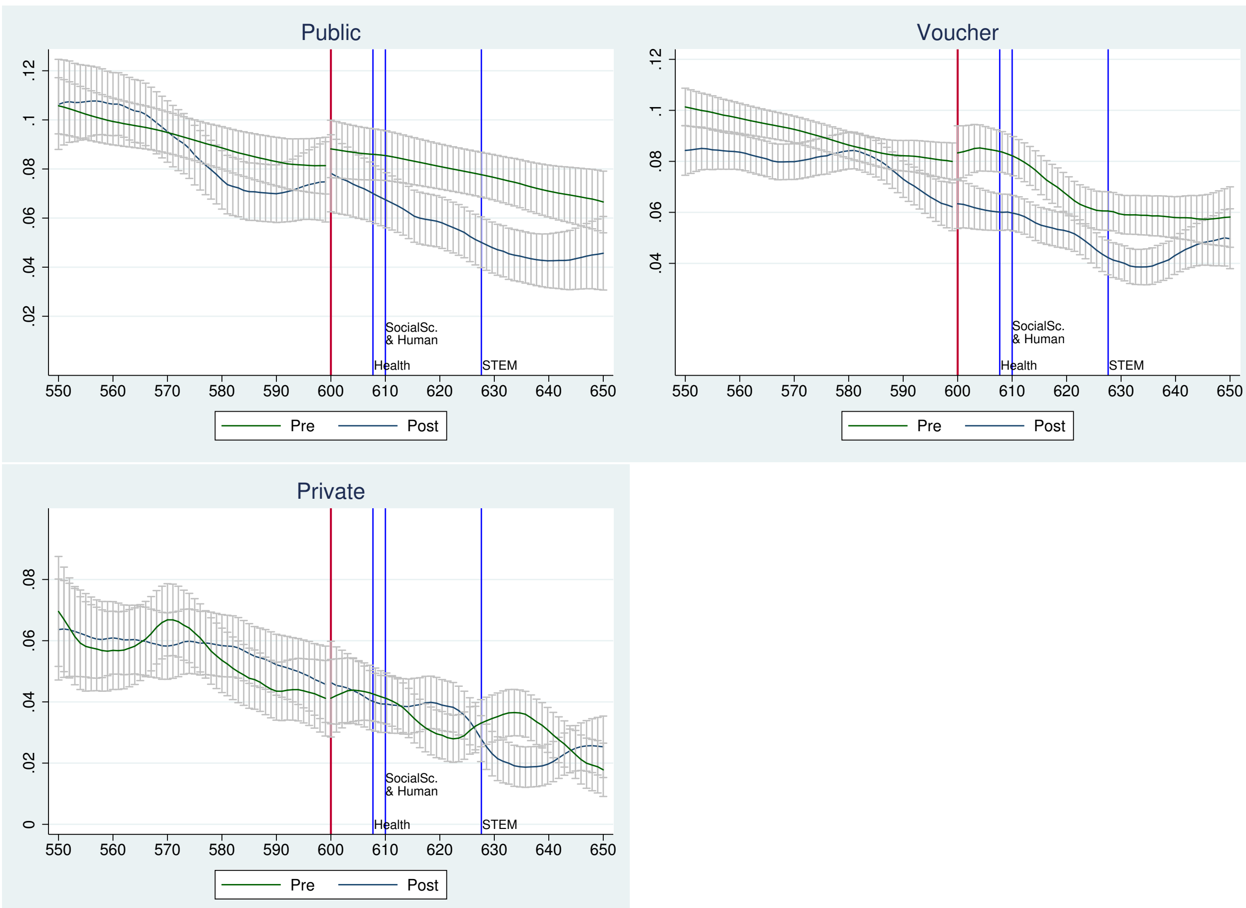
Note: Local mean smoothing estimated with Epanechnikov kernel using optimal bandwiths. Dependent variable takes the value of 1 of student listed a teaching major anywhere in her choice set and 0 otherwise. Capped spikes represent confidence intervals at the 90% level. Vertical lines present the average PSU score of those accepted to health, social sciences and humanities, and STEM majors in 2015.

at which the application behavior gaps begin to emerge.

7 Discussion

In this paper, we study the extent to which making college tuition free affects the pool of students pursuing a teaching career. We exploit a major reform carried out in Chile in 2016 that eliminated tuition costs of undergraduate studies for students from the lower half of the income distribution. We study how the introduction of a free-college policy affects the

Figure 4: Probability of Listing a Teaching Major as Top Choice and PSU Score by School Type



Note: Local mean smoothing estimated with Epanechnikov kernel using optimal bandwiths. Dependent variable takes the value of 1 of student listed a teaching major as her top choice and 0 otherwise. Capped spikes represent confidence intervals at the 90% level. Vertical lines present the average PSU score of those accepted to health, social sciences and humanities, and STEM majors in 2015.

application behavior of students who were eligible for the BVP tuition grant, a scholarship implemented in 2011 that had been successful in bringing high-quality students into teaching majors. We do so because the free-college policy equalizes the relative price of studying a wide range of different majors and therefore it has the potential of offsetting the incentives set out by the BVP.

