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

Rosa Castro-Zarzur
University of Maryland

Ricardo Espinoza
OECD

Miguel Sarzosa
Purdue University

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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 programs. 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 programs 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 key input in the formation of early human capital. 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 disadvantaged students. Research shows not only that teacher performance impacts student learning outcomes and academic achievement at all levels of education [Araujo et al., 2016, Schacter and Thum, 2004, Bau and Das, 2019, Hanushek et al., 2018], but that teacher's effects on students are persistent [Konstantopoulos, 2011]. For example, US students who are assigned to high-quality teachers exhibit better long term outcomes, such as a higher probability of attending college, and higher salaries [Chetty et al., 2014].

Because of the importance of teacher quality on a broad range of outcomes, attracting the best candidates to the teaching profession has become central to improving education systems around the globe. But, where and how to find the best teachers? There is convincing evidence that highly effective teachers were once among the best students in school [Glazerman et al., 2005, Xu et al., 2011, Alfonso et al., 2010].[1] For this reason, in countries with highly successful education systems such as Finland, Singapore, and South Korea prospective teachers are selected from among top high school students [Auguste et al., 2010, Seng Tang, 2015]. However, in most countries, universities still struggle to attract the best students to become teachers. The evidence suggests that students who pursue teaching program 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 perform lower on cognitive tests than students in other fields [Lang and Palacios, 2018].

[1] 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].

To a large extent, the difficulty of attracting top students to the teaching profession can be explained by a combination of low expected labor market returns and low social recognition of the profession [Elacqua et al., 2018, OECD, 2018]. For example, teachers are among the lowest-paid college graduates and are paid, on average, 15% less than similarly educated workers in OECD countries [OECD, 2017b].[2]

Moreover, recent international evidence shows that the net economic returns of teaching degrees are low on average [Hastings et al., 2013, Gonzalez-Velosa et al., 2015, Espinoza and Urzua, 2016], and that top students are significantly more likely to choose programs with higher economic returns, such as in STEM, business or law. As a result, several countries have implemented policies to make the teaching profession financially more attractive [OECD, 2005, Bruns and Luque, 2015]. Such policies include raising teacher salaries, offering more attractive professional development opportunities, making dedicated financial aid available in the form of grants, scholarships or special allowances, among others [Santiago, 2002, Claro et al., 2013]. At the same time, there has been increasing pressures to make higher education more affordable. In the US, for example, the idea of making universities tuition-free has been discussed and there are concrete plans for eliminating tuition fees in community colleges across the country. Both types of policies affect the relative return of university degrees and, ultimately, student choices [Bucarey, 2018]. For this reason, to continue attracting top students to the teaching profession, it is important to understand the interplay between policies that incentivize qualified students to pursue teaching degree programs and broader efforts to alleviate the financial burden of attending higher education.

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

[2] Studies in middle-income countries find that this difference is still significant after controlling for observable characteristics typically linked to labor productivity [Mizala and Ñopo, 2016].

of students depending on their eligibility to the *Beca Vocacion de Profesor* (BVP) tuition grant, a scholarship program introduced five years before, 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 subsequent introduction of the free-college policy equalized the relative prices of studying a wide range of different majors, potentially offsetting the incentives set out by the BVP.

Using difference-in-difference and triple-difference strategies 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 tuition-free policy. Thus, we identify the causal effect of eliminating tuition fees on students' 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. The probability of applying to a teaching major among high-performing students who come from relatively poor backgrounds fell by about 15.8%, offsetting the gains obtained by the BVP scholarship during its first years of implementation. In consequence, students admitted to teaching degrees achieve, on average, lower academic performance than before the policy, while the average score of those who were accepted into other majors remained unchanged or even improved. The drop was concentrated on the relatively poor high school graduates whose scores fell by around 10% of a standard deviation.

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, high performers from poorer backgrounds can substitute programs that were relatively cheap with programs that were more expensive and provide better returns. 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 and 6 present the results and section 7 discusses the results and concludes.

2 Institutional Background

2.1 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 undergraduate students 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, the net enrollment rate in Chile is 90.3%, ranking fourth in the world. Higher education is supplied by three types of institutions. Firstly, 59 Universities (*Universidades*), 40 of which are private, offer undergraduate and postgraduate degrees and enroll 42% of higher education students. Universities are further divided into "traditional" or CRUCH (acronym for *Consejo de Rectores de Universidades Chilenas*) and "non-traditional" or non-CRUCH. The former comprises all public universities and private universities founded before a large reform in 1981, receive direct funding from the government and their students are eligible for exclusive scholarships. The second type of institutions are Professional Institutes (PI, *Institutos Profesionales*), which offer 2-5 year non-academic degrees. There is a total of 39 PIs, all of which are private, and enroll 31% of the students in the higher education system. Finally, Technical Training Centers (TTC, *Centros de Formación Técnica*) offer two-year vocational degrees. There is a total of 51 TTCs across the country that enroll 11% of the students in the system [Centro de Estudios MINEDUC, 2017].

Higher education is Chile is financed by private and public sources. Until 2015, all students paid tuition fees and the government supported low-income through scholarships [see Beyer et al., 2015]. However, as a result of massive student protests that started in 2011, a large reform in 2015 made universities tuition-free for students from the poorest 50% families [Espinoza and Urzua, 2015].[3]

The admission to universities is primarily based on a nationwide university entrance exam called *Prueba de Selección Universitaria* (PSU) and, to a lesser extent, high school grades. A group of 41 universities, including private and public institutions use a centralized matching system to select students to their programs. Students applying to these universities submit an ordered list containing up to 10 choices. Using a deferred-acceptance matching algorithm, the system matches students with one specific university-degree pair (e.g., teaching in university

[3]Universities' participation in the tuition-free program was voluntary. All public universities automatically joined the program along with 14 private institutions joined the program. The reform did not include Professional Institutes (PIs) and Technical Training Centers (TTCs), which continued to charge fees.

1, psychology in university 1, etc.) based on student's PSU scores, high school grades and programs' vacancies [Espinoza et al., 2017]. The universities that do not participate in the centralized system, as well as PIs and TTCs, select students independently, although PSU scores are still required.

2.2 The Teaching Profession in Chile

As in many other parts of the world, Chile' s teaching programs struggle to attract top-performing students [Eide et al., 2004, OECD, 2005, Alvarado et al., 2012, Balcázar and Ñopo, 2014, Castro-Zarzur, 2018, Gomez et al., 2019]. Table 1 shows that, as measured by the average PSU scores of admitted students, teaching programs are less selective than programs in other fields. Interestingly, the observed score gap between teaching and non-teaching programs is explained by top-scoring students. For example, while the difference between cutoff scores across types of programs is near zero, the average maximum score among admitted students in STEM programs is 37.48 points higher—one third of a standard deviation—than in teaching programs. Not surprisingly, top-performing students are significantly less likely to apply to teaching programs in the first place. Figure 1 shows the correlation between the probability of applying to a teaching program and applicants' math performance in SIMCE, a nationwide student assessment, in 4^{th} grade, when they were 10 years old. Indeed, the figure shows that students performing in the bottom quintile in 4^{th} grade are twice as likely to apply to a teaching program eight years later when they finish high school than students in the top quintile.

