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“The impact of free tuition on college enrollment and attrition: quasi-experimental evidence from Chile”

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ABSTRACT IN ENGLISH:

Using a fuzzy regression discontinuity design we estimate the effect of a country-wide free tuition policy on university enrollment and attrition in Chile. Exploiting an administrative dataset of the 2019 cohort of applicants we find significant impacts on both enrollment and attrition. The results are robust even after controlling for potential confounders and fixed effects. We find evidence of significantly larger effects among typically disadvantaged applicants such as rural an aboriginal. Results support the argument that free-tuition policy in higher education reduces socioeconomic gaps in access and attrition and such effects are larger for marginalized groups.

ABSTRACT IN SPANISH:

Usando un diseño de regresión discontinua estimamos el impacto de una política universal de gratuidad sobre la matrícula y la deserción universitaria en Chile. Explotando información administrativa de la cohorte de aplicantes del 2019 encontramos impactos significativos sobre ambas variables. Hallamos evidencia de que los efectos fueron significativamente mayores para grupos típicamente desaventajados como estudiantes rurales y aborígenes. Los resultados son consistentes con el argumento de que las políticas de gratuidad en la educación superior reducen las brechas socioeconómicas en el acceso y la deserción y que dichos efectos son mayores para grupos marginalizados.

ABSTRACT IN CATALAN:

Utilitzant un disseny de regressió discontínua estimem l'impacte d'una política universal de gratuïtat sobre la matriculació i deserció universitària a Xile. Explotant dades administratives de la cohort de sol·licitants del 2019 trobem impactes significatius sobre ambdues variables. Descobrim evidència que els efectes van ser significativament majors per a grups típicament en inferioritat de condicions com estudiants rurals i aborígens. Els resultats són consistents amb l'argument que les polítiques de gratuïtat a l'educació superior redueixen les escletxes socioeconòmiques a l'accés i la deserció i que aquests efectes són majors per a grups marginalitzats.

KEYWORDS IN ENGLISH:

Free-tuition, enrollment, dropout

KEYWORDS IN SPANISH:

Gratuidad, matrícula, deserción

KEYWORDS IN CATALAN:

Gratuïtat, matrícula, deserció

MASTER PROJECT

The impact of free tuition on college enrollment and attrition: quasi-experimental evidence from Chile

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Abstract

Using a fuzzy regression discontinuity design we estimate the effect of a country-wide free tuition policy on university enrollment and attrition. Exploiting an administrative dataset of the 2019 cohort of applicants we find significant impacts on both enrollment (6.1 percentage points) and attrition (3.8 percentage points). The results are robust even after controlling for potential confounders and fixed effects. We find evidence of significantly larger effects among typically disadvantaged applicants such as rural an aboriginal students. Results support the argument that free-tuition policy in higher education reduces socioeconomic gaps in access and attrition and such effects are larger for marginalized groups.

Contents

1 Introduction

Improving higher education access and continuity among poorer individuals can be a powerful vehicle to promote intergenerational mobility and reduce inequality. As it has been thoroughly documented around the world, students from richer families have a higher probability of attending, continuing, and finishing tertiary education (Bonneau and Grobon 2022, Bolton and Lewis 2023, Broer et al. 2019), which in turn has an influence on the persistence of income inequality (Chetty et al. 2020, Denning et al. 2019, Zimmerman 2014). There has been a debate on whether this gap is driven by a long-term difference in educational investment that conditions the level of academic preparation (Cameron and Heckman 2001, Carrell & Sacerdote 2017, Hai and Heckman 2017) or by the fact that liquidity constraints make it harder to access and perform in college for vulnerable students (Belley et al. 2007, Dillon and Smith 2017).

Nevertheless, recent evidence shows that large-scale interventions aimed at reducing this gap by the means of minimizing academic barriers or financial constraints are both very effective. For instance, one can mention successful affirmative action policies in the developed world (Bleemer 2022, Hill 2017) and in developing economies (Brotherhood et al. 2023, Mello 2022). On the other hand, while the literature analyzing the impact of reducing credit constraints on enrollment, persistence and graduation is

abundant in rich countries as the United States (Castleman and Long 2016, Denning 2017), it remains scarce in poorer and more unequal countries where the potential impact of financial aid policies may be bigger.

In this context, Chile represents an interesting case to study because of the recent implementation of a country-wide free tuition policy. First implemented in 2016 for students belonging to the bottom 50% of the income distribution, the actual free higher education policy (Ley N°21.091, from now on "gratuidad") was formally enacted in 2018 and states that college tuition fees of students belonging to the lower 60% of the income distribution ("vulnerable students") would be paid by the State of Chile.

Prior to the implementation of this policy, the main channel used by vulnerable students to pay tuition fees in Chile were government grants and State-subsidized loans. Solís (2017) showed that access to these credits doubled the likelihood of immediate enrollment and increased the probability of ever enrolling by 50%, helping to reduce the income gap in enrollment and years of schooling. Moreover, research in the region has mainly studied the impact on enrollment, paying less attention to the impact on dropout (Melguizo et al. 2016) . While a correlational study from Flores et al. (2020) suggests that "gratuidad" had an effect on reducing the number of dropouts and improving academic progress in a vocational education institution, system-wide causal evidence in this area is still missing.

Therefore, in this paper we first seek to clarify whether the free tuition policy had or not an impact on enrollment. Additionally, we investigate the existence of a causal impact on student attrition. To answer these questions, we exploit the sharp eligibility criteria of the policy, as the income threshold determined by the law (being part of the lower 60% of the income distribution) allows to identify a quasi-random variation in the assignment to the benefit around this cutoff. Hence, a comparison of students just below and just above this threshold provides exogenous variation in financial constraints, allowing for a regression discontinuity design (RDD) that overcomes problems associated with unobserved variation and self-selection.

The availability of data on socioeconomic characteristics, academic background, financial aid accessibility and centralized university application system for an entire cohort

of students facilitated our task massively. Specifically, we identified the cohort that completed the "Prueba de Selección Universitaria" (standardized college admission test, from now on "PSU") at the end of the 2018 academic year and applied for a college degree for the 2019 academic year (from now on, "2019 cohort"). Then, by comparing individuals' propension to enroll and dropout on both sides of the cutoff we were able to identify the causal impact of "gratuidad" on enrollment and attrition.

For the sake of comparability between treatment and comparison groups, we restricted our baseline sample to the richest (poorest) 90% of the sixth (seventh) income decile students of the 2019 cohort. Our results show that "gratuidad" beneficiaries are six percentage points more likely to enroll than their counterparts from the seventh income decile. Additionally, we identified a substantial causal reduction of attrition among free tuition recipients, whose average first year dropout rate was four percentage points lower. Considering that first year attrition rates are around 20% on average at baseline, we can conclude that the free tuition policy generated a 19% reduction on immediate dropout. This result is maintained over time, as the effect on attrition over the first two years of college is also equivalent to a 4 percentage points drop.