Our results suggest that granting tuition-free access to college for individuals coming from the lower half of the income distribution decreased the demand for teaching programs of top-performing students. In consequence, it deteriorated the academic quality of students pursuing a teaching career. The introduction of the free-college policy reduced by about 17% the probability of applying to a teaching major among the high-performing students (i.e. BVP-eligible) that come from relatively poor backgrounds. In addition, among those who still consider the teaching profession, the introduction of free college made teaching majors less appealing as they are less likely to put them as their first choice and more likely to list them as a less preferred option. Importantly, these changes in application behavior translated into a deterioration of the academic qualifications of the pool of students who were offered admission to teaching majors. While the introduction of free college did not change the average PSU score of students accepted to non-education majors, the mean score of those admitted to teaching programs fell by 4% of a standard deviation. Such decrease is explained by a decrease in the scores of student from public or voucher schools and with relatively less educated mothers, while the average PSU score of the relatively wealthier (students coming from private schools) teaching freshmen remains unchanged.

Our findings are important for several reasons. First, they highlight the potential unintended consequences of policies distorting equilibrium prices in markets such as higher education. Second, our findings illustrates the lack of complementarity between two education policies, the BVP and the free college reform. The latter offsets the benefits of the former. In our case, our results suggest that with the introduction of free college, the achievements of the

BVP in terms of bringing high performing students into teaching majors were reversed. This is worrisome as there is convincing evidence in favor of the notion that top performing high school graduates are very likely to be better teachers and, in turn, high-quality teachers positively impact the long-term outcomes of their students. Third, our findings also provide an important input to the ongoing international debate on free college. For example, college tuition-free policy has emerged as one of the central themes in recent U.S. Presidential Elections where the initiative has show to be appealing to a numbers of policymakers.[22] This paper shows a potential unintended consequence of such policy acting through a relative price change which affects the sorting of students into majors. Our paper shows that in regards to students' preferences over teaching degrees, the free college policy has the potential to negatively affect long-term teacher quality.

Finally, our findings are likely to apply even in the absence of previous ability-based scholarships, such as the BVP. Teaching majors tend to be the least costly in many countries, including the United States where differential tuitions are being increasingly used; hence, in the absence of tuition-free college the relatively cheaper teaching majors are a pathway to higher education for low-income students. As free college equalizes the tuition cost across all majors, this allows high performers from poorer backgrounds to substitute relatively cheap majors with other - likely costlier - programs. In that sense, the BVP is just a vehicle for identification as it allows us to implement a difference-in-difference strategy while providing important insights on the potential impact of free college on self-selection into the teaching profession in more general settings.

[22] Additionally, the free-college movement in the US has continuously gained strength since the last years. As of 2019, eleven states—Oregon, Nevada, Arkansas, New Jersey, Maryland, Tennessee, New York, Rhode Island, Delaware, Kentucky, and Indiana—have programs that typically offer two years of free tuition in certain colleges for low- and middle-income students. More recently, in September 2019, New Mexico announced a plan for free college for state residents regardless of family income. Some examples of widely-known tuition-free college programs include the Kalamazoo Promise Program in Michigan and the State of New York's Excelsior Scholarship program.

References

Abraham, K. G. and Clark, M. A. (2006). Financial Aid and Students' College Decisions Evidence from the District of Columbia Tuition Assistance Grant Program. *Journal of Human Resources*, XLI(3):578–610. 2.3

Alfonso, M., Santiago, A., and Bassi, M. (2010). Estimating the Impact of Placing Top University Graduates in Vulnerable Schools in Chile. *Education Division SCLEDU Technical Notes*, pages 1–51. 2

Alvarado, M., Duarte, F., and Neilson, C. (2012). Efectos Preliminares de la Beca Vocación de Profesor. Technical report, Santiago de Chile. 2.2, 4

Araujo, M. C., Carneiro, P., Cruz-Aguayo, Y., and Schady, N. (2016). Teacher Quality and Learning Outcomes in Kindergarten. *The Quarterly Journal of Economics*, 131(3):1415–1453. 1

Auguste, B. G., Kihn, P., and Miller, M. (2010). *Closing the Talent Gap: Attracting and Retaining Top-third Graduates to Careers in Teaching*. McKinsey and Company. 2, 4

Balcázar, C. F. and Ñopo, H. (2014). Broken Gears: The Value Added of Higher Education on Teachers' Academic Achievement. *IZA Discussion Paper Series*, pages 1–28. 1, 2.2

Bau, N. and Das, J. (2019). Teacher Value-Added in a Low-Income Country. *American Economic Journal: Applied ...*, pages 1–44. 1

Beyer, H., Hastings, J., Neilson, C., and Zimmerman, S. (2015). Connecting Student Loans to Labor Market Outcomes: Policy Lessons from Chile. *American Economic Review*, 105(5):508–513. 8

Bonomelli, F. (2017). Seguimiento de la Beca Vocación de Profesor: Desde su implementación hasta puntos de encuentro con la Gratuidad y el Nuevo Sistema de Desarrollo Docente. Technical Report 3. 2.2