Table 2 compares the characteristics of students enrolled in teaching programs with those enrolled in STEM and other disciplines. The average PSU score of students in teaching programs is roughly 30% of a standard deviation lower than students in STEM programs. Similarly, students in non-STEM programs (e.g., liberal arts, social sciences) outperform teaching students in PSU by more than 10% of a standard deviation. These gaps are mainly

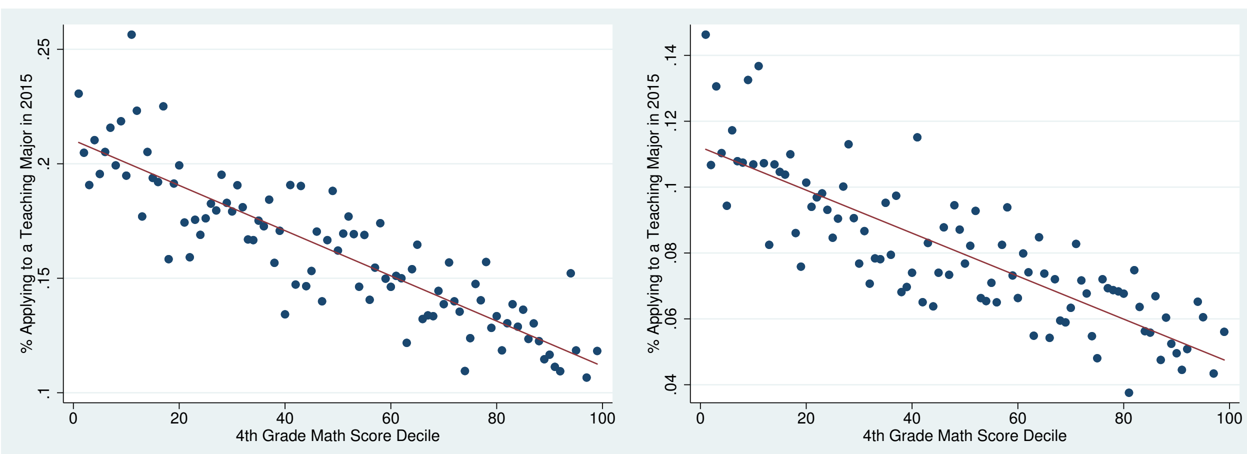
Table 1: Characteristics of Undergraduate Degrees Offered by Type

	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 admissions system. We exclude from the sample degrees offered by Professional Institutes and universities not in the centralized admission process. Teaching programs include only primary and secondary teaching programs. Pre-primary and special education majors are categorized as "others". Standard deviation in parentheses. Source: DEMRE and SIES, 2015.

Figure 1: Share of Students Applying to Teaching Programs and 4^{th} Grade Math Score (2015 Cohort)

(a) Applied to teaching program (b) 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 list of preferences and performance in SIMCE 4^{th} grade math SIMCE, by 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.

explained by the performance on the math section of the PSU exam. Students admitted in STEM programs score on average 61.6% of a standard deviation higher in math than teaching students.[4] Furthermore, and consistent with the student application patterns shown in Figure 1, only 12.3% of students admitted to teaching programs perform in the top 10% of the PSU. In contrast, one third of STEM students do.

These gaps show that teaching programs are much less attractive and competitive than programs in other fields. Indeed, only 20% of teaching students listed a teaching program as their top choice in the university application process. Students who ended up enrolling in STEM programs did not consider teaching majors as alternative professional paths: less than 1% of them listed a teaching major within their top three choices when applying to college. Table 2 also shows that teaching is overwhelmingly female-dominated. While two thirds of the students entering a teaching major were female, only a fourth of students entering STEM programs were so. Finally, students admitted to teaching programs come from more disadvantaged backgrounds. Compared with students in other fields, a higher share of teaching students attended a public school, and their mothers have completed less years schooling.

The reasons behind the low demand for teaching programs among relatively skilled students and those coming from affluent backgrounds are multiple and intertwined. First, in Chile there is low social recognition of teachers [Elacqua et al., 2018]. For instance, according to related surveys, only one third of parents would like their children to be teachers [Cabezas and Claro, 2011]. Similarly, two-thirds of teenagers find that the teaching profession is, along with music and theatre, among the least prestigious occupations. Second, teachers are underpaid [Mizala and Ñopo, 2016]. According to the OECD, teacher salaries are around 37% lower than the earnings of tertiary-educated workers. Moreover, despite the relatively

[4] 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, even behind countries that are vastly less developed, like Botswana and Philippines [Elacqua et al., 2018].

Table 2: Characteristics of Admitted Students 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 programs 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 majors in the fields of Sciences and Engineering according to the UNESCO classification of degrees. Source: DEMRE and SIES, 2015.

low tuition fees of teaching programs (see Table 1), the net labor market returns are very low. For example, Gonzalez-Velosa et al. [2015] estimate that the net financial return to teaching degrees in Chile is -1%, on average. What is more, Espinoza and Urzua [2016] find that teachers' income across the life course is similar to income obtained by workers without a college degree. Third, career development and salary raises are mostly based on seniority and not on merit. Despite these downsides, data from the US show that the teaching profession is still attractive to some individuals, particularly to those who are relatively more risk averse [Lang and Palacios, 2018], since teachers enjoy greater job stability and typically have longer holidays.

As a response to this worrying picture, over the last decade the Chilean government has introduced reforms to improve the attractiveness of the teaching profession [OECD, 2017a, Santiago et al., 2013]. These reforms include increasing teachers salaries, improving and expanding professional development opportunities, and dedicated financial aid to students pursuing teaching programs. The most recent and well-known is the introduction in 2011 of the "Teaching Calling Scholarship" (*Beca Vocacion de Profesor*) or BVP. The BVP scholarship covers all tuition costs of accredited teaching programs to students scoring 600 or more in the PSU exam (top 30%), irrespective of their income.[5]

Until the tuition-free reform, the BVP was the only public scholarship covering the full tuition costs of a university program in Chile, and had succeeded in attracting students with high PSU score into teaching programs. Alvarado et al. [2012] finds that in its first year of operation, eligible students were significantly mote likely to apply to, and enrolling in teaching programs. Consequently, the share of students from the top 30% increased from 10.7% in the year prior the BVP to 18.1%. Moreover, the evidence shows that, in relative terms, the BVP helped students from poorer backgrounds more than richer students [Claro et al., 2013]. Finally, Castro-Zarzur [2018] studies the local impact of the BVP using a regression discontinuity design approach (RDD). She finds a positive but decreasing local effect of the BVP around the eligibility threshold on the probability of applying and enrolling in teaching programs.