However, our results should be considered a lower bound of the impact of "gratuidad" for two reasons. First, the effect is local in the sense that we are only considering the "gratuidad" beneficiaries that are classified in the sixth income decile, which correspond to the richest among this group. Hence, assuming that eliminating financial constraints will have a larger impact on more financially deprived students, it is straightforward to see that the effect will be larger among those classified in deciles 1 to 5. Secondly, a robustness analysis shows that the average effect estimates have a larger magnitude when the sample is narrowed to a subgroup closer to the income eligibility criteria. This suggests that, if income does affect enrollment or attrition around the cutoff, an eventual bias would be attenuating our baseline estimates as poorer students will be less (more) likely to enroll (dropout).

We also explored the heterogeneity of the results by gender, rurality, ethnicity, high school type and expected returns of the degrees. Historically disadvantaged groups such as rural and aboriginal students are found to be the most benefited by the effect

of the free tuition policy . Rural students show the largest effect with a 16 percentage point increase in their enrollment rate. With respect to high school type we found mixed results, as the effect on enrollment was higher among public school students but the effect on attrition is not significant for them. Moreover, we show that the positive effect on enrollment is stable among all levels of degree expected returns, whereas the attrition reduction is larger for degrees with medium and high expected returns.

The findings of this paper represent a novel contribution to the literature, with this being the first causal estimation of the impact of a country-wide free tuition policy on enrollment and attrition in a developing economy. The magnitude and the robustness of the results suggest that "gratuidad" contributed to the reduction of socioeconomic gaps in higher education enrollment and persistence. The fact that historically underrepresented groups perceived the largest impact is a promising result that is suggestive of a social mobility enhancement. However, further research on the impact of the policy on degree completion and labor market outcomes is necessary to be able to draw conclusions in this sense.

The remainder of the paper is organized as follows. Section II presents the Chilean background and the data. In section III we explain the identification strategy. In section IV we show the results of this paper. Finally, section V concludes discussing the novelty and limitations of the results, as well as the potential policy implications.

2 Background and Data

2.1 Chilean Higher Education System

The higher education system is composed of vocational institutions -which typically offer short cycle degrees- and universities, which represent 60% of higher education enrollment. In this paper we focus on the University sub-system (USS) for three reasons. First, access to universities is determined by a centralized and unique admission system ("Sistema Único de Admisión", from now on SUA) that defines a homogenous selectivity criterion, based on PSU scores and high school GPA. Additionally, the public institution in charge of the administration of the admission system (DEMRE) provides standardized information about the students' socioeconomic background, high school of graduation, PSU scores, application process, and degree of enrollment. Further-

more, participating in the process is free and allows for multiple degree applications (maximum of 10), minimizing the credit constraints associated to apply.

In the Chilean USS, 70% of undergraduates are enrolled in private institutions, which differs notably from the worldwide trend where enrollment is concentrated in public institutions. Nevertheless, there exists a categorization of universities within the system that has a huge implication in terms of institutional financing. The "traditional institutions" -25 public and private universities founded before 1981- receive an important direct funding yearly form the government, whereas the other 30 universities don´t receive direct funding and are mainly financed through students' tuition fees.

Regardless of this classification, tuition fees are relatively high as the average yearly fee in 2019, for both traditional and non-traditional universities, was around 3.9 million Chilean pesos (6,000 USD in 2019). This is about 10 times the median monthly income of the time. Hence, it is very unlikely that most families can afford the tuition fees without any financial aid. In fact, as it was documented by Solís (2017) and is summarized in Figure 1, the rise of low-income student participation in higher education was possible due to the introduction of state financial aid such as loans (FSCU), state-subsidized credits (CAE) and different scholarships provided by the government of Chile (the most important being the "Beca Bicentenario", BBIC).

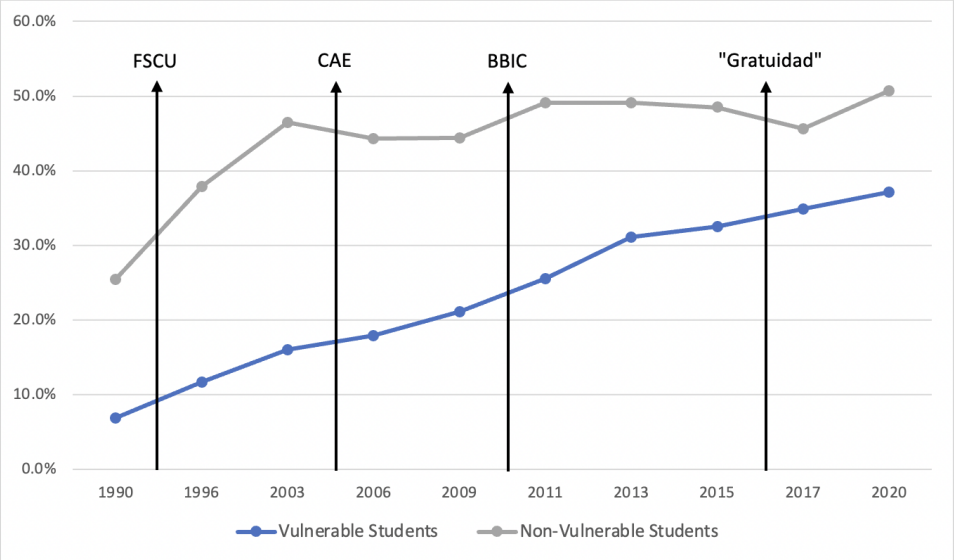
The coverage of these financial benefits is massive today, as 77% of the 2019 cohort benefited from at least one of the state aids. Nevertheless, high levels of copayment [1] have been highlighted systematically by students and institutions as a not yet solved problem. While almost one half of the 2019 cohort benefited from free tuition, the other half had to afford an average level of copayment of 2.9 million Chilean pesos (4,500 USD in 2019). It is certain that students need to find a financial alternative to cover this copayment, which may go from private credits or family borrowings to having to find a job while studying.

It is worth noting that, since we compare students from income deciles six and seven, the financial constraint relaxation we are studying corresponds to the elimination of the copayment around the threshold. To be more specific, almost 80% of first year en-

[1] Copayment corresponds to the fraction of the tuition fees that is not financed with state financial aid mechanisms.

rollees classified in decile seven use as main financing mechanism the BBIC, which is a government grant given to those in the bottom 70% of the income distribution and that allows to finance on average 71% of the tuition fee. The remaining 20% of decile seven students use state-provided (FSCU) or subsidized (CAE) loans with a limit that falls below the real tuition fee. In a nutshell, these students had to afford an average copayment of around one million Chilean pesos (1,500 USD).

Figure 1 – Net Enrollment Rate in Higher Education by Vulnerability Status, population between 18 and 24 years old



Source: CASEN 1990-2020, Ministerio de Desarrollo Social y Familia.