Bruns, B. and Luque, J. (2015). *Great Teachers*. How to raise stundent learning in Latin America and the Caribbean. World Bank Group, Washington, DC. 1

Bucarey, A. (2018). Who Pays for Free College? Crowding Out on Campus. 1, 4

Cabezas, V. and Claro, F. (2011). Valoración social del profesor en Chile: ¿cómo atraer a alumnos talentosos a estudiar pedagogía? *Temas de la Agencia Publica*, 6(42):1–18. 2.2

Castro-Zarzur, R. (2018). Can Service Scholarships be Effective in Bringing High-Quality Students to Teaching Programs in a Context of Increasing College Aid? Evidence from Chile. 1, 2.2, 12, 4, 20

Castro-Zarzur, R., Espinoza, R., Sarzosa, M., and Sarz (2018). College Tuition and the Taste for STEM Majors. pages 1–30. 16, 5.1

Centro de Estudios MINEDUC (2017). *Estadisticas de la Educación 2016*. Ministerio de Educación, Santiago de Chile. 2.1

Chetty, R., Friedman, J. N., and Rockoff, J. E. (2014). Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood. *American Economic Review*, 104(9):2633–2679. 1

Claro, F., Paredes, R. D., Bennett, M., and Wilson, T. (2013). Incentivos para estudiar pedagogía: El caso de la Beca Vocación de Profesor. *Estudios Publicos*, 131:37–59. 3, 2.2

Correa, J. A., Parro, F., and Reyes, L. (2014). The Effects of Vouchers on School Results: Evidence from Chile's Targeted Voucher Program. *Journal of Human Capital*, 8(4):351–398. 4

Dynarski, S. M. (2003). Does Aid Matter? Measuring the Effect of Student Aid on College Attendance and Completion. *American Economic Review*, 93(1):279–288. 2.3

Eide, E., Goldhaber, D., and Brewer, D. (2004). The Teacher Labour Market and Teacher Quality. *Oxford Review of Economic Policy*, 20(2):230–244. 1, 2.2

Elacqua, G., Hincapie, D., Vegas, E., and Alfonso, M. (2018). *Profesión: Profesor en América Latina ¿Por qué se perdió el prestigio docente y cómo recuperarlo?* Inter-American Development Bank, Washington D.C. 1, 6, 2.2

Elacqua, G. and Santos, H. (2013). Preferencias reveladas de los proveedores de educación privada en Chile. *Gestión y Política Púbica*, 23(1):85–129. 4

Espinoza, R. (2017). Loans for College: Strategic Pricing and Externalities. 4

Espinoza, R., Lee, S., and Lopez, H. (2017). Endogenous Market Formation: Theory and Evidence from Chilean College Admissions. 2.1

Espinoza, R. and Urzua, S. (2015). Las Consecuencias Económicas de un Sistema de Educación Superior Gratuito en Chile. pages 10–44. 2.3

Espinoza, R. and Urzua, S. (2016). The Economic Returns to Higher Education: Funding, coverage and quality in Latin America. 1, 2.1, 2.2

Glazerman, S., Mayer, D., and Decker, P. (2005). Alternative routes to teaching: The impacts of Teach for America on student achievement and other outcomes. *Journal of policy analysis and management*, 25(1):75–96. 2

Gobierno de Chile (2017). Metodología de arancel de Referencia 2018 para universidades acreditadas. pages 1–5. 11

Gomez, C., Cabezas, V., Madeiros, M. P., Martinez, F., and Crisostomo, B. (2019). Attracting Students to the Teaching Career: How Public Policy Affects Enrolment into Teaching Training Programs. 2.2

Gonzalez-Velosa, C., Rucci, G., Urzua, S., and Sarzosa, M. (2015). Returns to Higher Education in Chile and Colombia. *IDB Working Paper Series*. 1, 2.2

Hanushek, E. A., Piopiunik, M., and Wiederhold, S. (2018). The Value of Smarter Teachers: International Evidence on Teacher Cognitive Skills and Student Performance. *Journal of Human Resources*, pages 0317–8619R1–75. 1

Hastings, J., Neilson, C., and Zimmerman, S. (2013). Are Some Degrees Worth More Than Others? Evidence from College Admission Cutoffs in Chile. 1

Hastings, J. S., Neilson, C. A., Ramirez, A., and Zimmerman, S. D. (2016). (Un)informed college and major choice: Evidence from linked survey and administrative data. *Economics of Education Review*, pages 1–16. 4

Konstantopoulos, S. (2011). Teacher Effects in Early Grades: Evidence From a Randomized Study. *Teachers College Record*, 113(7):1541–1565. 1

Lang, K. and Palacios, M. D. (2018). The Determinants of Teachers' Occupational Choice. *NBER Working Paper*, pages 1–41. 1, 2.2

Mizala, A. and Ñopo, H. (2016). Measuring the relative pay of school teachers in Latin America 1997–2007. *International Journal of Educational Development*, 47:20–32. 4, 2.2

OECD (2005). Teachers Matter: Attracting, Developing and Retaining Effective Teachers. Technical report. 1, 3, 2.2