3 Data

We use four 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

[5] In addition to covering the tuition costs, student scoring above 700 also recieve a monthly stipend of about USD$150. Finally students scoring 720 or more in the PSU, covers the costs of a one-semester exchange program in a foreign university [Bonomelli, 2017].

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 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 high school 2^{nd} grade SIMCE because it is the one that correlates the most with the PSU—which ultimately defines college acceptance—while still being far enough in the past to not influence college/program choice. Importantly, students never learn their own SIMCE scores.

Lastly, we obtain individual income quintiles from the FUAS (*Formulario Unico de Acreditacion Socioeconomica*) form, which is completed by all prospective students applying to any public higher education scholarships or tuition aid, including the BVP and the free-tuition program. Along with the FUAS form, applicants must submit their households' relevant tax and income documentation to the Ministry of Education, which is in charge of assessing these information and determining each student's income quintile. Throughout the income assessment process, the Ministry of Education may cross-validate individual and household data with information from other sources such as the Ministry of Social Protection.

4 Empirical Strategy

4.1 Application Behavior

The tuition-free policy changed the relative price of different majors for a subpopulation of prospective students and as such may have affected how they self-sort into different college programs. The value that student i gives to program $j \in \mathcal{J}$ 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 program in set $\mathcal{J}$. Therefore, the value derived from the different programs in $\mathcal{J}$ will not be the same with and without the free-tuition policy and students' application behavior will change accordingly. Teaching degree programs have the lowest tuition fees in Chile (Table 1) and yield some of the lowest returns to their graduates [Gonzalez-Velosa et al., 2015, Espinoza and Urzua, 2016]. Thus, 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—as their preferences for a teaching major may have been influenced by its relatively low price. Therefore, tuition-free college has the potential to change eligible students' choices. The impact of such change on the pool of students pursuing a teaching program 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. Specifically, 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. Table 3 helps explain how we use the interplay of eligibility criteria of both financial-aid programs to that aim. It shows the scholarships offer for 2015 and 2016 along with their PSU score and income eligibility criteria. As explained above, eligibility for the BVP teaching scholarship was independent of income and only required

Table 3: Scholarship Eligibility by Household Income and *PSU* Score: 2015 - 2016

	$500 \leq PSU < 600$		$PSU \geq 600$	
	2015	2016	2015	2016
Income				
Decile ≥8			*BVP*	*BVP*
Decile = {6, 7}	B&J	B&J	B&J, *BVP*	B&J, *BVP*
Decile ≤5	B&J	B&J, **Free**	B&J, *BVP*	B&J, *BVP*, **Free**

Note: "Free" stands for the free college policy. "B&J" stands for *Beca Bicentenario* and *Beca Juan Gomez Millas*. The free-college policy had no explicit PSU cutoff. So, even students with $PSU < 500$ were eligible. However, given their low score, they were unlikely to be accepted to any program.

scoring more than 600 points in PSU. The introduction of tuition-free college in 2016 with its income requirement freed high-PSU-scoring applicants in the bottom half of the income distribution from the constraint of having to choose a teaching major to get free college. Changes in the application behavior of precisely this population of students is at the heart of our identification strategy.

The basis of our empirical strategy throughout the paper will entail the comparison of application behavior before (2015) and after (2016) the introduction of tuition-free college among those who score above and below 600 points in the PSU. It is easy to see from Table 3 that our base estimates are from a difference-in-difference strategy, where one difference comes from the introduction of the policy (i.e., 2015 versus 2016) and the second difference comes from the BVP scholarship eligibility criterium (PSU≥600 versus PSU<600). Our typical difference-in-difference strategy can be described by the following:

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

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-effects. 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.[6]

Table 3 also indicates that we can use additional variation to strengthen our empirical strategy. In particular, we can use the changes in application behavior from students in the top half of the income distribution—who are not eligible to tuition-free benefits—to control for confounding effects that could stem from cohort-specific changes. In that sense, we implement a triple-difference strategy where the third difference comes from the income eligibility criterium. To do so, let $Y_{i,t}$ be an indicator variable that takes the value of 1 if student i's household income belongs to the bottom half of the income distribution and 0 otherwise. Thus we can write our estimating equation as:

$$\begin{aligned} P_{i,t} = \beta_0 Post_t + \gamma_0 \mathbf{1}[PSU_{i,t} \geq 600] + \delta_g Post_t \mathbf{1}[PSU_{i,t} \geq 600] + \beta_Y Y_{i,t} \\ + \beta_g Y_{i,t} Post_t + \gamma_g Y_{i,t} \mathbf{1}[PSU_{i,t} \geq 600] + \delta_g Y_{i,t} Post_t \mathbf{1}[PSU_{i,t} \geq 600] \\ + X_{i,t}\theta + \mu_s + \varepsilon_{i,t} \end{aligned} \quad (2)$$

δ_g is thus the parameter that captures the tripe-difference estimator.[7]

[6] 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 C. We also need to assume that the effect of the BVP is stable across years, which Castro-Zarzur [2018] shows in her paper.

[7] As we explain in Section 4.1.2, in addition to proxying eligibility for the tuition-free college policy by income quintile, we use two long-term household income proxies: school type and mother's education. These proxies do not let themselves directly to the estimation of a triple-difference specification as in equation (2). Therefore, when we use the income proxies, we implement a somewhat different specification. 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:

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

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.

4.1.1 The Role of Contemporaneous Scholarships

Table 3 also show that throughout the period under study there were additional scholarships available to eligible students. In particular, the *Beca Bicentenario* and the *Beca Juan Gomez Millas* grants (B&J in Table 3) were also available to students scoring over 500 points in the PSU who wanted to pursue a college program in any field of study and came from households with incomes below the 70th percentile. However unlike the BVP or the tuition-free college policy, the B&J grants only cover up to 80% of the full tuition costs. The remaining 20% is still meaningful for families in the margin. It corresponded to approximately 150% of the yearly legal minimum wage, which is economically significant as per-capita incomes in the fifth decile—the tuition-free college policy eligibility threshold—ranged between 56% and 69% of the legal minimum wage in 2015.[8] Therefore, before the introduction of free college, the BVP was effectively enabling an important portion of low-income students access higher education through teaching programs.

In addition, based on Table 3 It is easy to see that our difference-in-difference identification strategy allows us to net out the effects of the B&J grants, whose incentives and eligibility criteria do not change during the period under study and are therefore differenced-out in our approach.

