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Abstract

This paper provides new evidence on the importance of short-run liquidity constraints in a tuition-free post-secondary education setting. We exploit two sources of exogenous variation in enrollment in free tertiary education to disentangle the role played by liquidity constraints, and show that eligibility for financial aid increases enrollment by 11.9 percentage points. We show that individuals with larger returns to education are more affected by the availability of grants. In contrast, when variation in enrollment is not derived from changes in the relative cost of education, compliers to such variation are not necessarily individuals with large returns to education. Our results support the hypothesis that low-income youths encounter liquidity constraints, even when entering free tertiary education.

JEL: I26, C36, J21

Keywords: Liquidity constraints, tertiary education, regression discontinuity.

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1 Introduction

The income gap in tertiary education enrollment is well documented in both developed (Carneiro and Heckman, 2002, Lochner and Monge-Naranjo, 2011) and developing economies (Murakami and Blom, 2008, González-Velosa et al., 2015). Nonetheless, the debate on how important liquidity constraints are in explaining this gap is still undecided.[1] The majority of the literature associates the problem of liquidity constraints with a household's ability to pay tuition fees. However, little is known about how individuals may under-invest in their own human capital when free education is available.

As explained in Carneiro and Heckman (2002), short-run liquidity constraints represent a lack of family resources or access to credit to invest in education. In contrast, long-run constraints to education, associated with income, reflect differences in cognitive and non-cognitive skills when investing in tertiary education. Skills strongly correlate with family income because high-income households can invest in better quality education over their child's formative years. In the absence of tuition fees, short-run liquidity constraints imply that individuals are not able to smooth consumption while they are studying. Thus, personal expenses (e.g., transport, living, etc.) and foregone income become important factors when deciding on schooling investments. Understanding the barriers to tertiary education beyond analyzing tuition fees gains importance in middle and low-income countries where educational learning programs, such as vocational education, are regularly used to increase the human capital of poor individuals. These programs usually provide specific skills; for a lesser cost or even without any tuition fees, and smaller time investment than professional studies or college degrees. Therefore, any attempt to shed light on the importance of the monetary and non-monetary costs associated with the demand for these programs is crucial for developing economies.

This paper aims to fill this gap in the existing literature by directly testing the importance of liquidity constraints in an environment where individuals do not have to pay any tuition fees. Some authors such as Fuller et al. (1982), Cameron and Taber (2004), and Flannery and O'Donoghue (2013) acknowledge how changes in the opportunity and maintenance costs affect schooling decisions by using variations in local labor markets. Furthermore, other authors explore the effect of financial aid on students' outcomes after enrollment, meaning additional income only affects students' outcomes after tuition fees have been paid.[2] However, to the best of our knowledge, no study directly estimates how in the absence of tuition fees imperfect credit markets could still affect enrollment in tertiary education.

We analyze the case of a large-scale program in Colombia, named Youth in Action (YIA).[3] This program offers a monthly cash transfer to low-income young individuals throughout the time they are enrolled in free vocational education at a nationwide public institution named Servicio Nacional de Aprendizaje (SENA) (Prosperidad-Social, 2017). The monetary aid aims to reduce the barriers of entry in tertiary education among low-income individuals by covering the maintenance and opportunity costs of its beneficiaries.

The selection process of both YIA and SENA provides an ideal scenario to disentangle the role of liquidity constraints by generating exogenous variations in vocational education enrollment in the fashion of two different Regression Discontinuity (RD) frameworks. First, YIA uses a poverty score named SISBEN with a set of predetermined cutoffs as one of the eligibility conditions of the program.[4] This targeting strategy allows us to compare individual's outcomes when they are eligible and ineligible for financial aid. Second, all applicants to SENA take a standardized exam when applying. When a given course is in high demand, SENA prioritizes applicants by their exam scores and offers the seats accordingly until the course is filled. This selection process with an entry exam allows us to compare individuals who enrolled in vocational education with individuals who are very similar but did not enter because their scores were marginally lower (Kirabo Jackson, 2010, Abdulkadiroğlu et al., 2014).

This framework is unique in that it allows us to compare individuals' educational choices in the presence and absence of financial aid and without the usual biases from unobservable characteristics thanks to the RD style environments. In other words, we can contrast cases where an educational decision was driven by the availability

[1] Some works have shown how parental income or access to credit are strong predictors of access to tertiary education (Lochner and Monge-Naranjo, 2011, Brown et al., 2011, Belzil et al., 2017). Meanwhile, other authors have found small or null effects when examining these indicators (Keane and Wolpin, 2001, Carneiro and Heckman, 2002, Cameron and Taber, 2004). In Latin America, there is more robust evidence supporting the existence of short-run liquidity constraints when enrolling in tertiary education (for example Rau et al., 2013, Melguizo et al., 2016, Solis, 2017, Didriksson, 2018, Cáceres-Delpiano et al., 2018, Londoño-Vélez et al., 2020).

[2] See Murphy and Wyness (2016) for a review of this bibliography.

[3] Jóvenes en Acción, in Spanish.

[4] SISBEN is a continuous score developed and implemented by the Colombian government to allocate multiple social benefits (Castañeda and Fernandez, 2005).

of financial aid with scenarios where the cost of education is constant and did not play any role determining educational choices.

We use different strategies to exploit the advantage of this setup. First, we show evidence that both scores, SISBEN and the exam, create discontinuities in the enrollment rates which can be understood as a random shock in enrollment to SENA. Second, we use both discontinuities together using a Multiple Regression Discontinuity Design (MRD) (as Papay et al., 2011) to understand the scenarios where one discontinuity explains variations in enrollment better than the other. Third, we follow Card (2001) comparing Ordinary Least Squares (OLS) and Instrumental Variables (IV) estimations to directly test for the presence of short-run liquidity constraints. By considering the analogy between Fuzzy Regression Discontinuity (FRD) and IV estimations (Lee and Lemieux, 2010), both discontinuities are used as instruments for enrolling in vocational education in an estimation of the returns to SENA's education. In this case, instrumenting with the SISBEN score captures changes in enrollment resulting from changes in the relative cost of education, while instrumenting with the entry exam represents exogenous changes in enrollment keeping the cost of education constant. Thus, the resulting estimates can be interpreted as the Local Average Treatment Effects (LATE) for different groups and allow us to compare the returns to schooling of the compliers to each instrument.

Our results are conclusive. First, eligibility for financial aid increases the probability of enrolling in vocational programs from 13.6% to 19.1% for one-year courses, and from 16.6% to 28.5% for two-year courses. Second, MRD estimates show that the availability of financial aid only overcomes the effect of receiving an offer to enroll when the individual gets an exam score above the cutoff for two-year courses. Finally, we also find that IV estimates are larger than OLS estimates when we instrument enrollment with the eligibility for financial aid. Meanwhile, the IV estimates are not significantly different than the OLS estimates when we use the discontinuity of the entry exam as an instrument of enrollment. This last result is more prevalent for individuals who applied to a two-year course. Following previous literature, the three results listed above support the hypothesis that some individuals who applied to two-year courses at SENA may not enroll because they do face liquidity constraints.

Our framework allows us to overcome the limitations of testing for liquidity constraints by comparing OLS and IV estimates, highlighted by Carneiro and Heckman (2002). The main constraints come from: (1) weak or invalid instruments; (2) unobserved comparative advantages in labor markets; and (3) the choice of school quality. However, our multiple RD estimates and the fact that all individuals in our analysis applied to the same educational institution allow us to overcome these limitations.

The contribution of this article is threefold. First, we provide new evidence by directly testing the existence of liquidity constraints when tertiary education is free, expanding the knowledge of the role played by income on explaining investments in education. In this sense, our results also enrich the literature on the limitations of tuition-free education in reducing the differences in human capital accumulation within developing countries (as Molina and Rivadeneyra, 2021).

Second, we provide new evidence on the importance of vocational education as an alternative to tertiary education for low-income individuals (for example Carroll and Ihnen, 1967, Chakravarty et al., 2019). In addition, our work adds to the understanding of the impact of supporting complementary costs such as maintenance and opportunity costs in vocational studies (Attanasio et al., 2011). These costs are usually forgotten in the literature but, as we point out in this paper, they are important in the public policy debate.

Third, this paper differs from the previous analyses of the YIA program in Attanasio et al. (2011, 2017) and Kugler et al. (2020). The difference arises from changes in the program design from 2012. The first version of YIA was implemented between 2001 and 2005. The program then offered six months of in-work training providing a setup to study the short, medium and long-run effects of professional training for low-income individuals, as the papers listed before did. However, as described above, YIA's new design focuses on increasing the demand of post-secondary education. Thus, we exploit these new features of YIA to answer questions linked with the income gap in tertiary education instead of focusing on the effects of training on labor market outcomes and welfare.