Furthermore, it is important to clarify some aspects regarding the application process of the 2019 cohort for college degrees and financial aid. Students took the PSU by the end of the academic year during November 2018, when they also had the first chance to apply for financial aid by submitting a socioeconomic form ("Formulario Único de Acreditación Socioeconómica", FUAS). The Ministry of Education of Chile (MINEDUC) cross-checks this information with tax records to finally determine the income decile of each applicant, making it very difficult for families to self-select into the income decile they want to be classified in. Although Chile has non-negligible levels of informal occupation (29%), these families are mostly classified in the lowest category of income decile which is an aggregation of deciles one to four [2]

[2]Due to the difficulty of identifying differences in per capita income of families belonging to the bottom 40% of the income distribution, the FUAS classification groups them all in the same category.

Towards the end of 2018 students received their PSU scores and had to define their degree applications in order of priority, with a maximum of ten degree-institution combinations. It is important to note that at that moment financial-aid applicants didn´t know yet in which income decile they were classified and therefore didn´t know if they were eligible for free tuition (or any state financial aid) when they submitted their degree priority. By mid-January 2019, accepted students were informed in which program they were admitted and which financial benefits they had access to, having three days to decide if they would enroll or not. This implies that for those applicants around the threshold, being classified in decile six (free tuition) doesn't determine their degree priority decision, but may only affect the decision of enrolling or not. Once students had accepted or declined their offers, the Ministry of Education informed institutions about enrollees' income decile and financial benefit assignment.

With respect to "gratuidad", it is important to mention that there are some institutions that aren't part of the policy and therefore their vulnerable students don't receive free tuition. In fact, the law requires universities to have certified their quality standards, a title that is granted by a public autonomous institution, in order to be able to affiliate to the policy. Thus, low-quality universities that haven't received the certification yet are not part of "gratuidad". Moreover, as the tuition fee paid by the state for each beneficiary is regulated and in some cases falls below the real tuition fee, there are some universities that have decided not to subscribe to the policy. Nonetheless, affiliated universities account for most of the enrollment and almost 80% of the 2019 cohort entered one of these institutions.

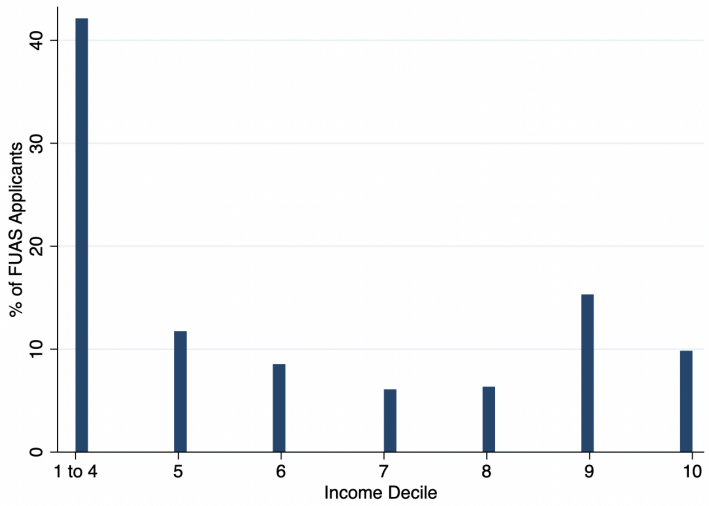
2.2 Data and Baseline Sampling

The main data sources used were the DEMRE administrative files, which contain information about the 137,029 applicants of the 2019 cohort, their socioeconomic characteristics and the corresponding enrollment derived from the process. Apart from applications and enrollment status this source contains applicants' PSU scores, self-reported family income, city and high school of origin, parents' years of schooling, ethnicity and many other socioeconomic characteristics. The second set of data used were the MINEDUC official enrollment files of the years 2019 to 2021, which contain individual-level enrollment information in all the higher education institutions of the

country. These sources allowed us to identify whether or not students continued in their degrees during the two years that followed their enrollment.

Additionally, we used the 2019 FUAS application data to identify the income decile of all those who applied for financial aid, as well as the benefits (grants, credits or free tuition) provided. The rate of application to financial benefits is very high, as 84% of the 2019 cohort filled the FUAS and received a socioeconomic characterization. Again, the key feature of this income decile classification is that it is validated by the tax authorities, which makes it very hard to influence the result. Usually, students who don't apply to financial aid are assumed to be at the top of the income distribution, because otherwise it seems impossible that their families are able to pay the tuition fees. Figure 2 shows the income decile distribution of FUAS applicants, where the spike of the first category comes from pooling students from deciles one to four in one group.

Figure 2 – 2019 Cohort Financial Aid Applicants by Income Decile



Source: DEMRE and FUAS data 2019.

In the same line, we also used the "Comisión Ingresa" data -organization created to manage the state-subsidized credit (CAE)- to identify the beneficiaries of the loan and the proportion of their corresponding tuition fee that they financed through this mechanism. The fifth source of data used corresponds to the MINEDUC's administrative data on high schools' vulnerability index, as well as the historical data with the high school GPA of all students that attended this educational level between 1990 and 2018. This enabled us to observe the academic background of every student and the average

vulnerability of their peers during high school. Lastly, we also used a public dataset constructed by the MINEDUC in collaboration with tax authorities that contains the average earnings of the graduates of each degree.

After pooling all these sources of data, we proceeded to define the baseline sampling used for the enrollment impact evaluation. To do so, we first narrowed our population to the group of accepted applicants classified in the sixth and seventh deciles of the income distribution. Then, as our running variable (income decile) is discrete we had to use an auxiliary variable to get a sample that was closer to the eligibility cutoff. Hence, among the accepted applicants classified in the sixth decile we discarded the 10% with the lowest self-reported family per capita income, while from the seventh decile accepted applicants we disposed of the 10% with the highest family per capita income. After doing so, we were left with 8,004 accepted applicants from the sixth decile (treatment group) and 5,574 from the seventh decile (control group), which is the baseline sample used to compute the effect on enrollment.

To define the baseline sample for the attrition analysis we followed an analogous procedure, but starting from the universe of enrolled students as dropout can only be computed for those that were enrolled at the beginning of the 2019 academic year. Among the 2019 cohort enrollees classified in the seventh decile we excluded the 10% with the highest self-reported income, and from the sixth income decile enrollees we dropped the 10% with the lowest self-reported income. Thus, the remaining 4,510 seventh decile enrollees constitute the baseline control group for the attrition analysis, whereas the 6,699 six decile enrollees leftover formed the baseline treatment group to compute the effect of free tuition on dropout.

In Table 1 we present a mean comparison between our enrollment analysis baseline treatment and control groups for the main covariates available in our data. Only in five out of fourteen variables the differences are statistically significant, yet we don't see substantial differences for these variables in levels. For example, the 0.025 difference in average high school GPA is equivalent to a 0.05 standard deviations difference. Moreover, in those cases where these slight differences arise, the sign generally suggests that the treatment group is a marginally less privileged group, which is consis-

tent with them having a smaller family per capita income.