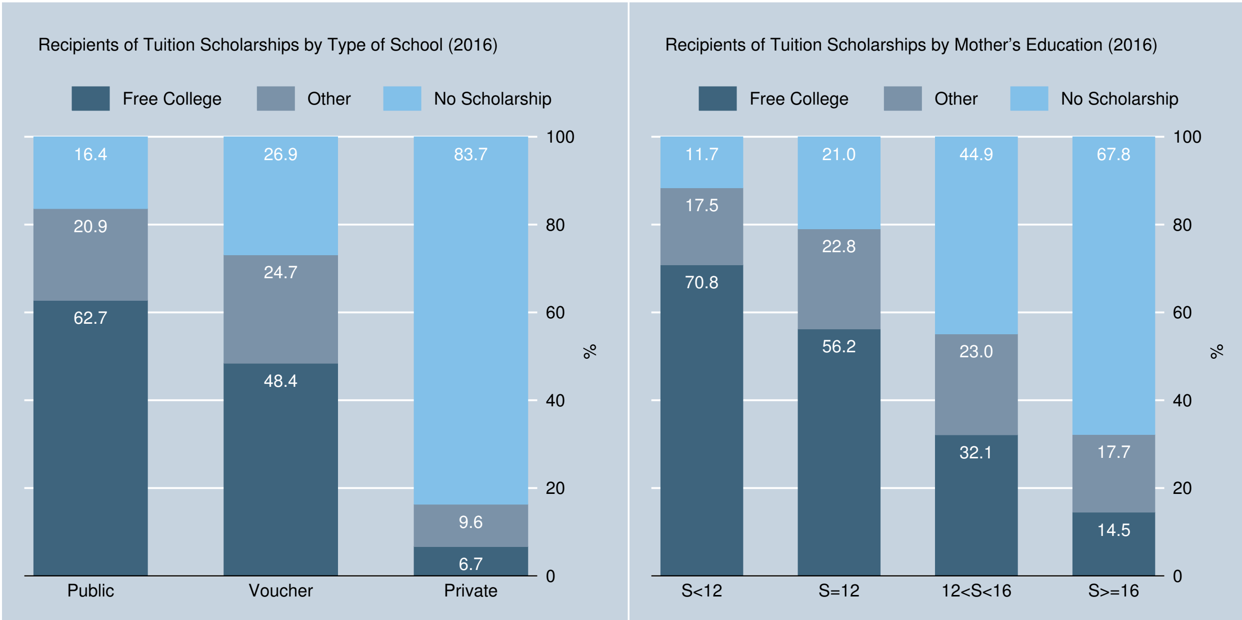
4.1.2 Observing Income Eligibility

We do not perfectly observe applicants' household income. Instead, we observe the income quintiles to which they belong. This creates a difficulty in our empirical analysis as the tuition-free college policy is intended for those in decile five or below. Therefore, our third quintile comprises both eligible and ineligible applicants (i.e., fifth and sixth deciles). We chose to include all the applicants whose income belongs to the third quintile into the income-eligible pool. Thus, ours will be conservative estimates of the effect as we mix into the treated

[8] https://portales.inacap.cl/becas-y-financiamiento-old/que-son-los-deciles-y-como-se-calculan

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.

group some applicants for whom the introduction of the policy would not merit any behavioral change.

In addition to the household income quitiles, we proxy income eligibility 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. These measures indicators of long term socio-economic status, allow us to 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 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.[9] 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. For instance, while 83.6% of applicants coming from public schools have access to a scholarship, 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.

4.2 Effect on Academic Quality

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 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

[9] 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.

versions of (2) with measures of academic proficiency as dependent variables and comparing the enrollees to teaching programs with those who enrolled to other fields:

$$Score_{i,t} = \beta_0 Post_t + \gamma_0 Teach_{i,t} + \delta_g Post_t Teach_{i,t} + \beta_Y Y_{i,t} + \beta_g Y_{i,t} Post_t + \gamma_g Y_{i,t} Teach_{i,t} + \delta_g Y_{i,t} Post_t Teach_{i,t} + X_{i,t}\theta + \mu_s + \varepsilon_{i,t} \quad (3)$$

where $Teach_{i,t}$ takes the value of 1 if the applicant was accepted to a teaching program and 0 otherwise. In this case, δ_g provides a triple-difference estimate of the effect the introduction of tuition-free college had on the average academic proficiency of accepted applicants. By including the comparison between teaching and non-teaching majors as one of the differences, we capture any overall shifts in scores that the free college policy might have caused. As measures of academic proficiency we use PSU score, high school GPA, and scores of the SIMCE standardized tests which students took when they were in their high school sophomore year. We refer to those past SIMCE 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 10^{th} grade SIMCE scores, having no bearing on the college acceptance decisions, do not influence students' application behavior.

It is important to note that in order to avoid an increase in the number of vacancies as a response to an expanded financial support (see evidence in [Dynarski, 2003, Abraham and Clark, 2006]), universities were not allowed to expand the supply. Indeed, Table A1 in the Appendix shows that universities complied with the restriction, as the number of vacancies did not increase after the tuition-free policy.

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 the introduction of the tuition-free college policy. 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%.[10]

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

[10]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 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.

variables. The first takes the value of 1 if the student applied to at least one teaching degree, independent of the order in which she listed it. In the second one, the dependent variable takes the value of 1 if the student applied to a teaching degree as her top choice. Table 5 present our main set of results. We report the changes in applicaiton behavior between 2015 and 2016 (i.e., before and after the introduction of the tuition-free college policy) for each eligibility group. We then present the difference-in-difference estimate for each category of free college eligibility. That is, the comparison of the changes in applicaiton behavior between BVP elibility groups while keeping the free college income eligibility fixed. As indicated in Section 4, we can obtain an estimate of the effect of the tuition-free college policy on the applicaiton behavior from the difference-in-difference estimate among those whose household income makes them eligible for free college. Furthermore, Table 5 presents triple-difference estimates of the effect, in which we substract the difference-in-difference estimates of those

Table 5: Effect of Free College on Applications to Teaching Majors Triple-Diff

	Apply to at least one teaching major			Apply to teaching major as top choice		
	$PSU < 600$	$PSU \geq 600$	Diff-in-Diff	$PSU < 600$	$PSU \geq 600$	Diff-in-Diff
$\Delta(t)$						
Household Income						
Decil ≤ 6	-0.0028	-0.0257***	-0.0230***	-0.0081***	-0.0181***	-0.0100**
	(0.004)	(0.005)	(0.006)	(0.002)	(0.003)	(0.004)
Decil > 6	-0.0014	-0.0029	-0.0015	-0.0034	-0.0028	0.0006
	(0.004)	(0.003)	(0.005)	(0.003)	(0.002)	(0.004)
Triple-Diff			-0.0215***			-0.0106**
			(0.007)			(0.005)
Obs			154,653			154,653
Avg. de. var.			0.171			0.086

Note: We present the size of the effect for each category calculated based on the regression results presented in Table A6 in the Appendix. The diff-in-diff column represents the difference-in-difference estimate from substracting the change in applications between 2015 and 2016 among those who score more that 600 points in the PSU minus the change in applications between 2015 and 2016 among those who score less that 600 points in the PSU for a given type of income eligibility. The Triple-Dif is obtained be substracting the difference-in-difference result for the income-eligible minus the difference-in-difference result for the income-ineligible. 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. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

ineligible to free college from the difference-in-difference parameter obtained from free college elible students. The additional difference will capture any potential confounding factors that stem from cohort effect affecting all applicants regardless of their household income.