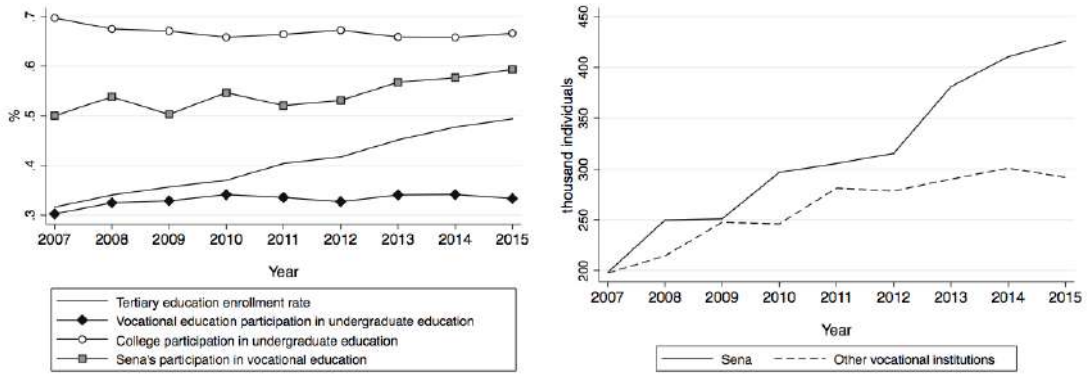
2 Institutional context

Tertiary education has been growing steadily over the last two decades in Colombia, from 23.7% to 48.9%, between 2002 and 2015, respectively (see Figure 1.a).[5] The continuous increase in tertiary education has been balanced

[5]Data from the National System of Information for Higher Education – SNIES, for the name in Spanish.

between university studies and vocational education. As shown in Figure 1.a, the participation in vocational studies in tertiary educational remains stable around 33% over the period 2007 to 2015.

Figure 1: Enrollees in tertiary education, vocational education and SENA. Total and participation rates



(a) Enrollment rate in tertiary and vocational education (b) Enrollees in vocational education by institution

Source: SNIES

However, the increase in vocational education is being mostly driven by the increase in SENA enrollment. Figure 1.b shows that from 2007 to 2015, enrollment in SENA doubled, while the increase in enrollment in other institutions over the same period was about 47%. As result, in 2007 SENA accounted for about 50% of total vocational enrollment, and rose to 59% in 2015.

The size of SENA is not only important because of the number of students involved but also because of the variety of the courses offered. SENA offers one and two-year courses depending on the trade. They are divided into several fields such as: construction (carpentry, mechanics and welding); economics (accounting, marketing and finance); culinary (cooking, baking); linguistics; agricultural crop management, etc.

There are three main characteristics of SENA's education for our study: (1) SENA offers both one-year and two-year courses for free ; (2) Individuals should participate in an internship in the last six months of their program; and (3) SENA uses an entry exam to allocate available seats in each course when there is an excess of demand.

2.1 The program *Youth in Action (YIA)*

The Colombian government created the nationwide program YIA under the management of *Prosperidad Social* (Department of Social Prosperity in charge of social policy).[6] This program includes support for students in SENA. First, the program offers a bimonthly grant of USD 136 to its beneficiaries (around USD 68by month), with the condition of remaining enrolled in SENA. This financial aid is equivalent to 34% of the average monthly income for people with similar conditions.[7] Second, when a course is in high demand, YIA reserves 30% of available seats for its beneficiaries, regardless of their score on the entrance exam. Third, beneficiaries can participate in an optional component intended to strengthen their non-cognitive abilities called *Habilidades para la Vida*. Although YIA has three components, in Appendix B, we provide strong, detailed evidence that the first component of YIA (monetary aid) drives all impacts. The structure of the program changed from August 2014 and differs from a previous version studied which focused on professional studies (Attanasio et al., 2017, 2011, Kugler et al., 2020).

YIA selected its beneficiaries using two broad criteria. First, beneficiaries are selected according to *poverty-based* index known as SISBEN score. Second, YIA offers its benefits to individuals that belong to a minority group or a group with special vulnerabilities.[8] Between 2014 and 2015 87% of total YIA beneficiaries (163,479) were admitted because of their SISBEN scores was belong the predefined cutoff.

[6] See the Resolution No. 1970 of 21/nov 2012 and Prosperidad-Social (2017) for details.

[7] We compare the financial aid with the monthly wage of young individuals (18 to 24 years old) who have completed secondary education.

[8] The groups are: the adoption list of the ICBF *"Instituto Colombiano de Bienestar Familiar"*, individuals from recognized indigenous groups, individuals from *Red Unidos* (RU), which is the program that coordinates different social welfare interventions, and individuals from the victims registry of the Colombian armed conflict.

2.2 Credit constraints for the youth in Colombia.

In a perfect credit market, an applicant who was admitted to SENA should be able to take out a loan to cover the expenses incurred over the two years of studying in order to increase her own human capital, when the returns to this educational investment are larger than the market's interest rate. Therefore, a first question arises: Is vocational education a profitable investment for young individuals?

We use information from the National Household Survey (GEIH) in 2015 to estimate changes in income derived from access to vocational education to help answer the preceding question. Following Kugler et al. (2020), we only use the information on individuals from the two lowest socioeconomic strata. We then estimate the probability of having a formal and an informal job, and the respective income for different cells by age, gender, and education (if they completed high school or vocational studies). We can then calculate the present value for men and women in two scenarios. The first is if their highest level of education is high school and the second is if their highest level of education is vocational studies.

According to our calculations, vocational education increases lifetime income by USD 6,323 and USD 7,947 for men and women, respectively.[9] The income lost from the two years invested in SENA is around USD 1,254 for men and USD 1,078 for women. Given that SENA is tuition-free, both men and women have large and positive returns.

However, as in many developing economies, Colombian credit markets are highly segregated and disadvantaged youths are usually excluded (Murcia, 2007, Rodríguez-Raga and Rodríguez, 2016). The supply of educational loans comes from private banks and ICETEX, a public institution for higher education financing. This market suffers from many issues. First, creditors target professional studies (4-5 years) and do not provide loans for vocational studies (Melguizo et al., 2016). Second, private banks and ICETEX require collateral from their customers, limiting the access of the population that does not have physical assets to leverage the payment of their debts against their expected incomes.

In order to scale down the negative effects of these market imperfections, YIA aimed to reduce beneficiaries' liquidity constrains through its monetary aid.

3 Data

We combine information from different sources. First, we use administrative data from SENA on all the individuals who applied for a one-year or two-year course from the second semester of 2014 to the first semester of 2015. In addition to basic demographics (age and gender), we have information about the course each individual applied to, the entry exam result and if the individual enrolled or not.

Second, we merge this data with the administrative registries of SISBEN scores at the household level.[10] By using this combined database, it is possible to determine which individuals were eligible for YIA. Third, we use YIA's registry records to identify which individuals were beneficiaries of the program.

After studying at SENA, individuals may move into the labor market. In order to assess the medium and long term effects of financial aid for post-secondary students, we combine our data with information on the social security contributions from the Colombian Ministry of Labor (PILA), from August 2014 until December 2017. The PILA database contains information on compulsory contributions made by employed individuals to social security. In addition, we also have information about the type of contract (temporary or permanent), firm size, sector (public or private) and an identifier for self-employment. Attanasio et al. (2017) defined an individual as a formal worker if they make their compulsory contributions to social security. Therefore, if, in a given month we find an individual in PILA's database, it is because that individual had a formal job that month. Individuals with no reports to PILA are either not working (unemployed or inactive) or working in the informal market.

[9] We use a 10% interest rate and an exchange rate of COP 4,000 per USD.
[10] We use the data from SISBEN version III, which was used to allocate social benefits from 2011 to 2016.