Table 1 – Control and Treatment Group Mean Comparison, Enrollment Analysis Sample

Variable	Control	Observations	Treatment	Observations	Difference	P-Value
Age	18.89	5,574	18.97	8,004	0.080	0.094
Mother Education	14.57	5,370	14.39	7,757	-0.190	0.000
High School GPA	5.84	5,286	5.86	7,612	0.030	0.001
PSU Average Age	595.22	4,257	597.30	6,479	2.080	0.146
Men	0.47	5,574	0.46	8,004	-0.014	0.101
Ocupancy Rate	0.11	5,574	0.11	8,004	-0.001	0.911
Metropolitan Region	0.38	5,574	0.38	8,004	-0.003	0.690
Rural	0.09	5,574	0,09	8,004	0,006	0.266
Aboriginal Rate	0.16	5,574	0,17	8,004	0.006	0.363
Public School	0.27	5,285	0,29	7,611	0,0235	0.004
Subsidized School (1-7)	0.67	5,29	0,67	7,611	0.000	0.990
Private Schools	0.07	5,285	0,04	7,611	-0,024	0.000
School IVE	0.65	4,966	0,66	7,336	0.010	0.002
Best 10% of HS Promotion	0.16	5,286	0.17	7,612	0.007	0.302

All in all, we can conclude that our groups are very similar in terms of observables and that assignment to treatment is almost as good as random in this sample. Moreover, as will be shown in the results, the point estimates obtained are not sensible to controlling for the variation of all fourteen observables, which reinforces the statement that the assignment to treatment in our baseline sample is quasi-random.

3 Identification Strategy

3.1 Effect on Enrollment

To estimate the causal effect of free tuition on college enrollment we rely on a fuzzy Regression Discontinuity Design (RDD), where assignment to treatment means that the applicant was classified in the sixth income decile and was accepted in any degree, independent of whether the institution is affiliated to the free tuition policy or not. However, receiving the treatment corresponds to the case in which the sixth decile applicant was accepted at an institution affiliated to "gratuidad", which means that she was actually offered a free tuition placement. As we showed in Table 1, among accepted students the sixth decile individuals (treatment group) are similar to their peers of the seventh decile (control group) in terms of observables, which allows us to rea-

sonably assume that students' assignment to treatment is quasi-random in this sample.

Also, it is important to remember that students don't know their income decile when they decide to which degree apply, which allows us to discard the possibility of selection bias at least for individuals near the cutoff who have similar aspirations of being eligible for free university (propension to apply is independent of treatment status). Then, as the assignment to the benefit is informed just hours before the enrollment period opens, we can use accepted applicants just above the income cutoff as a counterfactual of those just below. Therefore, we used the following IV specification to identify the mean difference in enrollment propensity between free tuition beneficiaries and those without the benefit in our baseline sample:

$$\begin{aligned} Enrollment_i &= \alpha + \hat{Treatment}_i\beta + \epsilon_i \\ Treatment_i &= \pi + Decile6_i\theta + \xi_i \end{aligned} \tag{1}$$

Where $Enrollment_i$ takes value 1 if the applicant finished the admission process enrolled and 0 otherwise. The endogenous instrumented variable $Treatment_i$ takes value 1 if the individual was offered free-tuition in the institution in which she was accepted and 0 otherwise. Similarly, $Decile6_i$ is equal to 1 if she was classified in the sixth income decile and 0 otherwise (seventh decile). Since in this setting we are in the presence of no-shows (sixth decile students accepted at institutions without free tuition) and in the absence of crossovers (no seventh decile students will receive free tuition) the estimated β will identify the average treatment on the treated (ATT) around the cutoff [3].

However, given differences in some of the covariates between the two groups (Table 1) we also estimate the same IV-regression including controls - all covariates in the balance check - and district of residence fixed effects φ_r:

$$\begin{aligned} Enrollment_{ir} &= \alpha + \hat{Treatment}_{ir}\beta + Controls_{ir}\delta + \varphi_r + \epsilon_{ir} \\ Treatment_{ir} &= \pi + Decile6_{ir}\theta + +Controls_{ir}\delta + \varphi_r + \xi_{ir} \end{aligned} \tag{2}$$

This strategy is equivalent to estimating the mean difference between free tuition beneficiaries and their counterparts without this benefit while controlling for observables. The IV regression framework also provides robust standard errors that facilitate infer-

[3] We compute the causal estimate for individuals in the 6th decile, but the effect might differ in other parts of the distribution where the removal of the financial constraint might have a lower or higher effect given different baseline levels of constraint.

ence. All that being said, a source of potential bias must be considered as it leads the estimate to be a lower bound. Cattaneo et al. (2023) establishes that RDD strategy with discrete running variables must consider not only the assumption of continuity of the error term distribution around the threshold, but also that the running variable must not have an effect on the outcome variable.

Regarding the first assumption, despite not being testable, we have already shown the balance check and included the relevant controls. While self-selection of individuals into the sixth decile would undermine the validity of estimates, Figure 2 is not suggestive of individuals self-selecting to get the treatment as the histogram follows a smooth shape. Moreover, as explained in the data section, students apply to certain degrees before knowing in which decile they will be classified, which guarantees that around that threshold the incentives to apply are similar.

Arguing that the income decile doesn't affect enrollment, even if it is just around the threshold, would be conflicting with the hypothesis that reducing financial constraints has an effect on enrollment propensity. Yet, if anything, richer students within our baseline sample would be more prone to enroll and then our estimate would be biased downward. Therefore, our baseline estimates should be interpreted as a lower bound of the effect of "gratuidad" on the enrollment propensity of sixth decile beneficiaries.

3.2 Effect on Attrition

The estimation of the effect on attrition follows a similar specification but considering a different baseline sample. As it was described in section II, for this analysis we only consider those applicants of the 2019 cohort that ended up enrolled in a degree. If free tuition has a positive impact on enrollment, then those students from the sixth decile that would have not enrolled without free tuition (from now on, "marginal students") might be different and potentially come from a more deprived environment. Hence, it is important to consider that our baseline treatment group (sixth decile enrollees) for the attrition analysis is probably slightly less advantaged in terms of unobservables than the comparison group (seventh decile enrollees), which means that they will be more likely to dropout and then our estimate will again be a lower bound of the effect of free tuition on dropout probability.

$$
\begin{aligned}
Attrition1_i &= \alpha + \hat{Gratuidad_i}\beta + \epsilon_i \\
Gratuidad_i &= \pi + Decile6_i\theta + \xi_i
\end{aligned} \tag{3}
$$

$$
\begin{aligned}
Attrition2_i &= \alpha + \hat{Gratuidad_i}\beta + \epsilon_i \\
Gratuidad_i &= \pi + Decile6_i\theta + \xi_i
\end{aligned} \tag{4}
$$

The IV specifications (3) and (4) are similar to (1), what changes is the dependent variable, the treatment variable and the sample considered. $Attrition1_i$ takes value 1 if individual i dropped out during the first year of degree and 0 otherwise, which was computed by evaluating if she was enrolled or not in the same degree in 2020. Similarly, $Attrition2_i$ is equal to 1 if she dropped out during the first two years of degree and 0 otherwise (0 if she was enrolled in the same degree in 2021). Further years' attrition are not considered since undergraduate degrees in Chile go from 3 to 5 years. $Gratuidad_i$ is a dummy that takes value 1 if the individual benefited from free tuition and 0 otherwise (sixth decile students enrolled at an institution affiliated to the policy).