Table 5 shows that the introduction of tuition-free college reduced the applicaiton to teaching programs among students that were eligible to the BVP scholarship. We find that applications to teaching majors among BVP-eligible students that come from poor households—and thus eligible to free college—dropped by 2.57 percentage points, while they did not change among BVP-ineligible or free college ineligible students. The difference-in-difference estimate indicates an 2.3 percentage points drop in the application to teaching majors among students from poor households. That amounts to a drop of about 13.5% in application to teaching majors from one year to the next. As expected the introduction of the tuition-free college policy did not affect the applicaiton behavior to teaching programs of those among richer household who would not be eligible. Therefore, the triple-difference estimate is no different from the difference-in-difference estimate among free college eligible students.

When we analize how the introduction of the tuition-free college policy affected the choice of a teaching major as the top preference, we find similar results. We see that the incidence of choosing a teaching major as the top preference fell among free college eligible students only. Interestingly, it fell both among BVP eligible and ineligible applicants, indicating that some poor students might have chosen a teaching major as their top preference in the absence of free college because it is the cheapest program even for those who are not BVP-eligible. However, as expected, the drop was significantly larger among the BVP-eligible applicants. The difference-in-difference estimate indicates a one percentage point drop. Therefore, the introduction of the tuition-free college reduced the incidence of choosing a teaching major as the top preference by 11.6%. Again, the triple-difference estimate is no different from the difference-in-difference estimate among free college eligible students.

5.1.1 Using long-term income proxies

As indicated in Section 4, 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 6. Their structure is similar to that of Table 5.

Table 6 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 difference-in-difference estimate finds that the likelihood of listing a teaching major among public and voucher school students falls by 2.5 and one percentage points. These drops correspond to a 14.6% and

Table 6: Effect of Free College on Application Behavior to Teaching Majors by School Type and Mother's Education

	$\Delta(t)$ in the Prob. of listing at least one teaching major					
	$PSU < 600$		$PSU \geq 600$		Dif-in-Dif	
Household Income Proxy:						
School Type (N=154,277)						
Public	0.002	(0.006)	-0.023***	(0.008)	-0.025***	(0.009)
Voucher	-0.004	(0.003)	-0.014***	(0.005)	-0.010*	(0.019)
Private	0.000	(0.007)	-0.001	(0.003)	-0.001	(0.019)
Mother's Education (N=140,984)						
$S < 12$	-0.005	(0.006)	-0.027**	(0.012)	-0.022*	(0.013)
$S = 12$	-0.004	(0.004)	-0.019***	(0.006)	-0.014**	(0.027)
$12 < S < 16$	-0.003	(0.006)	-0.010*	(0.005)	-0.007	(0.027)
$S \geq 16$	0.005	(0.007)	-0.007*	(0.004)	-0.012	(0.027)
Avg. depend. var.						0.171

Note: We present the size of the effect for each category calculated based on the regression results presented in Tables A7 and A8 in the Appendix. S stands for mother's years of schooling. The distribution of mothers' schooling years is as follows: 19.4% have incomplete high school or less ($S < 12$), 36.9% are high school graduates ($S = 12$), 22.4% went beyond high school but did not complete a 4-year tertiary education ($12 < S < 16$), 21.3% have a college degree or more ($S \geq 16$). All regressions include gender, and linear PSU score controls. The model using school type includes *comuna* fixed-effects, while the midel using mother's education include school fixed-effects. The 600 threshold for the PSU score was chosen based on the minimum score required to apply for BVP scholarship. Standard errors in parentheses are clustered at the school level. $*p < 0.1$, $**p < 0.05$, $***p < 0.05$.

6% decrease, 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.

Our findings remain overall consistent when we proxy household income with mother's years of education.[11] BVP-eligible students from relatively poor socioeconomic backgrounds (i.e.

[11] Results in the top and bottom panels of Table 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.

with relatively less educated mothers) respond to the introduction of free college by opting out of the teaching profession. 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 they did so by significantly more than applicants from equally poor household who would not have been eligible for the BVP. The difference-in-difference estimate indicates that the tuition-free college policy caused applications to teaching majors from students with high school dropout mothers and high school graduate mothers to drop by 12.8% and 8.2% respectively, while we find non-statistically signifficant differences among students with the relatively more educated mothers.

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 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, 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 C. 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 7,200 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 Appendix C. 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.

5.2 Effect on Enrollment

Table 7 shows that the free college policy not only altered application behavior to teaching programs, it also ended up changing the pool of students that were accepted to them. It documents that the students who were eligible to the tuition-free college policy were less likely to join a teaching major. Furthermore, that drop is more pronounced among those who also would have been eligible to the BVP scholarship. In fact, out triple-difference estimator indicates that the free college policy caused a 1.17 percentage points drop in the acceptance rate to teaching majors. That amounts to a drop of 18% in acceptance to teaching majors relative to pre-free college policy levels.

The change in application behavior due to the introduction of free college translated into 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 8, we present the changes in academic proficiency due to the introduction of free college for teaching programs and non-teaching programs separately. In Panel A, we show that while the introduction of free college did not change the average PSU score of the students accepted to non-teaching programs, the scores among the accepted to teaching ones did deteriorate. Importantly, the deterioration in the quality of the students admitted to teaching programs as measured by the PSU score is limited to those eligible to tuition-free college. That drop in the score is not mirrored by comparable students that were accepted into other programs. The triple-difference estimate indicates that the PSU score of accepted applicants to teaching majors drop by five points or 7.4% of a standard deviation due to the introduction of the tuition-free college policy.[12]

[12]While the standard deviation of the PSU among the entire population that took the exam is 110, when

Table 7: Effect of Free College on Acceptance to Teaching Majors Triple-Diff

	Accepted to a teaching major					
	$PSU < 600$		$PSU \geq 600$		Diff-in-Diff	
$\Delta(t)$						
Household Income						
Decil ≤ 6	0.0069***	(0.002)	-0.0180***	(0.003)	-0.0110***	(0.004)
Decil > 6	0.0083	(0.002)	0.0002	(0.002)	0.0006	(0.003)
Triple-Diff					-0.0117**	(0.005)
Obs						154,653
Avg. de. var.						0.066