OECD (2017a). *Education at a Glance 2017*. OECD Indicators. OECD, Paris. 4

OECD (2017b). *Education in Chile*. Reviews of National Policies for Education, OECD Publishing, Paris. 2.2

OECD (2018). *Effective Teacher Policies: Insights from PISA*. PISA, OECD Publishing, Paris. 1

Sánchez, C. (2018). Targeted or Universal? Mobilizing Students Through School Vouchers. 4

Santiago, P. (2002). Teacher Demand and Supply: Improving Teaching Quality and Addressing Teacher Shortages. Technical Report 1, Paris. 3, 1

Santiago, P., Benavides, F., Danielson, C., Goe, L., and Nusche, D. (2013). *OECD Reviews of Evaluation and Assessment in Education Teacher Evaluation in Chile 2013*. OECD Publishing. 2.2

Schacter, J. and Thum, Y. M. (2004). Paying for high- and low-quality teaching. *Economics of Education Review*, 23(4):411–430. 1

Seng Tang, O. (2015). *Teacher Polices: Global Best Practices for Developing the Teaching Profession*. National Institute of Education, Singapore. 2, 4

Solis, A. (2017). Credit Access and College Enrollment. *Journal of Political Economy*, 125(2):562–622. 4

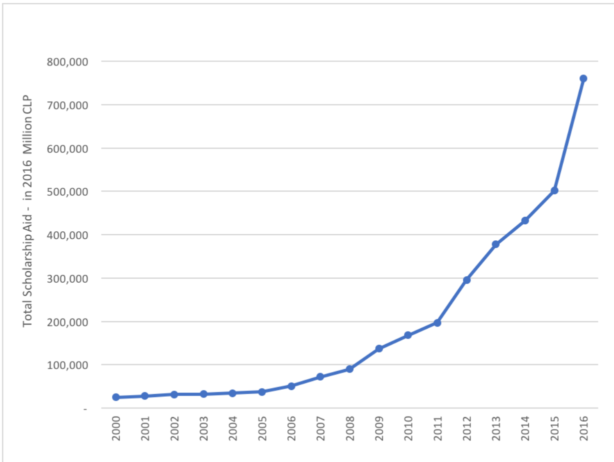
Sutcher, L., Darling-Hammond, L., and Carver-Thomas, D. (2016). A Coming Crisis in Teaching? Teacher Supply, Demand, and Shortages in the U.S. Technical report, Learning Policy Institute, Palo Alto, CA. 1

Xu, Z., Hannaway, J., and Taylor, C. (2011). Making a difference? The effects of Teach For America in high school. *Journal of policy analysis and management*, 30(3):447–469. 2

Appendix

A Evolution of Tuition Aid

Figure AF1: Evolution of Tuition Aid: 2000-2016



Source: Mi Futuro - Chile. Amount in 2016 includes funds spent through the free-college policy. Own calculations.

B Income Deciles Used in Scholarship Assignment Processes

Table A1: Income Deciles Used in 2015 Scholarship Assignment Process

Income decile	Lower bound (in CLP)	Upper bound (in CLP)
1	-	48,750
2	48,752	74,969
3	74,970	100,709
4	100,710	125,558
5	125,559	154,166
6	154,167	193,104
7	193,105	250,663
8	250,664	352,743
9	352,744	611,728
10	611,729	up

Source: http://portales.inacap.cl

C Percent of Recipients of Tuition Scholarships: 2015 - 2016

Table A2: Percent of Recipients of Tuition Scholarships by Mother's Education: 2015-2016

Programs in	2015				2016			
	$S \leq 12$	$S = 12$	$12 < S < 16$	$S \geq 16$	$S \leq 12$	$S = 12$	$12 < S < 16$	$S \geq 16$
Education								
Free tuition	0%	0%	0%	0%	74%	62%	40%	19%
BVP	12%	17%	23%	24%	5%	9%	14%	21%
BBIC	64%	56%	38%	22%	8%	11%	11%	9%
BEA	1%	1%	0%	1%	1%	1%	0%	1%
BJGM	10%	10%	9%	5%	3%	5%	6%	4%
Other	0%	1%	1%	4%	0%	0%	1%	3%
Non-Education								
Free tuition	0%	0%	0%	0%	71%	57%	33%	15%
BVP	1%	1%	1%	1%	0%	0%	1%	1%
BBIC	63%	56%	35%	19%	8%	10%	10%	7%
BEA	3%	3%	2%	2%	2%	2%	2%	1%
BJGM	12%	13%	11%	5%	8%	9%	9%	4%
Other	0%	1%	1%	5%	0%	1%	1%	4%

Tables A2 and A3 present descriptive evidence further supporting the use of mother's education and school type as proxies of family income. The percentage of awardees of the free-tuition grant is higher for students with relatively less-educated mothers, as well as for those coming from public and voucher schools. Additionally, between 2015 and 2016, the percentage of BVP awardees decreased more for those with relatively less-educated mothers and/or coming from public and voucher schools, while the total proportion of scholarship recipients increased (mostly through the free-tuition grant). This is also the case if we look at the substitutions patterns between the other two large scholarship programs (i.e., BBIC and BJGM) and the free-tuition grant, both across education and non-education majors. To sum up, we see that groups of students whom we consider as relatively poorer are recipients of the free-tuition grant and substitute out of economically dominated grants into free-tuition status at a larger extent than those who we label as relatively wealthier.