Additionally, we estimate the same IV regressions including the same controls as before and fixed effects for district of residence φ_r, university ϕ_u, and degree λ_d:

$$
\begin{aligned}
Attrition1_{irud} &= \alpha + \hat{Gratuidad_{irud}}\beta + Controls_{irud} + \varphi_r + \phi_u + \lambda_d + \epsilon_{irud} \\
Gratuidad_{irud} &= \pi + Decile6_{irud}\theta + Controls_{irud} + \varphi_r + \phi_u + \lambda_d + \xi_{irud}
\end{aligned} \tag{5}
$$

$$
\begin{aligned}
Attrition2_{irud} &= \alpha + \hat{Gratuidad_{irud}}\beta + Controls_{irud} + \varphi_r + \phi_u + \lambda_d + \epsilon_{irud} \\
Gratuidad_{irud} &= \pi + Decile6_{irud}\theta + Controls_{irud} + \varphi_r + \phi_u + \lambda_d + \xi_{irud}
\end{aligned} \tag{6}
$$

As argued in the previous section, given the absence of crossovers, the β parameter identifies a lower bound of the ATT around the cutoff.

3.3 Inference

Regarding inference, we rely on the theoretical and simulation results of Kolesár et al. (2018). They argue that the usual practice in RDD literature of clustering standard errors at the running variable level is not robust to model misspecification and underestimates the actual standard error, leading to over rejection of the null hypothesis that causal estimates are not significant.

On the other hand, heteroskedasticity robust standard errors are a more appropriate choice for inference. While discrete running variables lead to bias in RDD estimation, this bias will be underestimating the causal effect. So, while confidence intervals will be biased, we can establish the direction of such bias and thus argue that if the estimate is statistically significant, the true causal effect will be different from 0. Moreover, Kolesár and Rothe (2018) argue that as long as one can reduce the bias by making the bandwidth smaller, as we did by removing top and bottom self reported incomes in 7th and 6th deciles, discreteness only causes problems of inference if number of support points in the bandwidth is not large enough (which is not our case).

4 Results

4.1 Baseline Results

In Figure 3 we present on the left side the probability of being treated among accepted students (first stage) and on the right side the discontinuity in enrollment propensity at the income eligibility cutoff. First, note that a fuzzy RDD is needed because 20% of the accepted students of decile six were offered a placement at an institution not affiliated to "gratuidad" and therefore did not receive the treatment. Second, we must highlight that the raw mean difference of around 4 percentage points in enrollment propension between decile six and seven accepted students should be interpreted as a lower bound of the Intention to Treat (ITT) of the free tuition policy.

Furthermore, in Table 2 we present the ITT and ATT parameters for the effect of free tuition on enrollment using our baseline sample. Following our identification strategy, we observe that "gratuidad" generated an average increase of 6.1 percentage points in enrollment likelihood, with this average treatment effect being statistically significant. It is important to note that our point estimates remain stable and are robust to the inclusion of controls and district of residence fixed effects, which provides further support to our identification strategy.

Similarly, Figure 4 shows the proportion of enrolled students that are "gratuidad" recipients (first stage) and the attrition probability discontinuity at the threshold (reduced form). Again, a fuzzy design is justified by the fact that not all vulnerable students are free tuition recipients as 20% of them enrolled in non-affiliated institutions.

Figure 3 – First Stage and Discontinuity at the Threshold of Effect on Enrollment

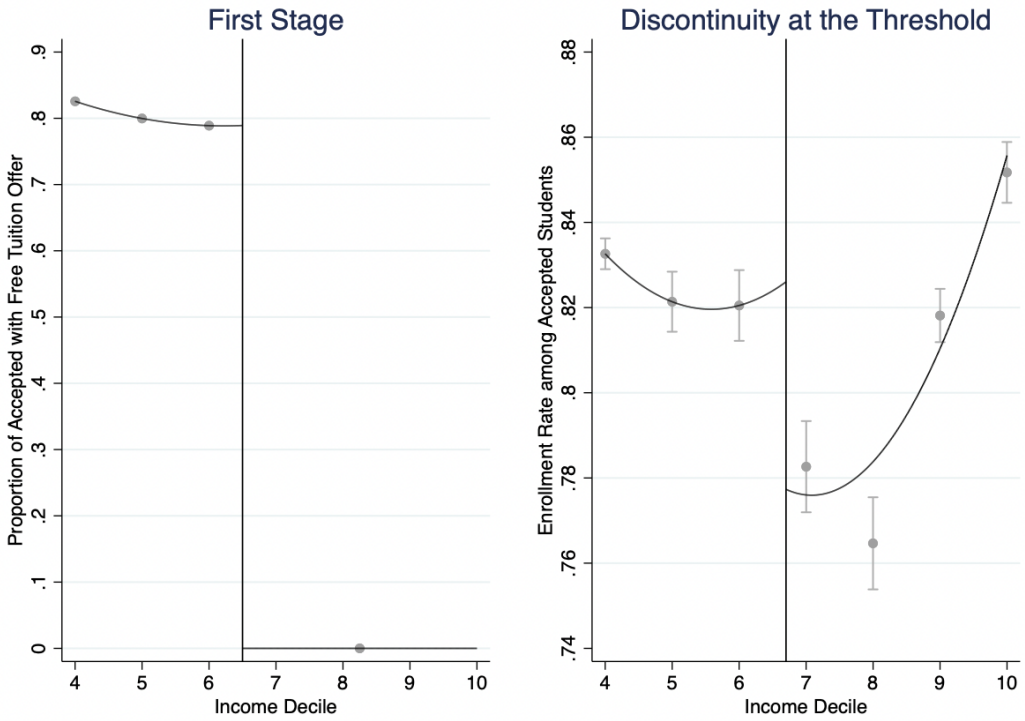


Table 2 – Free Tuition Impact on Enrollment, ITT and ATT parameters

	(1)	(2)	(3)	(4)
Variables	**ITT**		**ATT**	
Decile6	0.0473***	0.0484***		
	(0.00738)	(0.00789)		
Treatment			0.599***	0.0612***
			(0.00929)	(0.00978)
Constant	0.775***	0.0410**	0.775***	0.102
	(0.00590)	(0.0961)	(0.00590)	(0.0943)
Controls & Fixed Effects	No	Yes	No	Yes
Observations	12,430	10,921	12,430	10,921
R-squared	0.003	0.068	0.022	0.084

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The jump in attrition levels from decile six to seven is statistically significant and represents the ITT lower bound of the effect of "gratuidad" on first year dropout.