Note: We present the size of the effect for each category calculated based on the regression results presented in Table A6 in the Appendix. The diff-in-diff column represents the difference-in-difference estimate from substracting the change in applications between 2015 and 2016 among those who score more that 600 points in the PSU minus that change among those who score less that 600 points in the PSU for a given type of income eligibility. The Triple-Diff is obtained be substracting the difference-in-difference result for the income-eligible minus the difference-in-difference result for the income-ineligible. All regressions include school fixed-effects, gender, and linear PSU score controls. Standard errors clustered at the school level in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

These findings should be interpreted with caution as students decide which program to apply to based, in part, on their PSU scores. That is why we consider additional measures of academic proficiency that were collected years before the college application process, and thus avoid the feedback process between PSU scores and application behavior that would bias the results. We focus on their cumulative high school GPA, and the math and language SIMCE scores measured when the students were in their high school sophomore year, that is, two years before they consider their tertiary education decision. Note that college admission decisions do not take into account SIMCE scores.

Panel B of Table 8 shows further evidence of the sorting caused by the introduction of the tuition-free college policy. It shows that the high school GPA of the accepted applicants to teaching majors dropped, while the high school GPA of accepted applicants to other majors improved. Again, the gap is tightly related to the eligibility to free college. Relative to

we limit the sample to those who ended up being accepted in traditional universities, the standard deviation of the score becomes 68.5.

Table 8: Free College and Academic Proficiency of Accepted Applicants

	$\Delta(t)$ in Score					
	Other		Teaching		Diff-in-Diff	
Panel A: PSU (*N=114879*)						
Decile ≤ 6	-0.411	(0.562)	-4.746***	(1.157)	-4.335***	(1.306)
Decile > 6	-0.430	(0.623)	0.112	(1.812)	0.542	(1.877)
Triple-Diff					-4.877**	(2.235)
Panel B: High School PGA (*N=114872*)						
Decile ≤ 6	3.454***	(0.853)	-5.730***	(1.967)	-9.184***	(2.086)
Decile > 6	2.515***	(0.853)	-1.928	(2.707)	-4.443	(2.778)
Triple-Diff					-4.741	(3.470)
Panel C: SIMCE Language (High School Sophomore Year) (*N=103572*)						
Decile ≤ 6	-5.900***	(0.499)	-7.129***	(1.139)	-1.229	(1.134)
Decile > 6	-7.100***	(0.510)	-5.891***	(1.528)	1.209	(1.563)
Triple-Diff					-2.438	(1.948)
Panel D: SIMCE Math (High School Sophomore Year) (*N=103499*)						
Decile ≤ 6	1.921***	(0.495)	-2.336**	(1.139)	-4.257***	(1.156)
Decile > 6	1.443***	(0.471)	0.870	(1.426)	-0.573	(1.421)
Triple-Diff					-3.684**	(1.837)

Note: We present change for each category calculated based on the regression results presented in Table A9 in the Appendix. Each panel represents a regression. All regressions include gender controls and school fixed-effects. Column *Diff-in-Diff* presents the difference-in-difference estimate from substracting the change in scores between 2015 and 2016 among those who were accepted to *Teaching* programs minus that change among those who were accepted to *Other* programs. The Triple-Diff is obtained be substracting the difference-in-difference result for the income-eligible minus the difference-in-difference result for the income-ineligible. Standard errors clustered at the school level in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

applicants accepted to other majors, the GPA of free college eligible applicants accepted to teaching majors dropped by 9.2 points or 10.2% of a standard deviation. Panel B shows the importance of controlling for possible general cohort effects. In particular, we see a deterioration of the GPA of the accepted applicants to teaching majors relative that of the accepted applicants to other majors, even among students that were not eligible to the free college policy. Once we take this into account in our triple-difference estimate, we quantify that the high school GPA among the students accepted to teaching programs deteriorated by 4.7 points or 5.25% of a standard deviation due to the introduction of the free college policy.

Moving on to earlier scores, those measured during their high school sophomore year, Panels C and D show further evidence on how the introduction of the tuition-free college policy caused a deterioration in the academic proficiency of the students who were accepted to teaching programs relative to those accepted to other programs. The relative deterioration in the academic quality of the students admitted to teaching programs is limited to those relatively poor. Our results indicate that the tuition-free college policy incentivized academic proficient students who would have chosen teaching programs otherwise to move on to other programs. Thus, it left the teaching programs with a pool of students with lower academic achievement. Especially, in terms of math ability, where such deterioration reached 3.7 points or 8% of a standard deviation. These stronger negative results in math compared to language could be due to the fact that students with average language and above average quantitative abilities—relative to those who would enroll in teaching programs—are typically more interested in majors where both types of skills are important (e.g, Business) and have higher chances of succeeding at these types of programs. This result is consistent with the evidence presented on Tables 4 and A10, where we see that the introduction of free-tuition college was associated with an increase in applications to and enrollments in Business, Health, and Social Sciences majors among relatively poor students.

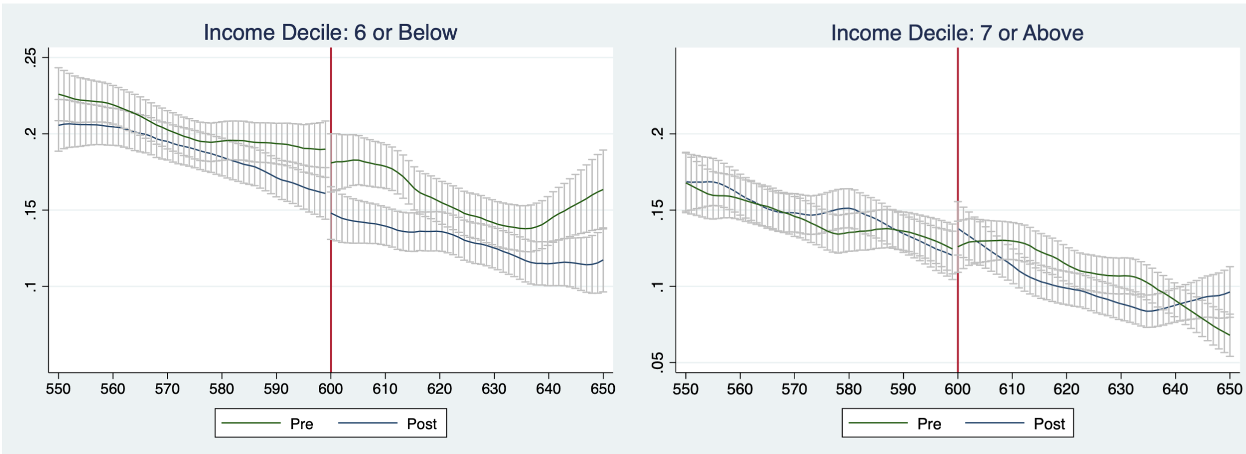
These findings provide evidence in favor of a mechanism in which the BVP scholarship had brought relatively high-quality students who could not afford college. Once the relative profitability of the teaching programs changed again due to the free tuition policy that covered the other majors, that subpopulation 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.