Table 1: Descriptive statistics. SENA applicants to one-year courses by position with respect to SISBEN's and exam's cutoffs

	one-year courses								**two-year courses**							
	By SISBEN's cutoff				By exam's cutoff				By SISBEN's cutoff				By exam's cutoff			
	below the cutoff		above the cutoff		below the cutoff		above the cutoff		below the cutoff		above the cutoff		below the cutoff		above the cutoff	
Variable	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Observations	52915	.	11171	.	48810	.	15276	.	55527	.	20042	.	49549	.	26020	.
Individuals	37920	.	7578	.	32952	.	12546	.	35224	.	11921	.	27022	.	20123	.
Individual level variables																
Enrolled	0.17	0.38	0.14	0.34	0.06	0.23	0.51	0.50	0.25	0.43	0.16	0.36	0.08	0.27	0.51	0.50
Enrolment period																
2014-II	0.35	0.48	0.40	0.49	0.36	0.48	0.36	0.48	0.58	0.49	0.57	0.50	0.55	0.50	0.62	0.49
2015-I	0.65	0.48	0.60	0.49	0.64	0.48	0.64	0.48	0.42	0.49	0.43	0.50	0.45	0.50	0.38	0.49
Targeting area																
Area 1	0.41	0.49	0.59	0.49	0.46	0.50	0.37	0.48	0.44	0.50	0.55	0.50	0.50	0.50	0.41	0.49
Area 2	0.53	0.50	0.36	0.48	0.49	0.50	0.56	0.50	0.47	0.50	0.39	0.49	0.42	0.49	0.50	0.50
Area 3	0.06	0.23	0.05	0.22	0.05	0.22	0.07	0.25	0.09	0.28	0.06	0.24	0.07	0.26	0.09	0.29
Migrante [1]	0.30	0.46	0.27	0.44	0.29	0.45	0.30	0.46	0.42	0.49	0.36	0.48	0.39	0.49	0.43	0.49
Male	0.43	0.50	0.57	0.49	0.44	0.50	0.51	0.50	0.46	0.50	0.55	0.50	0.47	0.50	0.50	0.50
Age	20.60	1.90	21.16	1.98	20.72	1.93	20.62	1.90	20.48	1.89	21.16	1.97	20.70	1.95	20.59	1.90
Entry exam score	37.01	17.24	37.76	17.13	33.50	17.63	48.77	8.53	41.48	16.30	42.23	16.29	36.76	17.46	51.05	7.56
Eligible FeA	0.61	0.49	0.11	0.31	0.51	0.50	0.54	0.50	0.52	0.50	0.08	0.27	0.38	0.49	0.45	0.50
Other support	0	0.07	0	0.07	0	0.04	0.01	0.12	0.01	0.09	0.01	0.10	0	0.06	0.02	0.13
Course level variables																
Courses	1270	.	1117	.	1227	.	1257	.	1773	.	1665	.	1724	.	1738	.
Seats	35.06	15.97	35.40	16.88	35.21	16.20	35.10	16.02	42.67	35.53	43.29	36.69	43.02	36.15	42.33	34.21
Demand	149.40	195.79	161.59	205.54	153.52	197.95	148.92	196.52	132	179.92	137.50	184.50	135.80	181.59	128.09	169
Takeout prop	0.51	0.28	0.53	0.28	0.51	0.28	0.51	0.28	0.50	0.33	0.50	0.33	0.50	0.32	0.50	0.33
Simulated cutoff	41.10	11.73	43.19	11.03	42.42	11.12	39.86	11.98	43.80	10.94	45.38	10.22	45.52	9.69	42.39	10.87
Labor market variables																
Formal job at least 1 month	0.53	0.50	0.68	0.47	0.54	0.50	0.60	0.49	0.69	0.46	0.78	0.41	0.69	0.46	0.73	0.44
Formal job at least 1 month [2]	0.50	0.50	0.64	0.48	0.50	0.50	0.57	0.49	0.61	0.49	0.71	0.45	0.62	0.49	0.66	0.47
Proportion of months working [2]	0.20	0.28	0.32	0.34	0.21	0.29	0.25	0.30	0.31	0.33	0.44	0.36	0.35	0.35	0.33	0.32
Longest employment spell [2]	4.99	7.28	7.52	8.53	5.22	7.52	5.90	7.66	5.52	6.22	7.21	6.70	5.92	6.53	5.98	6.20
Longest employment spell [2] [3]	9.99	7.52	11.74	8.03	10.37	7.69	10.29	7.59	8.90	5.66	10.05	5.85	9.46	5.87	8.93	5.55
Longest unemployment spell [2]	18.10	8.96	14.88	9.78	17.84	9.12	16.83	9.30	9.12	6.66	7.16	6.44	8.74	6.82	8.47	6.44
Working in the last semester	0.33	0.47	0.48	0.50	0.35	0.48	0.37	0.48	0.49	0.50	0.62	0.49	0.52	0.50	0.53	0.50

Notes: Authors' calculations using data from SENA and SISBEN only includes SENA centers where YIA beneficiaries applied.

[1] Migrant is defined as a person who studied in a municipality different from the one where they were interviewed for the SISBEN score. [2] 12 and 24 months after applying to SENA for one- and two-years courses respectively. [3] Conditional to having worked at least 1 month.

Given that our strategy is based on exploiting the changes of discontinuities in the SISBEN score and the entry exam, we limited the analysis to individuals who may be affected by both discontinuities. Hence, we only include individuals who applied to courses with an excess of demand and without a second entry exam, because in these courses the entry exam cutoff determines who receives the first offer to enroll. We also eliminated all the individuals who were younger than 18 years old when they applied to SENA because it is not possible to find them in the PILA registry due to changes in the national identification numbers.

As a result, we obtained information from 139,000 applications from 92,600 individuals. One individual can apply to more than one course. There were 64,000 applications submitted to one-year courses and 75,000 to two-year courses. For both one and two-year courses, the proportion of men is marginally below 50% (See Table 1). There is a considerable proportion of students below the SISBEN cutoff in one and two-year courses (83.45% and 77.65%, respectively), which shows that vulnerable people are being targeted with vocational education.

Enrollment levels are lower in one-year courses even if they obtain a score above the entry exam cutoff. There is a higher proportion of individuals enrolled in the first semester of 2015 in shorter courses, with longer courses trending in an opposite fashion. However, there is no evidence in favor of the hypothesis that the individuals choose the length of the course as a response to being eligible to YIA. The average score in the entry exam is similar between vulnerable and non-vulnerable applicants, as shown in Table 1 and Figure 15 (in Appendix C). Nevertheless, we observed that scores are higher for applicants of longer courses. Table 1 also shows that the average individual is about 20 years old and more than 90% of applicants were living in urban areas (Area 1 and Area 2) when they were assessed for the SISBEN score. The characteristics of applicants show patterns based on the type of course. First, the unconditional average size is higher in two-year courses, but there is no difference in wealth or ability, which was expected. There is a considerable demand for two-year courses. One in five individuals are admitted.

In terms of labor market indicators, there are unconditional differences in labor participation according to vulnerability and ability that grow with the length of the courses. In fact, the proportion of months spent working while in one and two-year courses is lower for the most vulnerable individuals (0.2 and 0.31) than for individuals with better socioeconomic conditions (0.32 and 0.44), respectively. This pattern also persists for other labor outcomes.

As evidenced by the role played by monetary aid, Figure 2 compares labor market participation trends from the moment each individual applied to SENA by course type (one- and two-year courses). After applying, enrollees in SENA work less than individuals who did not enroll. However, during the enrollees' internship period, formal employment grows sharply until the internship period finishes. Afterwards, enrollees' formal employment rates drop. This strong up and down pattern is more pronounced for those enrolled in two-year courses. Despite the drop, the formal employment rate for enrollees remains marginally above that for non-enrollees.

It is worth noting that, for both men and women, the formal employment rate for non-enrollees has a more gradual upward trend than the one of SENA enrollees. This evidences the importance of financial aid for covering expenses other than tuition fees. Individuals are able to study instead of work for a period of time in order to increase their labor market participation after completing vocational courses. In addition, it is observed that a higher number of individuals obtain formal jobs during the internship provided by SENA. This difference tends to dissipate after a period of time.