Figure 4 – First Stage and Discontinuity at the Threshold of Effect on Attrition

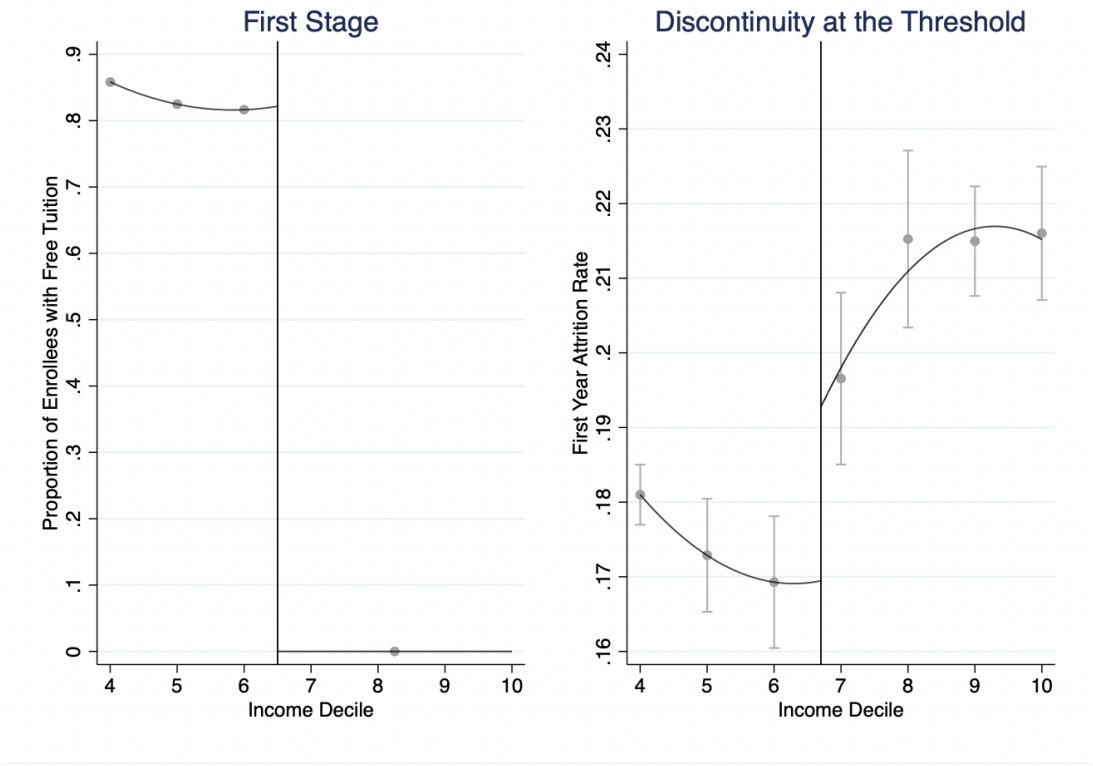


Table 3 – Free Tuition Impact on Attrition, ITT and ATT parameters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**ITT Attrition1**		**ATT Attrition1**		**ITT Attrition2**		**ATT Attrition2**	
Decile6	-0.0338***	0.0295***			-0.0400***	0.0299***		
	(0.00780)	(0.00835)			(0.00876)	(0.00916)		
Gratuidad			-0.0415***	-0.0382***			-0.0490***	-0.0388***
			(0.00956)	(0.0105)			(0.0107)	(0.0115)
Constant	0.199***	0.569***	0.199***	0.580***	0.271***	0.837***	0.271***	0.848***
	(0.00624)	(0.153)	(0.00624)	(0.149)	(0.00695)	(0.169)	(0.0695)	(0.164)
Controls & Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	10,368	9,151	10,368	9,151	10,368	9,151	10,368	9,151
R-squared	0.002	0.107	0.002	0.108	0.002	0.148	0.002	0.148

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 presents our baseline results for the effect on attrition. We observe that the free tuition policy decreased the probability of dropping out in the first year by approximately 3.8 percentage points, with this estimated ATT being again robust to control-

ling for individual characteristics and district, university and degree level fixed effects. To put this impact in perspective, we must mention that the average first year attrition rate among seventh decile students is around 20%, which means that in relative terms "gratuidad" reduced first year dropout by 19%.

Moreover, when we consider dropout rates over the first two years of degree (Attrition2) the ITT and ATT parameters are still significant and similar in magnitude, which suggests that the impact does not vanish after two years. Hence, students induced to persist to the second year are not dropping out right after. Note that in this case we see a slight drop in the estimates' magnitude once we include controls and fixed effects, but this was expectable as we are now considering in the treatment group the marginal students that were induced to enroll by the free tuition policy.

These baseline results should be considered local effects as we are only considering free tuition beneficiaries from decile six, which correspond to the richest "gratuidad" recipients. Then, under the assumption that credit constraint reduction has a greater impact among more financially deprived students, it seems reasonable to assume that the average effect would be higher among students classified in the bottom 50% of the income distribution. Thus, we believe that the point estimates presented in this section are a lower bound of the effect of "gratuidad".

4.2 Sensitivity and Placebo Tests

To further assess the robustness of our results we conducted a sensitivity analysis and a placebo test. As we explained earlier, in our baseline sampling we had to use an auxiliary variable (self-reported family per capita income) to narrow our sample closer to the income eligibility cutoff. In particular, we decided to drop the 10% with the lowest (highest) self-reported income among sixth (seventh) decile students. We deliberately chose this conservative narrowing criteria (n=10%) because the self-reported income variable is certainly not free from measurement error. Nonetheless, we decided to evaluate the sensibility of our baseline results to the variation of this narrowing criteria, replicating the ATT estimation of specifications (2), (5) and (6) using more narrow windows around the income threshold with n=20%, 30% and 50%, respectively.

In Table 4 we show the results of the sensitivity analysis, which consistently support

the idea that our baseline estimates represent a lower bound. In fact, the ATT on enrollment gradually increases from six to almost ten percentage points when we narrow the window around the cutoff. Although it is more moderate, the ATT point estimates for attrition also exhibit a consistent rise as the sample considered to compute the effect is concentrated around the income eligibility threshold. In brief, these results support our previous hypothesis that if income affects enrollment (attrition), it will be generating an attenuation bias in our baselines estimates as more financially deprived students have a smaller (larger) probability of enrolling (dropping out).