Table A3: Percent of Recipients of Tuition Scholarships by School Types: 2015-2016

Programs in	2015			2016		
	Public	Voucher	Private	Public	Voucher	Private
Education						
Free tuition	0%	0%	0%	66%	54%	10%
BVP	17%	18%	26%	9%	10%	23%
BBIC	60%	50%	9%	10%	11%	2%
BEA	1%	1%	0%	1%	1%	0%
BJGM	7%	11%	4%	3%	6%	3%
Other	1%	1%	0%	1%	1%	1%
Non-Education						
Free tuition	0%	0%	0%	63%	49%	7%
BVP	1%	1%	0%	0%	0%	0%
BBIC	61%	49%	8%	10%	11%	3%
BEA	3%	3%	0%	2%	2%	0%
BJGM	11%	13%	4%	7%	10%	4%
Other	1%	2%	1%	1%	2%	1%

D Eligibility Criteria for *Beca Bicentenario* (BBIC) and *Beca Juan Gomez Millas* (BJGM)

Table A4: Eligibility Criteria for *Beca Bicentenario* (BBIC) and *Beca Juan Gomez Millas* (BJGM)

Year	Decree	Beca Bicentenario (BBIC)	Beca Juan Gomez Millas (BJGM)
2011	Decreto 39 de 2011	To study at CRUCH universities 1-2 income quintiles $PSU \geq 550$	To study at CRUCH or quality-accredited institutions 1-2 income quintiles $PSU \geq 550$
2012	Decreto 116 de 2012	To study at CRUCH universities 1-3 income quintiles $PSU \geq 550$	To study at CRUCH or quality-accredited institutions 1-3 income quintiles $PSU \geq 550$
2013	Decreto 97 de 2013	To study at CRUCH universities 1-7 income deciles $PSU \geq 500$	To study at CRUCH or quality-accredited institutions 1-7 income deciles $PSU \geq 500$
2014	Decreto 167 de 2014	To study at CRUCH universities 1-7 income deciles $PSU \geq 500$	To study at CRUCH or quality-accredited institutions 1-7 income deciles $PSU \geq 500$
2015	Decreto 108 de 2015	To study at CRUCH universities 1-7 income deciles $PSU \geq 500$	To study at CRUCH or quality-accredited institutions 1-7 income deciles $PSU \geq 500$
2016	Decreto 253 de 2016	To study at CRUCH universities 1-7 income deciles $PSU \geq 500$	To study at CRUCH or quality-accredited institutions 1-7 income deciles $PSU \geq 500$

E Tuition-Free College and the Extensive Margin

Table A5: Effect of Free College on Program Vacancies and First-Year Enrollment

	(1) Closing Programs	(2) Vacancies	(3) Freshmen Enrollment	(4) Vacancies	(5) Freshmen Enrollment
Post	0.003	0.475	0.530	-0.711	-0.813
	(0.015)	(1.496)	(1.750)	(4.416)	(4.949)
				(3.839)	(4.159)
Post#Agric.				0.839	1.679
				(8.381)	(9.905)
Post#Arts				1.697	2.771
				(7.712)	(8.998)
Post#Scien.				0.965	2.748
				(8.462)	(9.955)
Post#Soc.Scien.				2.547	3.276
				(6.674)	(7.800)
Post#Law				0.802	2.632
				(10.462)	(12.516)
Post#Educ.				0.297	2.483
				(5.343)	(6.108)
Post#Human.				4.748	5.990
				(11.813)	(13.983)
Post#Health				0.698	1.288
				(5.722)	(6.624)
Post#Tech.				1.249	-0.284
				(5.131)	(5.769)
Constant	0.168***	49.931***	54.830***	62.135***	67.389***
	(0.011)	(1.080)	(1.246)	(3.334)	(3.587)
Observations	2,591	2,014	2,152	2,014	2,152

Note: All regressions area of study fixed-effects. Standard errors in parentheses. Vacancies and junior rnrollment regressions ran in a sample conditioned on being a non-closing program. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

F Checking the Parallel Trends Assumption

Table A6: Difference in Applications to Teaching Majors for Students with $PSU \geq 600$ Relative to Students with $PSU < 600$ by School Type (2015 Baseline Year)

	Teaching as a Choice		Teaching as Top Choice	
	Coef.	Std.Err.	Coef.	Std.Err.
Public				
2014	-0.009	(0.011)	-0.009	(0.007)
2016	-0.024***	(0.009)	-0.010*	(0.006)
Voucher				
2014	-0.004	(0.006)	-0.001	(0.004)
2016	-0.010*	(0.006)	-0.004	(0.004)
Private				
2014	-0.006	(0.007)	-0.007	(0.006)
2016	-0.002	(0.007)	-0.003	(0.005)
Obs.	223,846		223,846	