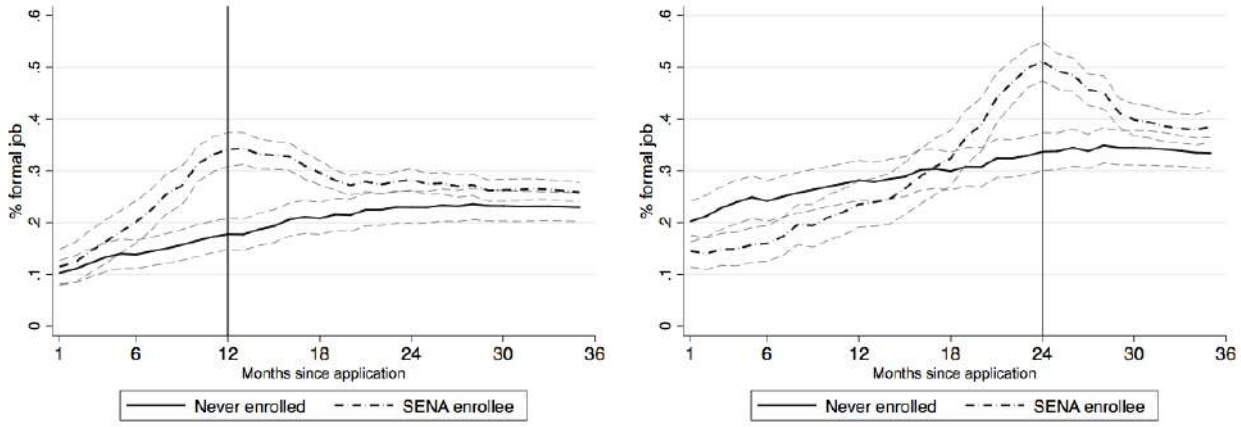
We measured the economic returns to the education provided by SENA, only taking into account information after the expected completion of studies. For example, for two individuals who applied in August 2014 to a one year course, we will only use information of their participation in the labor market from September 2015, regardless of whether or not they were enrolled in SENA. Without information about wages to estimate the returns to education (as Mincer, 1974), we use in our estimations different indicators of individual performance in the formal labor market such as: (1) working at least one month; (2) the number of months they have worked consecutively; (3) whether or not they worked during the last semester; (4) their longest period of employment; and (5) their longest period of unemployment.[11] The first three indicators measure participation and the last two measure stability in the labor market.

There are three main limitations to our data. First, as explained above, to match PILA data with the other data sources we use national identification numbers, but individuals only obtain these numbers when they are 18 years old. Therefore, we cannot include individuals who applied to SENA when they were 16 or 17 years old. These

[11] Longest employment/unemployment period is defined as the maximum number of continuous months employed/unemployed during the period of analysis.

Figure 2: Formal labor market participation by enrollment in SENA (by course length and gender)

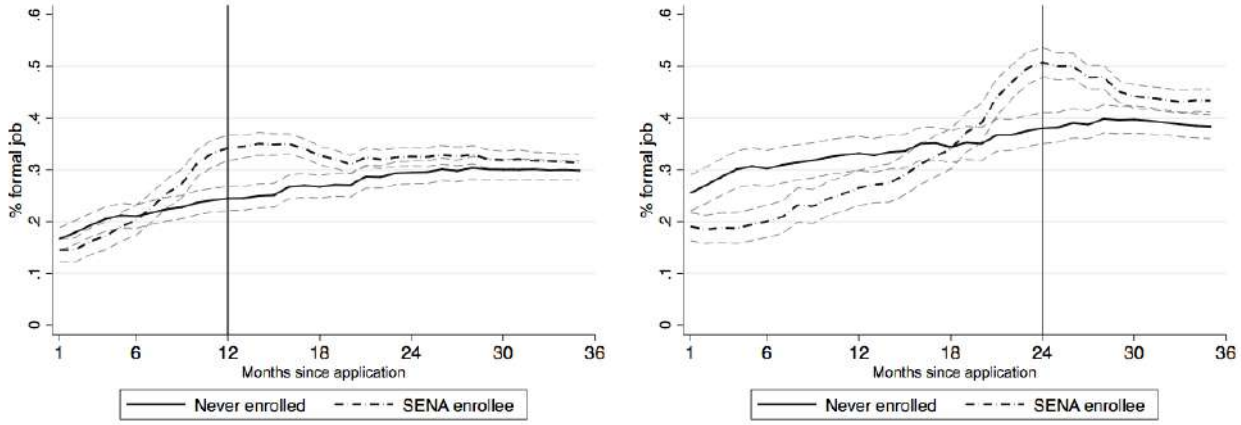
Women



(a) one-year course

(b) two-year course

Men



(c) one-year course

(d) two-year course

Notes: Authors' calculations using data from SENA and PILA information. Gray dashed lines represent 95% confidence interval.

may be individuals with a greater desire to enroll in tertiary education because they applied soon after finishing high school.

Second, PILA only reports on formal labor market participation. As we explained before, when an individual is not in the PILA database, they may be either unemployed, working informally or outside the labor market. This is a challenge for our analysis, as Colombia has the largest informal employment rate among the OECD countries. By 2016, the self-employment rate in Colombia was 51.3%, while the average among OECD countries was 16.2%.[12] Therefore, our estimates are not considering the returns to education through informal employment.

Third, in an ideal scenario, we would estimate the returns to SENA's education using information on earnings. In this case, earnings in the formal labor market. However, we only have information about labor market participation and some characteristics of the job, but we do not have access to earnings. This may hinder the scope of our results. Nevertheless, in the Colombian context, with high levels of informality and unemployment, having a formal job is a good indicator of high quality and high earning jobs.

4 Estimation strategy

To estimate the importance of liquidity constraints in free education, we take advantage of the existence of discontinuities in the probability of enrolling in SENA from two different continuous variables – i) SENAS's enrollment

[12]Self-employment is measured as the proportion of self-employed workers among all workers. Data from OECD employment and labor market statistics database.

system and, ii) YIA's selection criteria. Both discontinuities exogenously affect enrollment in SENAS's education but only one of them is linked with changes in the cost of education. We follow two approaches to test for the existence of short-run liquidity constraints. First, we exploit both discontinuities simultaneously using an MRD approach. Second, we compare IV and OLS estimations following the strategy used by Card (2001) and others.

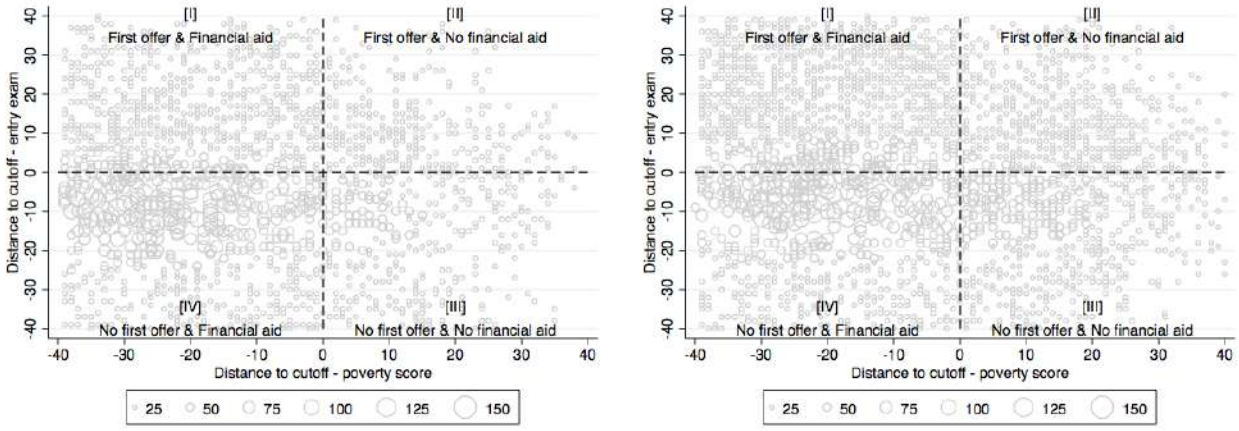
We define v_i as the difference between the SISBEN score of the individual i and the cutoff of set by YIA for her area. Therefore, $D_i = 1\,[v_i \leq 0]$, for individuals eligible for YIA. Furthermore, μ_{ij} is the distance between an individual's exam score and the admission cutoff of the course she applied to. Thus, $A_{ij} = 1\,[\mu_{ij} \geq 0]$ for individuals who receive the first offer to enroll in the course j. Finally, $S_{ij} = 1$ if the individual i enrolls in SENAS's course j.

4.1 Multiple regression discontinuity design (MRD)

Our first strategy focuses on individuals whose enrollment decisions may have been affected by both discontinuities. To do so, we can compare the discontinuities in SENAS's enrollment by v_i and μ_i using a double discontinuity analysis similar to Papay et al. (2011). This strategy allows us to establish when the chance of receiving monetary aid gains importance for the individual's decision.