Table 4 – ATT Sensitivity to Narrowing the Window around the Cutoff

	(1) Baseline Sample: n=10%	(2) n=20%	(3) n=30%	(4) n=50%
ATT Enrollment	0.0612***	0.0651***	0.0765***	0.0973***
	(0.00978)	(0.0104)	(0.0110)	(0.0132)
Observations	10,921	9,636	8,417	6293
ATT Attrition1	-0.0382***	-0.0404***	-0.0422***	-0.0468***
	(0.0105)	(0.0112)	(0.0120)	(0.0147)
Observations	9,151	8,022	7,007	5,041
ATT Attrition2	-0.0388***	-0.0434***	-0.0456***	-0.0509***
	(0.0115)	(0.0123)	(0.0132)	(0.0161)
Observations	9,151	8,022	7,007	5,041

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In addition, we performed a placebo test by comparing students around an alternative income decile threshold where students on both sides of the cutoff received similar financial aid benefits. In particular, we replicated our baseline specification with a narrowing parameter of 10% but using fifth decile students as a comparison group and those classified in decile 6 as the placebo treatment group [4]. Note that students on both sides of this placebo threshold are eligible for "gratuidad" and, under the assumption that they are similar in terms of unobservables, we shouldn't observe differences in enrollment and attrition likelihood between them.

[4] We didn't compare deciles 7 and 8 because there is a substantial difference between these groups in financial aid possibilities, as the BBIC is only accessible for the bottom 70% of the income distribution.

Table 5 shows the results of the placebo experiment and the analogous baseline estimates. As expected, the differences in enrollment and attrition likelihood between our placebo comparison and treatment groups are not significant at the 5% level even when these estimates were computed using more than ten thousand observations. Contrarily, our baseline results evidence significant differences at the 1% level between deciles six and seven for the three outcome variables. Briefly, these results endorse the validity of decile seven students as a counterfactual of what would have been the situation of decile six students without "gratuidad".

Table 5 – Placebo Experiment Comparing Income Deciles 5 and 6

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Enrollment**		**Attrition1**		**Attrition2**	
ATT	0.0612***	0.0111*	-0.0382***	0.00284	-0.0388***	0.00730
	(0.00978)	(0.00626)	(0.0105)	(0.00659)	(0.0115)	(0.00737)
Constant	0.102	0.196**	0.580***	0.629***	0.848***	0.977***
	(0.0943)	(0.0797)	(0.149)	(0.109)	(0.164)	(0.128)
Controls & Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,921	15,435	9,151	12,642	9,151	12,642
R-squared	0.084	0.049	0.108	0.085	0.148	0.125

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3 Heterogeneous Effects

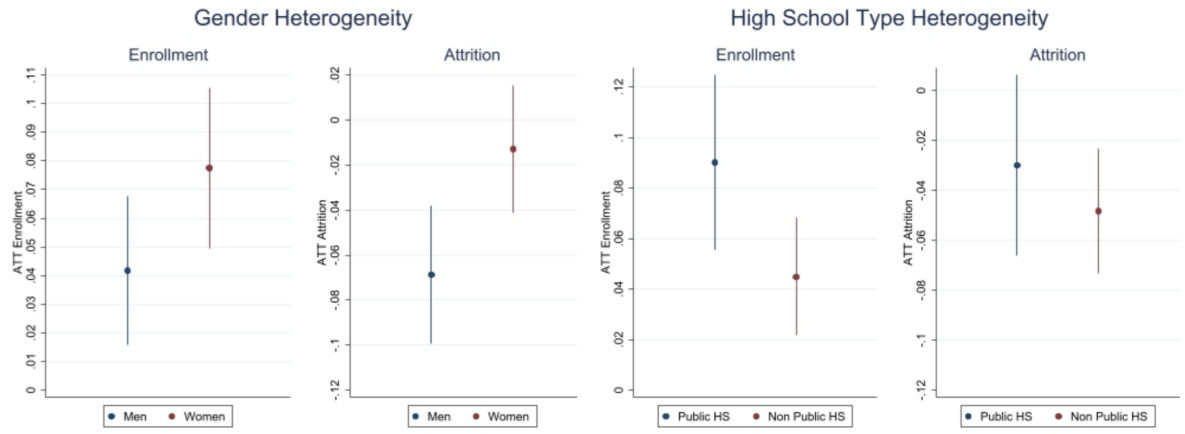
In this section we explore the heterogeneity of our baseline results by replicating specifications (2) and (5) for particular subgroups of our baseline sample.

In Figure 5 we present the heterogeneity of the ATT on enrollment and first year attrition by gender and high school type. While female applicants perceived a larger rise in enrollment propensity (8 pp vs 4pp for males), the attrition reduction effect was not significant among women. Reversely, male students experienced a substantial first year dropout reduction of around 7 percentage points, but the rise in enrollment likelihood was more moderate for them.

The right side of Figure 5 shows the heterogeneity of effects depending on the high school type of the applicant, where non-public pools together voucher (subsidized)

and private schools. For enrollment, the effect among public high school students doubled the impact observed for their non-public high school peers. However, the effect of free tuition on attrition is not significant among public high school graduates whereas we observe a significant 5 percentage point reduction in first year dropout for non-public school alumni. However, for both outcomes the effects are not statistically different as the confidence intervals overlap.

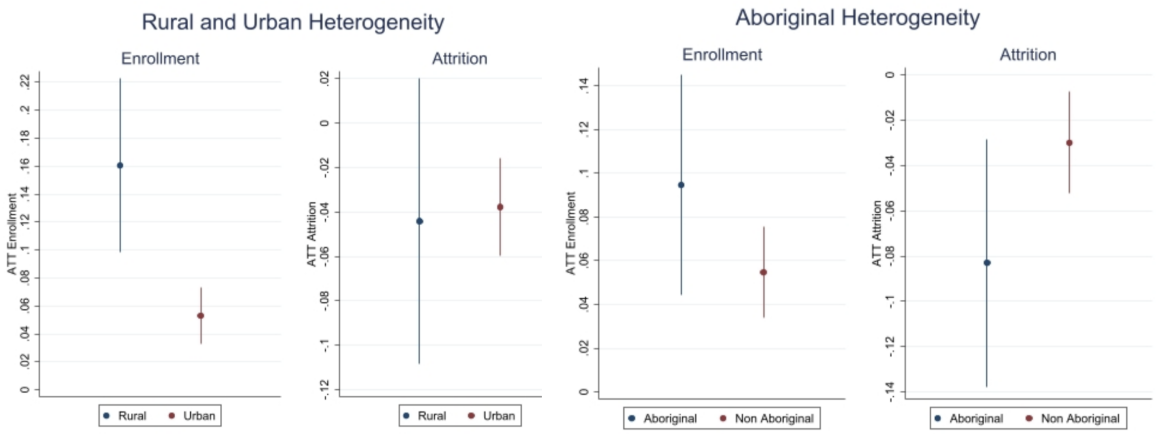
Figure 5 – Gender and High School Type ATT Heterogeneity



Moreover, in Figure 6 we exhibit heterogeneous effects by rurality and ethnicity of the applicants. First, we observe a surprising 16 percentage point increase in enrollment propensity among students coming from rural households, which is almost three times bigger than the impact reported for their urban counterparts. Despite the reduced number of rural observations, these differences are statistically significant. However, the small sample size leads to a non-significant attrition estimate for the rural subgroup. The effect on enrollment and attrition for students from urban households is significant and very similar to the overall ATT.