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 present our results. As expected, we find no significant 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 from poor households 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 wealthier households. Second, drops in application to teaching programs are not uniform across PSU scores. The biggest declines come from students between 600 and 615 points; those closest to the BVP eligibility threshold. Third, our findings suggest that by 2015 the BVP was not adding (bringing in) extra students to the teaching profession, but avoiding

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



Note: Local mean smoothing estimated with Epanechnikov kernel. Dependent variable takes the value of 1 of student listed a teaching major anywhere in her choice set and 0 otherwise. Lines labeled *Pre* plot application rates in 2015. Lines labeled *Post* plot application rates in 2016. Capped spikes represent confidence intervals at the 95% level.

larger shortages of qualified applicants to teaching majors.[13] With the introduction of the tuition-free policy, those shortages deepened as it made the BVP scholarship innocuous.

7 Discussion

IIn 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 fees of undergraduate careers for students from the poorest 50%. We study how making college tuition-free affects student preferences for teaching programs. We pay particular attention to the behavior of top students who, before the tuition-free policy, were eligible for a generous scholarship- the BVP grant- to study teaching programs. We examine the extent to which the tuition-free policy offset the incentives of the BVP grant, which had shown to be effecting in attracting top students to the teaching profession.

[13]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.

Our results suggest that the tuition-free policy reduces the demand of top performing from middle to low income families for teaching programs, who were 17% less likely to apply to a teaching programs. In addition, teaching programs became less popular among students. After the tuition-free policy students ranked teaching programs lower when applying to university.

Overall, after the tuition-free policy teaching programs attracted student with lower scores. 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 5% of a standard deviation. This decrease is explained by fewer top students from low socioeconomic backgrounds applying to teaching degrees, as the scores of the wealthier applicants remained 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. The paper illustrates that the interplay between different financial aid programs is complex and that unintended consequences may arise when new aid become available. Second, our findings illustrate the lack of complementarity between two overlapping benefits: the BVP and the tuition free college reform. Our results suggest that with the tuition-free benefit, the BVP ceased to bring high-performing students into the teaching programs. This is worrisome as there is convincing evidence suggesting that teachers who perform better in high school are more effective than those with lower performance. Third, our findings also provide an important input to the ongoing international debate about making college tuition free college. For example, making college tuition-free policy has emerged as one of the central themes in recent U.S. Presidential Elections where the initiative has shown to be appealing to a numbers of policymakers.[14] This paper shows a potential unintended consequence of

[14] Additionally, the free-college movement in the US has continuously gained strength during recent 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

such policy acting through a relative price change which affects the sorting of students into programs. This issue in particularly relevant countries with market-oriented higher education systems, as teaching programs tend to be cheaper and thus have usually been an affordable pathway for low-income students to obtain a higher education degree. In particular, 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.

This paper only examines the effects of the tuition-free policy in the teacher quality dimension. We show that the reform may affected teacher long-term quality by attracting students with lower scores to the teaching profession. We do not suggest, however, that the tuition?free policy was not beneficial for students. On the contrary, and as we showed in the paper, students tend to change their preferences for programs in areas that have, on average, higher returns.

a plan to make college tuition-free 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.

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Appendix

A Tuition-Free College and the Extensive Margin

Table A1: 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. $*p < 0.1$, $**p < 0.05$, $***p < 0.05$.

B Checking the Parallel Trends Assumption

Table A2: Tripple-Differnce Estimates Based on Income Eligibility by Year (2015 Baseline Year)

	Apply to at least one teaching major		Apply to teaching major as top choice	
	Coef.	Std.Err.	Coef.	Std.Err.
Year				
2014	-0.0127	(0.008)	-0.009	(0.006)
2016	-0.0232***	(0.007)	-0.0126**	(0.005)
Obs	224,222		224,222	

Note: We present the triple-difference obtained by substracting the difference-in-difference result for the income-eligible minus the difference-in-difference result for the income-ineligible where the base yaer is 2015. 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. $*p < 0.1$, $**p < 0.05$, $***p < 0.05$.

Table A3: 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 A4: 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. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

C “Sorting of students” *or* “New Applicants”?

The tuition-free policy, implemented in 2016, encouraged more students to apply for university admission. Even though the number of university applications had been increasing before 2016, the number of applications between 2015 and 2016 rose 12%, more than double the rate from 2014 to 2015 (4.58%). This expansion resulted in a change of the characteristics of applicants which may affect the comparability of the 2015 and 2016 cohorts, and potentially invalidate our empirical strategy if those new applicants are skewed towards being relatively poor, high-achieving and uninterested in teaching programs. In this appendix, we explore whether our results could be driven by the inflow of “new applicants”, or if the tuition-free policy affected student application behavior, and thus the “sorting of students” into teaching programs. Our analysis show that the latter effects dominates and that our results are indeed robust to changes in the pool of applicants.

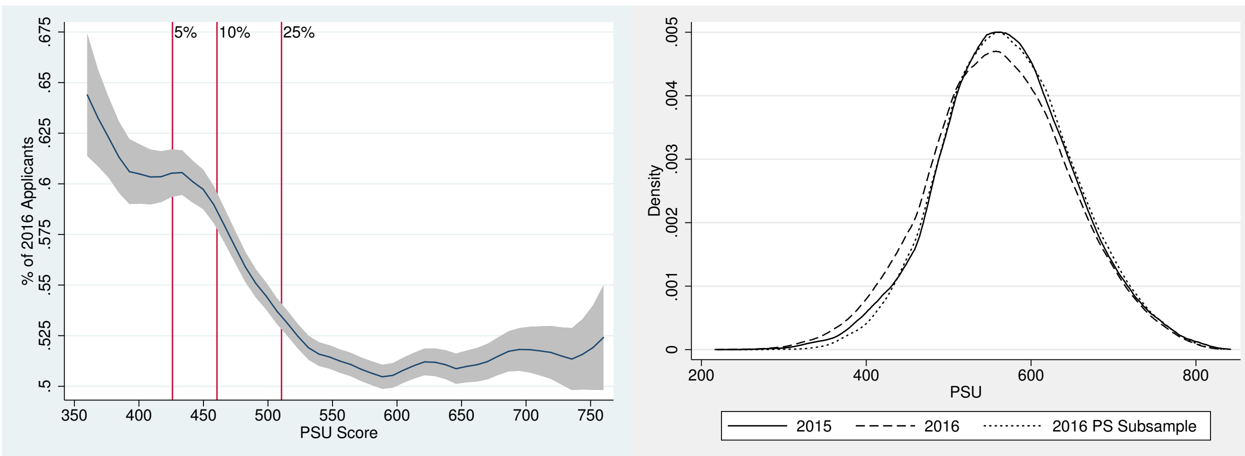
First, it is important to note that the gross enrollment in tertiary education in Chile was already high by international standards before the reform (85.3% in 2015). Thus, the room for expansion in the number of applications was limited.