Figure 3: Poverty score vs entry exam (distance to cutoff) by course length

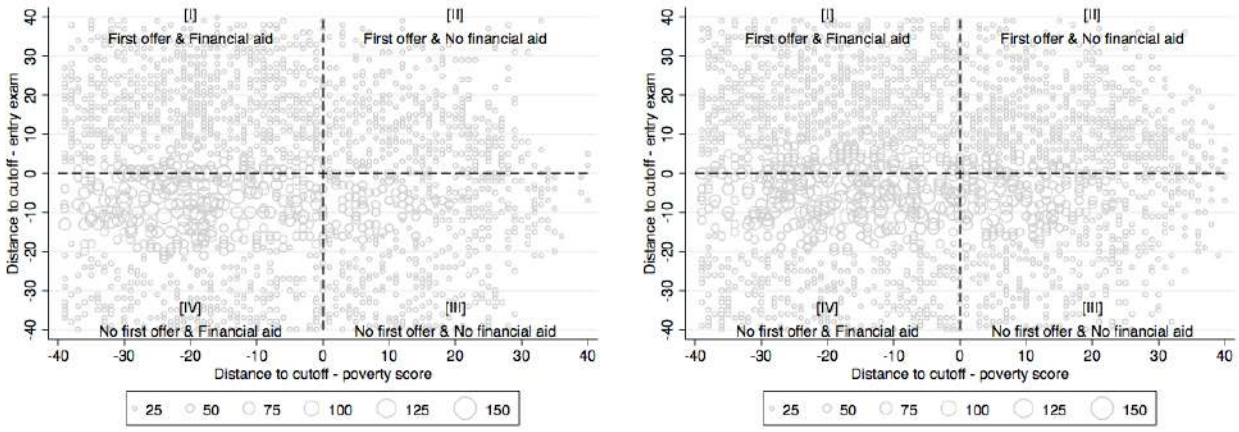
Women



(a) one-year course

(b) two-year course

Men



(c) one-year course

(d) two-year course

Notes: Grid size 1 x 1 points per variable. Circle size represents the number of individuals by grid.

To explain this approach, we split the population into four groups, seen in Figure 3. Quadrant $[I]$ includes individuals who received the first offer to join a course and are eligible for financial aid. Individuals in Quadrant $[II]$ received the first offer to join a course, but are not eligible for financial aid. Quadrant $[III]$ includes individuals who did not get either the first offer nor financial aid. Quadrant $[IV]$ includes individuals who did not get the

first offer, but are eligible for financial aid. The distribution of individuals over that figure indicates the absence of correlation between both forcing variables. Formally, we estimate the following equation:

$$S_{ij} = \alpha_0 + \alpha_1 D_i + \alpha_2 A_{ij} + \alpha_3 D_i \times A_{ij} + g(\upsilon_i) + f(\mu_{ij}) + \phi_{ij} \tag{1}$$

In this equation, α_1, α_2 and α_3 provide information on which forces are stronger when we focus on individuals who are marginally affected by both discontinuities. Then, linking the estimates from equation 1 with Figure 3, we can estimate the average enrollment in SENA $\bar{S}$. For example, the average enrollment rate for individuals who are eligible for financial aid and received the first offer to join a course is equivalent to $\bar{S}^I = \hat{\alpha_0} + \hat{\alpha_1} + \hat{\alpha_2} + \hat{\alpha_3}$. In addition, the average enrollment rate for individuals who are eligible for financial aid but did not receive the first offer to join a course is equal to $\bar{S}^{IV} = \hat{\alpha_0} + \hat{\alpha_1}$.

Comparing $\bar{S}^I, \bar{S}^{II}, \bar{S}^{III}$ and $\bar{S}^{IV}$, we can infer when financial aid gains importance on a case by case basis, when explaining changes in SENA enrollment.

4.2 RD-IV and OLS comparisons

Our analysis follows Card (2001) discussion about the comparison between OLS and IV estimated coefficients. In the standard estimation of returns to schooling (Mincer, 1974), OLS estimates are upper biased due to factors such as unobserved ability and/or desire for further education. Nevertheless, in the literature, IV estimates are usually larger that OLS estimates (Card, 2001, Brown et al., 2011).

Card (2001) states that IV estimates cannot be interpreted as an Average Treatment Effect (ATE), but instead they represent the weighted LATE of the compliers.[13] Taking into account the heterogeneity of returns to education, for a given instrument, the LATE of the compliers may be larger (smaller) than the ATE if the compliers' returns to schooling are larger (smaller) than the average returns to schooling of the population. Therefore, instrumenting schooling with a variable related to changes in the cost of education will result in IV estimates larger than the OLS if the compliers to such an instrument are individuals whose expected returns to education are larger than the expected returns to education of non-compliers. However, these compliers did not complete more education in the past due to the existence of liquidity constraints.

In our case, we can use a *Fuzzy Regression Discontinuity (FRD)* design to estimate the effect of SENAS's enrollment on labor market participation using SISBEN scores and SENAS's entry exam. What is more, our FRD estimates are analogous to IV estimates around each cutoff (Imbens and Lemieux, 2008, Lee and Lemieux, 2010). Hence, we can estimate the returns to education on formal labor market participation using two different RD-IV estimates. Then, if Y_i represents the formal labor market indicator of individual i, the RD-IV estimator around the SISBEN cutoff is:

$$\tau_Y = \frac{lim_{c\uparrow 0} E[Y|\upsilon_i = c] - lim_{c\downarrow 0} E[Y|\upsilon_i = c]}{lim_{c\uparrow 0} E[S|\upsilon_i = c] - lim_{c\downarrow 0} E[S|\upsilon_i = c]} \tag{2}$$

The RD-IV estimator around the exam cutoff is:

$$\gamma_Y = \frac{lim_{c\uparrow 0} E[Y|\mu_i = c] - lim_{c\downarrow 0} E[Y|\mu_i = c]}{lim_{c\uparrow 0} E[S|\mu_i = c] - lim_{c\downarrow 0} E[S|\mu_i = c]} \tag{3}$$

Both τ_Y and γ_Y are unbiased estimates of the effect of enrolling in SENA on the labor market indicator Y, conditional on the basic RD assumptions. Nevertheless, each estimator represents the LATE of different types of compliers. τ_Y quantifies the effect of an education at SENAS on the labor market for individuals who enrolled because they were eligible to receive financial aid through YIA but would not have enrolled without financial aid. Indeed, τ_Y includes the aggregated effect of monetary aid, preferential entry and soft skills training. In Appendix B, we show sufficient evidence to support that YIA's impacts are driven by financial aid more so than other benefits. γ_Y quantifies the effect of education at SENAS's education on the labor market for those individuals who receive the first chance to enroll.

Thus, if β_Y is the OLS estimate of the effect of S on Y, we expect that in the presence of liquidity constraints $\tau_Y > \beta_Y$. We do not have any prior beliefs about the relationship between γ_Y and β_Y. Indeed, given the local nature of this instrument, we can assume that the ability bias is small and our estimate represents an ATE of SENAS's schooling. Therefore, we can expect that $\gamma_Y \leq \beta_Y$.

[13] This was first discussed by Imbens and Angrist (1994).

This strategy is not free of critics. Griliches (1977) and Angrist and Krueger (1991) argue that IV estimates may be larger than OLS coefficients because of measurement error. Additionally, Carneiro and Heckman (2002) discusses the limitations of this type of analysis. First, instruments are usually weak or invalid. Second, even if the instruments are valid, then the IV estimates can be larger than the OLS estimates due to some unobserved comparative advantage in labor markets. Third, instruments do not usually take into account the quality of education at different schools. We will provide evidence about how our estimations overcome these drawbacks in the following section.

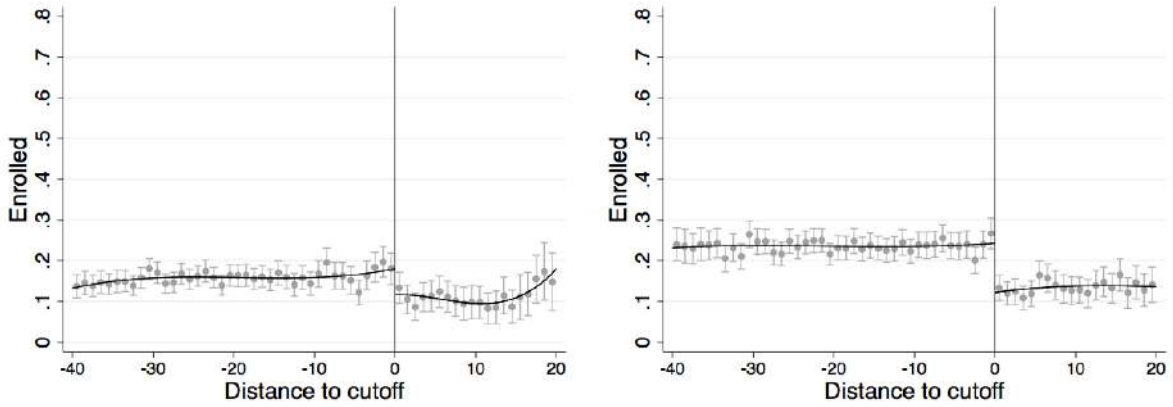
5 Results

Before explaining both strategies, it is important to point out that we separate our analyzes by course length and gender. Given that education at SENA is free, the length of the course might affect the size of the opportunity and maintenance costs for studying and implies a different response to each discontinuity. Also, young men and women face different incentives and barriers to tertiary education and labor markets. Therefore, aggregating both genders is invalid.