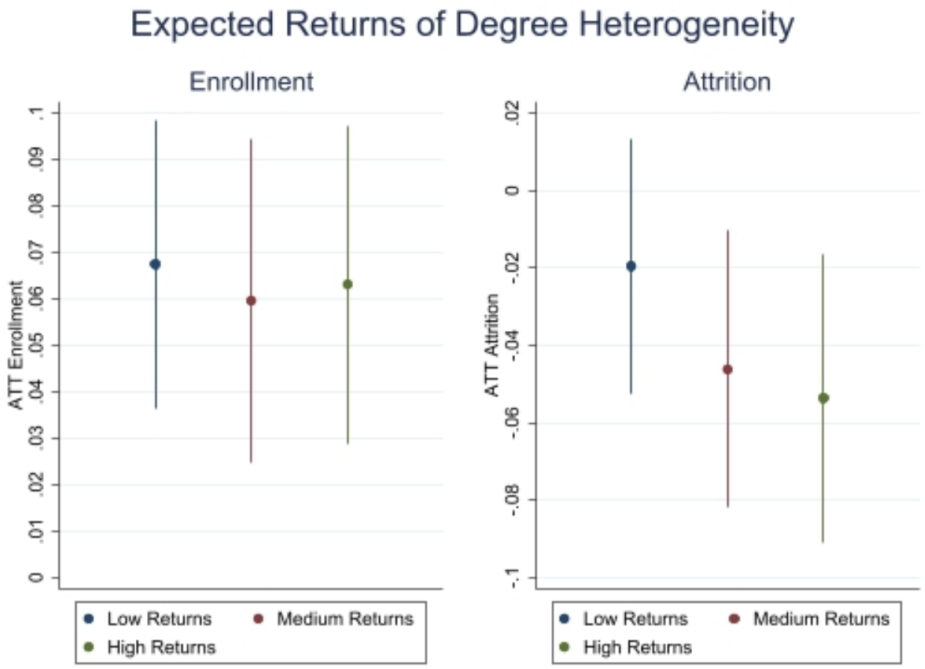
Effects also vary depending on the ethnicity of the applicants. On the left side of Figure 6 we report the effects over the subgroups of aboriginal and non-aboriginal students in our sample. As there are few aboriginal individuals in our data, the standard errors increase. Notwithstanding, point estimates suggest that the effect is larger for them, specially with respect to the attrition reduction where the impact is almost three times larger than for non aboriginal students.

Figure 6 – Figure 6: Rurality and Ethnicity ATT Heterogeneity



Finally, in Figure 7 we exhibit ATT heterogeneity with respect to the expected returns of the degree chosen by the applicants. To do so, the entire distribution of University degrees was ordered by average expected returns levels and divided into the following three tertiles: low, medium and high expected returns.

Figure 7 – ATT Heterogeneity by Degree Expected Return Levels



The effect on enrollment is stable around between six and seven percentage points for all three levels of expected returns. However, low-return degree enrollees exhibit a smaller and non-significant attrition reduction effect of only two percentage

points, whereas among medium and high-return degree students dropout propensity decreased by about 4.8 percentage points on average. Overall, the differences between these groups are not statistically significant as confidence intervals overlap.

5 Discussion

In summary, we have provided novel evidence on a robust and significant positive impact of "gratuidad" on enrollment and persistence. To our knowledge, this is the first causal estimation of the effect of a country-wide free tuition policy in a developing economy, which represents a relevant contribution to the literature. We found that the policy increased enrollment propensity by six percentage points while it reduced first year dropout rates by 19%. However, we must recall that these effects should be considered as a lower bound since we cannot rule out the existence of an income bias that would be attenuating the magnitude of the estimates. Similarly, our estimates consider only sixth income decile students and, as it is reasonable to assume that more financially deprived students would benefit more from receiving free tuition, we would expect an effect of larger magnitude in the bottom 50% of the income distribution.

The analysis of effect heterogeneity demonstrated that historically disadvantaged groups such as aboriginal and rural students were the most benefited by the policy. This is in line with previous research. For instance, regional evidence suggests that financial aid policies targeting more financially-constrained students have a greater impact on enrollment (Melguizo et al, 2016). Aboriginal students were also expected to experience a major improvement since they are outperformed by their non-aboriginal peers on several school-level variables (Canales and Webb, 2018). Furthermore, theoretical evidence points out that students that are integrated into their communities tend to show lower dropout rates in higher education (Tinto, 1975). This aspect is also important in the Chilean context as school-level evidence has shown that these students are highly segregated (Treviño et. al., 2019, Elacqua, 2012).

On the other hand, our results regarding expected returns heterogeneity are also in line with recent empirical evidence from both developed and developing countries (Beffy et al, 2012, Hastings et al, 2015, Busso et al 2017, Bonilla-Mejía et al, (2019)). In fact,

venues of research conclude that student's motivation, expected returns after graduation (Bennett, 2003) and outcome expectations (Landry, 2003) play an important role in the dropout decision.

In sum, the free tuition policy is increasing higher education participation and reducing dropout rates of groups that have been typically trapped in poverty, while the attrition reduction was more pronounced precisely on those degrees where the economic perspectives are better. If this increase in enrollment and persistence results in higher graduation rates, then "gratuidad" can end up contributing through an enhancement of intergenerational mobility and a reduction of income inequality. Consequently, further research evaluating the impact of the policy on completion rates and labor market outcomes will be very valuable.

From a policy perspective, important considerations can be drawn from the findings of this paper. The most straightforward implication is that, given the substantial impact that the financial constraint reduction has had on vulnerable students, it will be desirable to achieve similar improvements among seventh and eighth decile students.

Nevertheless, it is important to consider that after the implementation of the policy Chile became the country of the OECD with the highest public expenditure (5,4%) in higher education, which gives a dimension of how expensive this policy is. If we additionally consider that the ratio of marginal students to funded students is one to seventeen, it seems crucial to perform a rigorous cost-benefit analysis before considering expanding the coverage of the policy. Further research in this line will also represent an important contribution to the literature and for future policymaking. In this sense, it is important to consider that this policy will probably have long run general equilibrium effects related to a potential increase of high-skilled labor supply.

Finally, we must point out that the effect we identified is driven by the elimination of the copayment and therefore there are other potential policy instruments that will allow to achieve similar results without necessarily generating a considerable increase in government expenditure. For instance, Chile's income contingent loan (CAE) will probably facilitate a comparable effect if the current funding limit was extended to a point that allowed students to eliminate copayments. In that case, higher education

graduates would reimburse part of what was lended as long as they perceive a salarial reward after graduation and therefore the government expenditure needed to generate an analogous effect will be smaller.

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