Note: We present linear combination of the relevant coefficients for each category. All regressions include *comuna* fixed-effects, gender, and linear PSU score controls. The 600 threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. Standard errors clustered at the school level. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

The validity of the difference-in-difference strategy we use in this paper relies on the assumption that the application behavior among students in the treatment and control groups had the same trend before treatment ensued. We test this crucial assumption using data from 2014 college applications, one year before the timeframe of our analysis. Therefore, we expand our specification to include coefficients not only for 2016 (i.e., $Post = 1$ in the original specification) but also 2014. The regression becomes:

$$P_{i,t} = \sum_{g=0}^{G-1} \sum_{t=2014}^{2015} \left(\beta_g Y_{i,t}^g t + \gamma_g Y_{i,t}^g \mathbf{1}[PSU_{i,t} \geq 600] + \delta_g Y_{i,t}^g t \mathbf{1}[PSU_{i,t} \geq 600]\right)$$

$$+ X_{i,t}\theta + \mu_s + \varepsilon_{i,t}$$

If the pre-treatment trends assumption holds, and given that we treat 2015 as the baseline year, the coefficients associated with 2014 should not be statistically different from 0.

Table A7: Difference in Applications to Teaching Majors for Students with $PSU \geq 600$ Relative to Students with $PSU < 600$ by Mother's Education (2015 Baseline Year)

		Teaching as a Choice		Teaching as Top Choice	
		Coef.	Std.Err.	Coef.	Std.Err.
S<12					
	2014	-0.011	(0.014)	0.001	(0.010)
	2016	-0.022*	(0.013)	0.006	(0.008)
S=12					
	2014	-0.004	(0.008)	-0.005	(0.006)
	2016	-0.014**	(0.007)	-0.010**	(0.005)
12<S<16					
	2014	0.008	(0.008)	0.000	(0.006)
	2016	-0.006	(0.008)	-0.004	(0.006)
$S \geq 16$					
	2014	-0.012	(0.008)	-0.004	(0.006)
	2016	-0.011	(0.008)	-0.005	(0.005)
Obs.		204,487		204,487	

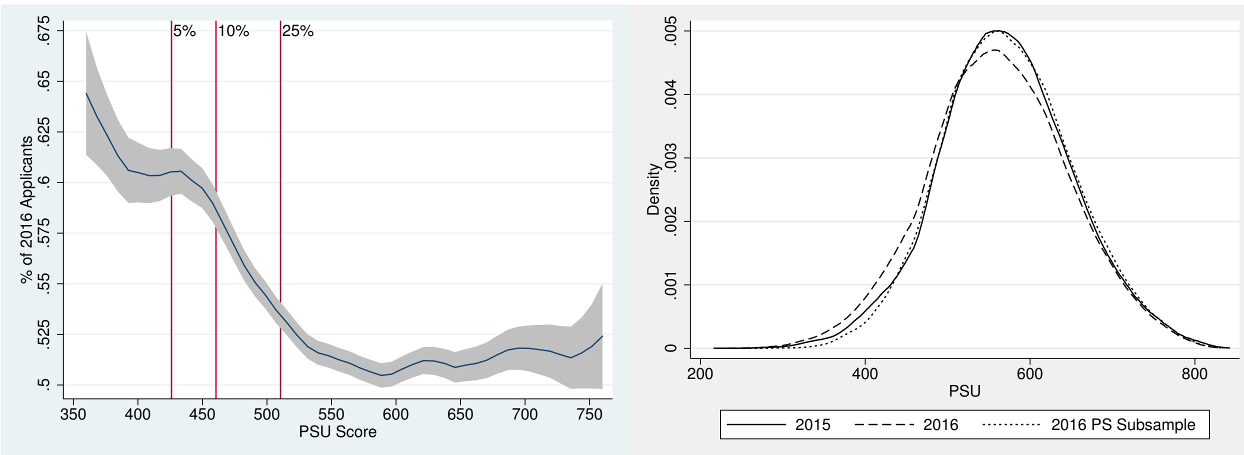
Note: We present linear combination of the relevant coefficients for each category. All regressions include *school* fixed-effects, gender, and linear PSU score controls. The 600 threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. Standard errors clustered at the school level. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

G "Reshuffle" *versus* "New Entrants"

Figure AF2: PSU Score and New Applicants

(a) Fraction of 2016 Applicants versus 2015 Applicants by PSU Score

(b) Distributions of Propensity Scores



Note: The left panel shows a linear polynomial regression where the dependent variable is takes the value of 1 if the student is a 2016 applicant and 0 if she is a 2015 applicant. The running variable is the PSU score. The range plot represents the 95% confidence intervals. The vertical lines show the location of the 5^{th}, 10^{th}, and 25^{th} percentiles. The right panel shows the PSU score distributions for different samples, namely, the PSU score distribution for college applicants in 2015, 2016, and the subsample of 2016 after dropping the observations that fall outside the propensity score's common support where "treatment" is having applied in 2016 and the predicting variables are gender, PSU score, school type, and municipality.