5.1 Reduced form estimations

Figure 4: Enrollment in SENA by distance to the SISBEN and entry exam cutoffs - women

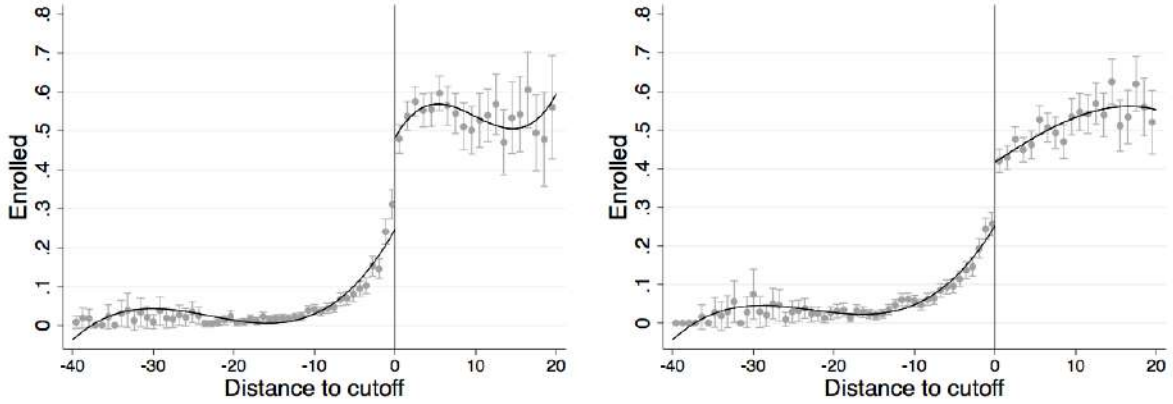
SISBEN score υ_i



(a) one-year course

(b) two-year course

Entry exam μ_i



(c) one-year course

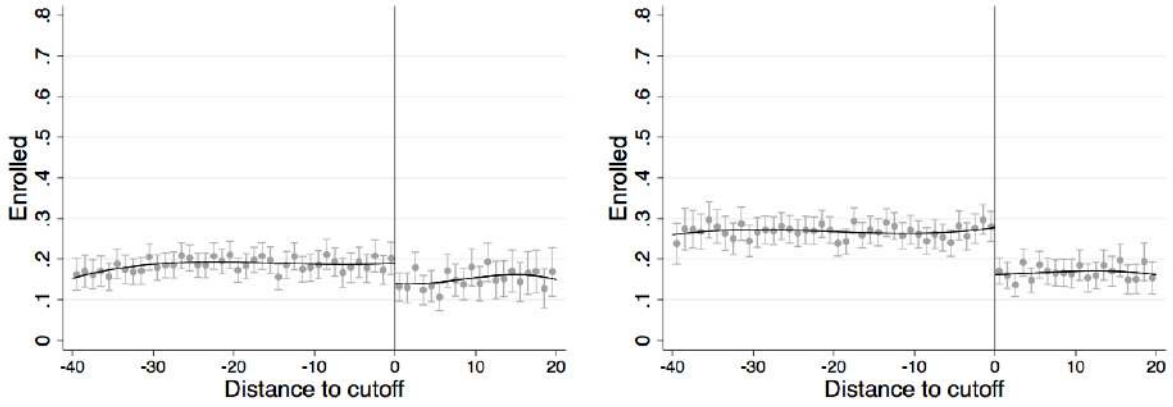
(d) two-year course

Notes: Authors' calculations using SENAS's inscriptions and SISBEN's data. The exam's cutoffs are simulated by considering YIA's preferential entry scheme. Dashed lines represent 95% confidence interval. Bin size of 1 point. Adjusted function form using third-degree polynomial.

We begin by showing evidence that YIA's eligibility and SENAS's exam system create exogenous changes in

Figure 5: Enrollment in SENA by distance to the SISBEN and entry exam cutoffs - men

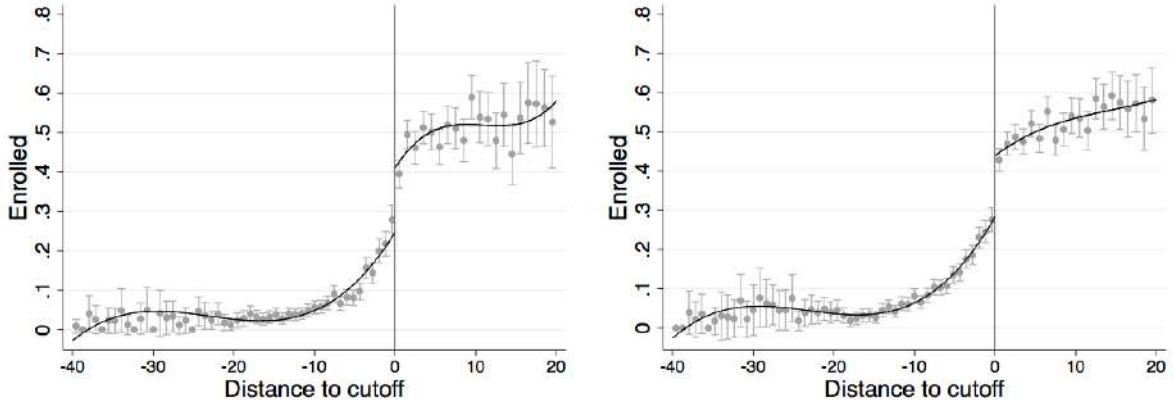
SISBEN score υ_i



(a) one-year course

(b) two-year course

Entry exam μ_i



(c) one-year course

(d) two-year course

Notes: As per Figure 4.

SENAS's enrollment. Figures 4 and 5 show the enrollment over SISBEN's score (υ) and SENAS's exam (μ), and the discontinuous jump around the cutoffs. In all cases there is a significant change at the cutoffs; however, the discontinuity in enrollment around the SISBEN cutoff is significantly larger for the two-year course applications than for the applications to one-year courses. This is our first piece of evidence of the existence of liquidity constraints. It is important to remember that our analysis only includes individuals who applied to SENA. However, even for those who receive the first offer, the enrollment rates are always below 70% (panels c and d in Figures 4 and 5). Therefore, given that the effect of eligibility for financial aid increases with the length of the course, we can infer that financial aid gains importance as the opportunity cost increases.[14]

Following Lee and Lemieux (2010), the changes in enrollment in SENA around the cutoffs can be considered exogenous under very simple assumptions. First, there is continuity of confounding factors around the cutoffs and second, individuals cannot manipulate their SISBEN score or exam results with respect to the cutoff. In Appendix A we show detailed evidence that both assumptions hold for our sample of analysis. Formally, we can quantify the changes shown in Figures 4 and 5 by estimating β_1 in the following equation for the case of the SISBEN scores:

$$S_i = \beta_0 + \beta_1 D_i + g\left(\upsilon_i, D_i\right) + \epsilon_i \tag{4}$$

[14] One alternative explanation could be that the differences in the effect of the SISBEN discontinuity come from individuals choosing different course lengths. Figure 15 in the Appendix C shows there is no sorting for one- or two-year courses around both discontinuities.