In Figure AF1a we show that when we compare the 2015 and 2016 cohorts by PSU score, post-reform applicants are over-represented in the lowest end of the PSU score distribution. If the distribution of scores had not changed, Figure AF1a would show a flat line close to 50%. However, as the figure shows, 6 out 10 applicants whose scores are at the lowest 5% mark are from 2016. Indeed, low-performing students are over-represented in the bottom 25% of the distribution, after which the curve flattens. Figure AF1b shows that indeed the distribution of 2016 scores shifts to the left with respect to the distribution in 2015.

Figure AF1: 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 takes the value of 1 if the student is from 2016 and 0 if from 2015. 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 university 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 PSU and SIMCE scores.

To address the potential effect of this change on our results, we use propensity score matching to define a subsample of students in 2016 who are comparable with the applicants in 2015. We use PSU and SIMCE scores to match pre- and post-students using the nearest neighbor matching method with n=1 (same final sample in both years). Then, we estimate our model by restricting the sample to students who most likely would have applied in 2015 when the tuition-free policy was not in place.

Table A5 shows the results of the same regression reported in Table 5 but using the 2016 PS subsample. The table shows results that are consistent with those reported in Table 5. Therefore, our main estimates do not hinge on the fact that the tuition-free policy expanded the pool of university applicants.

Table A5: Effect of Free College on Applications to Teaching Majors Triple-Diff

	Apply to at least one teaching major			Apply to teaching major as top choice		
	$PSU < 600$	$PSU \geq 600$	Dif-in-Dif	$PSU < 600$	$PSU \geq 600$	Dif-in-Dif
$\Delta(t)$						
Household Income						
Decil ≤ 6	0.0003	-0.0260***	-0.0263***	-0.0055*	-0.0166***	-0.0111**
	(0.004)	(0.005)	(0.008)	(0.003)	(0.003)	(0.004)
Decil > 6	0.0029	-0.0037	-0.0066	-0.0002	-0.0040*	0.0037
	(0.004)	(0.003)	(0.009)	(0.003)	(0.002)	(0.004)
Triple-Dif			-0.0197**			-0.0088
			(0.008)			(0.005)
Obs			128,956			128,956
Avg. de. var.			0.171			0.086

Note: We present the size of the effect for each category. The diff-in-diff column represents the difference-in-difference estimate from substracting the change in applications between 2015 and 2016 among those who score more that 600 points in the PSU minus the change in applications between 2015 and 2016 among those who score less that 600 points in the PSU for a given type of income eligibility. The Triple-Diff is obtained be substracting the difference-in-difference result for the income-eligible minus that of the income-ineligible. 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. *$p < 0.1$, **$p < 0.05$, ***$p < 0.05$.

D Full Regression Tables

Table A6: Effect of Free College by Type of School

	(1) Applied to a Teach. Program	(2) Apply to Teach. Program as Top Choice	(3) Accepted to Teach. Program
Decile $\leq$ 6	0.017***	0.011***	0.008***
	(0.004)	(0.003)	(0.003)
Post	-0.001	-0.003	-0.001
	(0.004)	(0.003)	(0.003)
Decile $\leq$ 6 *X* Post	-0.001	-0.005	-0.006*
	(0.005)	(0.004)	(0.003)
PSU>600	-0.007	0.007**	-0.068***
	(0.005)	(0.003)	(0.003)
Decile $\leq$ 6 *X* PSU>600	-0.001	-0.008*	0.006
	(0.006)	(0.004)	(0.004)
Post *X* PSU>600	-0.002	0.001	0.001
	(0.005)	(0.004)	(0.003)
Decile $\leq$ 6 *X* Post *X* PSU>600	-0.021***	-0.011**	-0.012**
	(0.007)	(0.005)	(0.005)
psu	-0.001***	-0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Male	-0.037***	-0.026***	-0.025***
	(0.002)	(0.002)	(0.002)
N	154,653	154,653	154,653

Standard errors in parentheses

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

Table A7: 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 A8: 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

Table A9: Effect of Free College on Academic Proficiency

	(1)	(2)	(3)	(4)
		High School	Sophomore Year: SIMCE	
	PSU	GPA	Language	Math
Decile ≤ 6	-5.174***	-3.494***	-2.151***	-1.763***
	(0.617)	(0.913)	(0.445)	(0.449)
Accepted Educ	-21.282***	-42.058***	-6.277***	-12.326***
	(1.493)	(2.117)	(1.070)	(0.988)
Decile ≤ 6 X Accepted Educ	12.732***	9.766***	6.062***	4.823***
	(1.785)	(2.523)	(1.333)	(1.248)
Post	-0.430	2.515***	-7.100***	1.443***
	(0.623)	(0.853)	(0.510)	(0.471)
Decile ≤ 6 X Post	0.019	0.939	1.200**	0.478
	(0.769)	(1.099)	(0.591)	(0.589)
Accepted Educ X Post	0.542	-4.443	1.209	-0.572
	(1.877)	(2.778)	(1.563)	(1.421)
Decile ≤ 6 X Accepted Educ X Post	-4.877**	-4.741	-2.438	-3.684**
	(2.235)	(3.470)	(1.948)	(1.837)
Male	12.777***	-26.111***	-7.788***	10.071***
	(0.390)	(0.680)	(0.303)	(0.288)
N	114,879	114,872	103,572	103,499

Standard errors in parentheses

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

Table A10: Change in Enrollment by PSU

Panel A: PSU<600	Before	After	Diff. (%)	p-value
Business	0.130	0.134	2.89	0.224
Education	0.119	0.124	5.00	0.047
Health	0.182	0.178	-1.88	0.330
Social Sciences/Humanities	0.117	0.117	0.44	0.860
STEM	0.294	0.295	0.36	0.801
Others	0.159	0.151	-4.93	0.018

Panel B: PSU≥600	Before	After	Diff. (%)	p-value
Business	0.107	0.113	6.09	0.032
Education	0.053	0.047	-11.46	0.004
Health	0.194	0.204	4.81	0.016
Social Sciences/Humanities	0.110	0.116	5.41	0.053
STEM	0.377	0.356	-5.52	0.000
Others	0.160	0.165	3.14	0.162