The introduction of free college in 2016 induced many new applicants, students who thought that the elimination of tuitions would ease their way into college. To see that, note that college applications from recent high school graduates increased by 3,201 students between 2014 and 2015, years with no access-to-college policy innovations. That represents a year-to-year increase of 4.58%. The introduction of free college in 2016 increased applications by 8,819 recent high school graduates year-to-year. That represents a relative increase of 12.%. That is, applications' growth after the introduction of free college more than doubled the existing trend. This inflow of new applicants effectively changed the pool of students we compare pre and post treatment, which could cast a cloud over the validity of our empirical strategy.

In this appendix, we show our results are robust to addressing the differences in the pool of applicants. First, note that Chilean net enrollment in tertiary education is extremely high:

90.3%. Thus, the room for expansions in applications is limited. In fact, Figure AF2a shows that if we pool 2015 and 2016 applications by PSU score, we find that 2016 applications are over-represented at the lowest quantiles of the PSU score distribution. If extra-applicants were evenly distributed across the PSU score range, Figure AF2a would be a flat line close to 50%. But that is not the case. For instance, 6 out of every 10 2015 and 2016 applications that come from the lower 5% on the PSU score distribution are from 2016 students. Such over-representation of 2016 applicants goes until the 25^{th} percentile of the PSU score, after which the line flattens to the expected level that results from natural cohort growth.

The over-representation of 2016 applicants in low quantiles of the PSU score obviously translates to a shift to the left of the 2016 applicants' PSU distribution relative to that of 2015 applicants, which is evident in Figure AF2b. To address the possible effect such a change in the pool of applicants may have on our results, we define a subsample of 2016 in which students were likely to have applied for college even in the absence of the tuition-free policy. To do so, we run a version of a propensity score matching where the "treatment" is having applied to college in 2016 *versus* 2015. As predicting variables we use gender, PSU score, school type, and municipality. Thus, we capture the differences in those variables between the applicants in each year. We then apply a nearest neighbor matching and, thus, we drop the 2016 applicants that are most dissimilar to those in 2015, at least in those observable domains. We end with a sample with the exact same size in both years.

Figure AF2b shows that keeping only the 2016 applicants who fall within the 2015 common support drops applicants from the left tail of the PSU distribution. In fact, the remaining 2016 sample—labelled "2016 PS Subsample" in the Figure—has a PSU distribution that mimics almost perfectly the one from 2015 applicants. We then run the same empirical strategy as the one that produce results Tables 5 and 6. In Tables A8 and A9, we show the estimates remain unchanged. Thus, our original estimates and the subsequent insight we infer from them do not hinge on the inflow of applicants in 2016 who would not have applied

Table A8: Effect of Free College on Application to Teaching Majors by School Type

	Teaching as A Choice		Teaching as Top Choice	
	Coef.	Std.Err.	Coef.	Std.Err.
Public				
$PSU < 600$	0.003	(0.006)	-0.006	(0.004)
$PSU \geq 600$	-0.024***	(0.008)	-0.016***	(0.004)
Diff	-0.026***		-0.010*	
Voucher				
$PSU < 600$	-0.003	(0.004)	-0.007***	(0.003)
$PSU \geq 600$	-0.014***	(0.005)	-0.012***	(0.003)
Diff	-0.010*		-0.004	
Private				
$PSU < 600$	-0.001	(0.007)	0.000	(0.005)
$PSU \geq 600$	-0.001	(0.003)	0.000	(0.002)
Diff	0.000		-0.001	
Obs.	145504		145504	
Avg. dep. variable	0.171		0.086	

Note: We present the size of the marginal effect for each category. All regressions include *comuna* fixed-effects, gender, and linear PSU score controls. The 600 threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. Standard errors clustered at the school level. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

in the absence of the tuition-eliminating policy.

Table A9: Effect of Free College on Application to Teaching Majors by Mother's Schooling

Note: We present the size of the marginal effect for each category. All regressions include school fixed-effects, gender, and linear PSU score controls. The 600 threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. Standard errors clustered at the school level. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

H Free College and Academic Proficiency of Those Who Get to College

Table A10: Effect of Free College on SIMCE Math Scores of Accepted College Applicants

Panel A: Overall					
N=110935	Other		Education		Diff.
Post	-1.782***	(0.317)	-3.441***	(0.630)	-1.659**
Panel B: School Type					
N=110719	Other		Education		Diff.
Post#Public	-2.685***	(0.724)	-4.952***	(1.119)	-2.267*
Post#Voucher	-2.585***	(0.410)	-4.167***	(0.797)	-1.582*
Post#Private	-0.314	(0.654)	1.083	(1.737)	1.397
Panel C: Mother's Education					
N=100814	Other		Education		Diff.
Post#$S < 12$	-3.179***	(0.821)	-3.752**	(1.511)	-0.573
Post#S=12	-2.682***	(0.513)	-4.655***	(1.006)	-1.973*
Post#$12 < S < 16$	-1.203**	(0.571)	-4.586***	(1.327)	-3.383**
Post#$S \geq 16$	0.111	(0.588)	0.173	(1.512)	0.062