And estimating ρ_1 the following equation for the case of SENAS's entry exam is:

$$S_i = \rho_0 + \rho_1 A_i + f(\mu_i, A_i) + \eta_i \tag{5}$$

Table 2: Effect of discontinuities in SISBEN score and SENAS's entry exam on enrollment in SENA

	one-year course				two-years course			
	Female		Male		Female		Male	
Discontinuity in the SISBEN score								
Sisben score $\leq cutoff$	0.093*	0.057*	0.055*	0.043*	0.156**	0.117**	0.119**	0.110**
	(0.039)	(0.025)	(0.021)	(0.018)	(0.032)	(0.030)	(0.038)	(0.016)
Constant	0.127**	0.115	0.136**	-0.106**	0.129**	0.301**	0.166**	0.236**
	(0.031)	(0.121)	(0.027)	(0.034)	(0.019)	(0.061)	(0.017)	(0.073)
Controls and FE	No	Yes	No	Yes	No	Yes	No	Yes
F test	5.62	5.29	6.55	5.59	24.38	15.30	10.05	45.26
R^2	0.01	0.26	0.00	0.27	0.02	0.31	0.01	0.26
Bandwidth	10.45	11.47	12.18	12.80	10.59	8.92	11.34	9.34
N	7595	8410	9495	10017	11398	9566	12832	10738
Discontinuity in the entry exam								
Entry exam $\geq cutoff$	0.159**	0.130**	0.113**	0.092**	0.133**	0.122**	0.125**	0.096**
	(0.034)	(0.032)	(0.025)	(0.027)	(0.040)	(0.037)	(0.021)	(0.019)
Constant	0.326**	1.636**	0.304**	1.202**	0.275**	0.456**	0.299**	0.337**
	(0.038)	(0.160)	(0.022)	(0.101)	(0.044)	(0.057)	(0.020)	(0.063)
Controls and FE	No	Yes	No	Yes	No	Yes	No	Yes
F test	22.55	16.80	21.08	12.02	11.18	10.75	34.63	25.55
R^2	0.14	0.31	0.13	0.27	0.09	0.29	0.09	0.25
Bandwidth	3.67	5.32	6.42	5.11	5.08	4.92	5.65	5.40
N	6377	8950	10015	8143	11384	11069	12971	12499

Notes: Standard errors clustered at municipality level, $+p < 0.1$, $*p < 0.05$, $**p < 0.01$. Estimation bandwidths computed following Calonico et al. (2014). We use a third-degree polynomial for the distance to each cutoff. Control variables include gender, age, participation in FeA, application year, SISBEN area, number of applications, course takeout (%), SENA center fixed effects and SENA program fixed effect. The F test is the Cragg-Donald Wald F statistic of $\beta_1 = 0$ or $\rho_1 = 0$.

Then, Table 2 shows the effect of each discontinuity on SENAS's enrollment. Regarding the SISBEN score (Table 2 upper panel), the effect of being eligible for financial aid is stronger for individuals who applied to two-year courses than for individuals who applied to one-year courses. This is reflected by larger and more significant coefficients. The total effect is around 5 percentage points and 11 percentage points for one-year and two-year courses, respectively. However, the entry exam discontinuity does not show a differential effect with respect to the length of the course (lower panel). As was mentioned before, the heterogeneity in the results is our first piece of evidence supporting the importance of liquidity constraints for opportunity cost. This means that for those enrolled in free education, the only difference in the cost of education comes from the time you have to leave the labor market in order to study. Therefore, longer courses imply a higher opportunity cost and a greater need for financial aid. Finally, it is important to point out that there is no differential effect of either discontinuity with respect to gender when enrolled in SENA.

Table 2 also shows the Cragg-Donald Wald F statistics for $\beta 1$ and ρ_1 depending on the case. Given that we are using the analogy between FRD and IV estimations in our strategy, we use this test as evidence to support strong instruments. Regarding SENAS's exam, we can argue that in all cases our instrument is strong. However, with respect to the SISBEN score in the case of one-year courses, the F test is between 5 to 6 which may be considered evidence of weak instruments, which would jeopardize the comparison between OLS and IV estimates.

5.2 MRD estimations

Table 3 summarizes the results of MRD estimations (equation 1) and allows us to see how both discontinuities work for those individuals who are close to both cutoffs.

Financial aid is important for encouraging enrollment in longer courses, while receiving the first offer is crucial for one-year courses. The coefficient of being eligible for financial aid alone (Quadrant IV in Figure 3) is not statistically significant. This is represented by α_1 in Table 3 for shorter programs (one-year courses). This means that eligibility for financial aid does not change enrollment if first offer is not given. Nevertheless, receiving the first offer without any financial aid does create a significant change in enrollment rates (Quadrant II in Figure 3).

Table 3: Double discontinuity estimation on SENA enrollment

	one-year course		two-years course	
	Female	Male	Female	Male
Sisben discontinuity (α_1)	0.084	0.137	0.014	0.146**
	(0.087)	(0.129)	(0.044)	(0.040)
Exam discontinuity (α_2)	0.188*	0.166**	0.120	0.013
	(0.071)	(0.059)	(0.096)	(0.070)
Sisben x Exam (α_3)	0.021	-0.014	0.037	0.034
	(0.048)	(0.025)	(0.039)	(0.026)
Joint significance tests				
$H_0 : \alpha_1 + \alpha_3 = 0$	0.187	0.346	0.441	0.000
$H_0 : \alpha_2 + \alpha_3 = 0$	0.001	0.003	0.030	0.429
$H_0 : \alpha_1 + \alpha_2 + \alpha_3 = 0$	0.008	0.050	0.014	0.002
Sisben's bandwidth	11.67	11.67	9.83	9.83
Exam's bandwidth	3.85	3.85	4.38	4.38
R^2	0.36	0.33	0.32	0.28
N	1644	1918	2757	3166

Notes: Standard errors clustered at municipality level, $+p < 0.1$, $*p < 0.05$, $**p < 0.01$. 10 points bandwidth for both scores. We use a third-degree polynomial for the distance to each cutoff. All estimations includes control variables as per Table 2. α_1, α_2 and $\alpha 3$ from equation 1. For the joint significance test we report the p-values of a Wald test on each null hypothesis.

The results suggest a different pattern for two-year courses. Individuals who received the first offer but were not eligible for financial aid (Quadrant II) do not have a differential enrollment rate when they are compared to individuals who were not eligible for financial aid but received the first offer to enroll (α_2 is not statistically significant). However, eligibility for financial aid does increase enrollment, independent of receiving the first offer in this case. In addition, the interaction of both discontinuities is only statistically significant for the case of two-year courses. This does not mean that individuals in Region I of Figure 3 do not have a larger probability of enrolling in one-year courses. When we test the sum of $\alpha_1 + \alpha_2 + \alpha_3$, the result is a p-value below 0.05. However, what we can conclude is that for two-year courses, receiving the first offer only increases the probability of enrolling if the individual is eligible for financial aid.

By combining the estimations from one and two-year courses it is possible to state that financial aid becomes more important when the opportunity cost of studying increases, which occurs when individuals need to leave the labor market for a longer period of time to complete their academic programs.

5.3 RD-IV estimations

The comparison of OLS and IV estimates helps to determine cases where the average return of schooling for compliers is larger than the average return for non-compliers (IV estimates greater than OLS estimates). This implies that if the instrument is related to changes in the cost of education and the IV estimates are larger than OLS estimates, one can argue that compliers with high returns to education were not entering tertiary education due to the existence of short-run liquidity constraints.

Table 4 summarizes the estimation of OLS and IV models for three variables related to labor market participation after the individual should had finished her studies at SENA: i) the probability of working at least one month; ii) the proportion of months worked; and, iii) the probability of working any month during the last semester of 2017. Furthermore, Table 5 shows the results of labor market stability (or dynamics): i) longest employment spell, ii) longest employment spell conditional on having worked at least one month, and iii) longest unemployment spell. These indicators are estimated two years after having applied to SENA to avoid any bias from those who are involved in SENAS's mandatory internship. We also add a test determining the difference between the OLS and IV estimates using a control function approach to our estimations.[15]

We previously showed that the SISBEN discontinuity estimates are weaker for one-year courses. F-tests determining financial aid eligibility are consequently small (Table 2). This limits our analysis because the SISBEN's discontinuity will be a weak instrument for enrollment in one-year courses. For two-year courses we have a strong instrument regardless of the discontinuity or the gender. Therefore, we only focus our analysis on the impact of SENAS's enrollment on labor market outcomes for applicants of two year-course. Results for one-year courses are available at Tables 10 and 11 in Appendix C.[16]

[15] In the case of linear models Wooldridge (2015) shows how the coefficient of introducing the residual of the first stage estimation into the second stage represents the difference between the OLS estimate and the IV estimate.

[16] Due to a lack of data from all cohorts and courses we do not analyze the effect of both discontinuities on studies completed. Thus, all

Table 4: Effect of enrollment in SENA for applicants to two-year courses on formal labor market participation. OLS vs IV estimates using SISBEN and entry exam discontinuities as instruments.