Note: All regressions include gender controls. Regressions in Panel A and C include school fixed-effects. Regressions in Panel B include *comuna* fixed-effects. Column *Diff* presents the difference between the point estimates of *Education* and *Other* and tests for whether they are statistically different from each other or not. Standard errors clustered at the school level in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

We estimate the same model as in Table 9 but on scores obtained when the students were in 4^{th} grade of elementary school, around the age of 10.[23] That is, eight years before they consider their tertiary education decision. Table A10 shows result qualitative very similar to the ones we report using the PSU in Table 9. The students who eight years later end up in teaching majors scored 8% of a standard deviation less in their 4^{th} grade math test. Our results when comparing across socioeconomic traits also hold. As is the case with the PSU, Table A10 documents that the negative selection that affected the teaching majors was

[23]These yearly national tests, called SIMCE, are part of an information system stablished by the Chilean government to periodically evaluate learning outcomes across the country. They are mandatory and consistently evaluate math and language (Spanish) proficiency.

greater among poorer students.[24]

I Effect of of Free College on PSU Score of Enrollees

Table A11: Effect of Free College on PSU Score of Enrollees

Overall		School Type		Mother's Education	
	PSU		PSU		PSU
Post		*Post#Public*		*Post#S* < 12	
Other	-0.314	Other	-4.850***	Other	-3.026***
	(0.523)		(1.153)		(1.120)
Education	-1.956**	Education	-5.562***	Education	-5.130***
	(0.523)		(1.459)		(1.770)
		Post#Voucher		*Post#S=12*	
		Other	0.550	Other	-0.917
			(0.668)		(0.817)
		Education	-1.820*	Education	-2.747**
			(1.106)		(1.313)
		Post#Private		*Post#*$12 < S < 16$	
		Other	1.440	Other	1.232
			(1.048)		(0.989)
		Education	3.373	Education	-0.885
			(2.672)		(1.789)
				Post#S ≥ 16	
				Other	0.399
					(0.959)
				Education	1.737
					(2.219)
Obs	90109		89947		81755

Note: All regressions include school fixed-effects and gender controls. Standard errors clustered at the school level in parentheses. $*p < 0.1$, $**p < 0.05$, $***p < 0.05$.

[24]The results hold regardless if we consider math scores like in Table A10 or language scores, omitted for brevity purposes, but available upon request.

J Full Regression Tables

Table A12: Effect of Free College by Type of School

	(1) Teaching as a Choice	(2) Teaching as Top Choice
Voucher	-0.019***	-0.006
	(0.005)	(0.004)
Private	-0.076***	-0.040***
	(0.008)	(0.005)
Post	0.002	-0.006
	(0.006)	(0.004)
Voucher *X* Post	-0.006	-0.002
	(0.007)	(0.005)
Private *X* Post	-0.001	0.008
	(0.009)	(0.006)
PSU>600	0.003	0.006
	(0.007)	(0.005)
Voucher *X* PSU>600	-0.014*	-0.003
	(0.008)	(0.006)
Private *X* PSU>600	-0.008	0.007
	(0.009)	(0.006)
Post *X* PSU>600	-0.025***	-0.010*
	(0.009)	(0.006)
Voucher *X* Post *X* PSU>600	0.015	0.006
	(0.011)	(0.007)
Private *X* Post *X* PSU>600	0.023**	0.007
	(0.011)	(0.008)
psu	-0.001***	-0.000***
	(0.000)	(0.000)
Male	-0.043***	-0.029***
	(0.002)	(0.002)
N	154,277	154,277

Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Table A13: Effect of Free College by Mother's Schooling

	(1) Teaching as a Choice	(2) Teaching as Top Choice
$S = 12$	0.004	-0.001
	(0.005)	(0.004)
$12 < S < 16$	0.001	-0.006
	(0.006)	(0.005)
$S \geq 16$	-0.016**	-0.020***
	(0.007)	(0.005)
Post	-0.005	-0.016***
	(0.006)	(0.004)
$S = 12$ X Post	0.001	0.010*
	(0.007)	(0.006)
$12 < S < 16$ X Post	0.002	0.013**
	(0.008)	(0.006)
$S \geq 16$ X Post	0.010	0.018***
	(0.009)	(0.007)
PSU>600	0.002	-0.003
	(0.010)	(0.007)
$S = 12$ X PSU>600	-0.010	0.006
	(0.011)	(0.008)
$12 < S < 16$ X PSU>600	-0.015	0.006
	(0.011)	(0.008)
$S \geq 16$ X PSU>600	-0.003	0.015*
	(0.011)	(0.008)
Post X PSU>600	-0.022*	0.005
	(0.013)	(0.008)
$S = 12$ X Post X PSU>600	0.007	-0.015
	(0.015)	(0.010)
$12 < S < 16$ X Post X PSU>600	0.015	-0.009
	(0.015)	(0.010)
$S \geq 16$ X Post X PSU>600	0.010	-0.011
	(0.015)	(0.010)
psu	-0.001***	-0.000***
	(0.000)	(0.000)
Male	-0.037***	-0.026***
	(0.003)	(0.002)
N	140,984	140,984

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01