	Work at least 1 month				Proportion of months working				Work in the last semester			
	SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Panel A: Women												
Enrolled	0.070**	0.042	0.085**	0.040	0.023*	0.222	0.050**	-0.171	0.012	0.070	0.038**	-0.185
	(0.014)	(0.386)	(0.012)	(0.270)	(0.011)	(0.268)	(0.011)	(0.173)	(0.015)	(0.334)	(0.010)	(0.205)
IV - OLS		-0.029		-0.045		0.199		-0.221		0.058		-0.223
		(0.390)		(0.279)		(0.278)		(0.217)		(0.346)		(0.249)
F test		25.498		11.943		32.345		12.817		26.320		11.943
R^2	0.17	0.17	0.18	0.18	0.15	0.12	0.17	0.12	0.13	0.13	0.13	0.10
Bandwidth		9.88		6.82		10.36		6.99		12.03		6.81
N	10600	10600	14711	14711	11147	11147	15017	15017	13029	13029	14711	14711
Panel B: Men												
Enrolled	0.073**	0.833**	0.053**	0.611*	0.047**	1.046**	0.032**	0.135	0.040**	0.888**	0.027**	0.372
	(0.014)	(0.227)	(0.007)	(0.280)	(0.006)	(0.283)	(0.006)	(0.211)	(0.009)	(0.243)	(0.008)	(0.318)
IV - OLS		0.761**		0.558*		1.001**		0.104		0.850**		0.346
		(0.213)		(0.248)		(0.206)		(0.210)		(0.297)		(0.312)
F test		48.019		24.160		35.037		24.160		36.156		25.903
R^2	0.20	-0.16	0.21	-0.02	0.18	-0.67	0.19	0.18	0.15	-0.25	0.16	0.08
Bandwidth		12.23		6.17		11.24		6.18		12.00		5.47
N	13914	13914	14006	14006	12737	12737	14006	14006	13617	13617	12624	12624

Notes: As per Table 2.

These results are conclusive. In the case of male applicants, SISBEN's discontinuity IV estimates are significantly larger than OLS estimates for all six variables. However, when enrollment at SENA is instrumented by exam discontinuity, IV and OLS estimates are not significantly different from each other. In addition, regardless of the instrument, IV estimates are neither significantly different from their respective OLS estimates nor statistically significant different from zero for the case of women. This implies that for women around the cutoffs we do not find evidence liquidity constraints and we do not find evidence of positive returns to SENAS's education. We further discuss this result later in this section.

5.4 Gender differences

Previous literature suggest that the analysis of education and labor market decisions are different for men a women Cameron and Taber (2004), Gamboa and Rodríguez-Lesmes (2018). Accordingly, our empirical strategy suggests that both discontinuities increase the probability of entering SENA for men and women (Figures 4 and 5 and Table 2). However, when we instrument SENAS's education using SISBEN scores we only find significant effects on formal labor market participation for men (Tables 4 and 5). In addition, the MRD analysis shows changes in the effects from one-year to two-years courses again only for men (Table 3). Therefore, our evidence only supports the existence of liquidity constraints for men.

The following questions arise; are the formal labor market returns to vocational education exclusive to men? Are liquidity constraints unimportant for women? Our previous results suggest that the answer to both questions is yes; however, it is important to point out that all our estimations come from FRD style estimations. Hence, our results are only relevant for women just around the exam and SISBEN's cutoffs.

Multiple hypotheses can explain this pattern. First, it could be that the expected returns to SENA education are smaller for women than for men. The estimated returns to education showed in section 2 do not support this hypothesis. According to our calculations, SENA has an *Internal Rate of Return (IRR)* above 30% for both men and women.

Second, women and men may choose different courses with lower average returns. To provide evidence towards or against this hypothesis we plot the average employment rate and the proportion of males by course in Figure 6, focusing on two-year courses. If this hypothesis is true, the slope in Figure 6 should be positive because courses

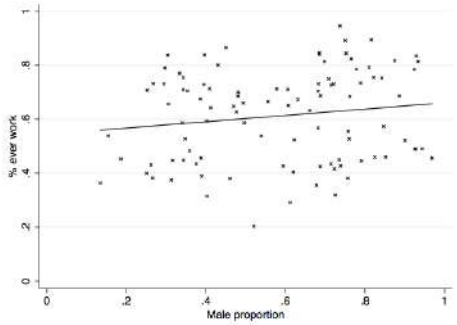
our estimates are related to the effect of having at least some SENA education.

Table 5: Effect of enrollment in SENA for applicants to two-year courses on formal labor market stability. OLS vs IV estimates using SISBEN and entry exam discontinuities as instruments.

	Longest employment spell				Longest employment spell[1]				Longest unemployment spell			
	SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Panel A: Women												
Enrolled	0.113	2.194	0.509**	-1.475	-0.690**	5.076	-0.138	-2.748	-0.527**	-2.793	-0.791**	4.571+
	(0.127)	(3.673)	(0.141)	(2.286)	(0.143)	(3.869)	(0.216)	(3.713)	(0.178)	(4.127)	(0.160)	(2.458)
IV-OLS		2.084		-1.988		6.309		-2.551		-2.271		5.371
		(3.811)		(2.226)		(3.992)		(3.298)		(4.259)		(3.680)
F test		30.982		18.058		31.505		16.191		28.829		9.976
R^2	0.16	0.15	0.17	0.16	0.10	-0.02	0.08	0.05	0.14	0.12	0.16	0.06
Bandwidth		10.84		11.40		8.19		8.40		12.48		6.41
N	11697	11697	22234	22234	5908	5908	11240	11240	13551	13551	13945	13945
Panel B: Men												
Enrolled	0.417**	20.918**	0.305*	4.602	-0.256**	13.140*	-0.224	-6.271+	-0.758**	-15.594**	-0.463**	-5.851
	(0.083)	(6.396)	(0.137)	(3.849)	(0.078)	(5.646)	(0.196)	(3.391)	(0.139)	(4.936)	(0.105)	(3.915)
IV-OLS		20.528**		4.301		11.541*		-5.940+		-14.857**		-5.393
		(4.970)		(3.603)		(4.622)		(3.046)		(4.032)		(3.797)
F test		46.198		21.774		81.922		22.579		40.885		14.807
R^2	0.21	-1.09	0.21	0.13	0.10	-0.62	0.10	-0.07	0.15	-0.58	0.16	0.04
Bandwidth		9.88		5.28		15.38		7.09		10.08		4.99
N	11327	11327	12237	12237	11994	11994	10559	10559	11515	11515	11634	11634

Notes: As per Table 2.
[1] Conditional on having worked at least one month.

Figure 6: Average labor market participation and male proportion by course (two-year courses)



Notes: Authors' calculations using SENA and PILA information. Estimations using 246 courses.

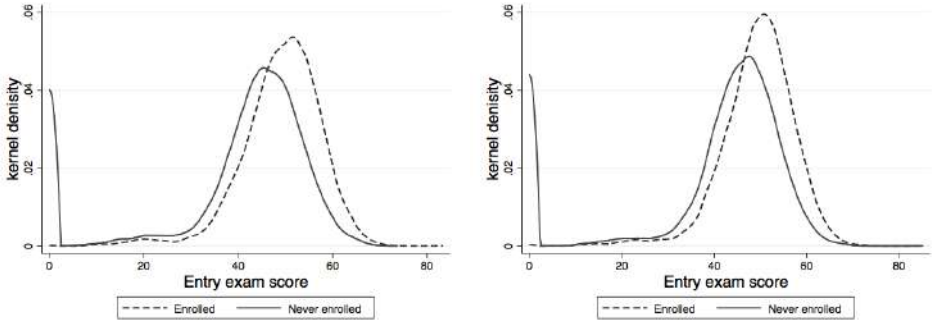
with larger expected employment rate should have a higher proportion of males. However, as shown in Figure 6, the slope is close to zero.

Third, the positive returns to education that we found for men are driven by unobserved differences in ability that exist for men but do not exist for women. However, we can argue that this is not the case. Our identification strategy relies on the assumptions of continuity of observed and unobserved factors around the cutoffs for both men and women. Second, we use the exam score as a proxy for ability. Figure 7 shows that enrollees obtained higher exam scores than individuals who did not enroll. Such a difference is not larger for men than for women. If anything, the difference is larger for women than men.

The latest evidence rejects the hypothesis of selection with respect to the course and the quality of enrolled women. Thus, the fact that we do not find positive returns for women may be related to frictions in the labor market.

One final possible explanation is related to the effects of fertility and informality. Our sample includes individuals from 18 to 24 years old (around 20 to 26 years old when we analyze labor market participation). According to our data, labor market participation is larger for men (63% and 56% for men and women, respectively). In addition, by age 25, 51% of women have already had their first child. The percentage increases to 73.5% by age 29 (Profamilia, 2016). Given that we do not observe unemployment, informal labor market participation or the likelihood of being

Figure 7: Entry exam distribution by SENA enrollment and gender - two-year courses



(a) women (b) men

Notes: Authors' calculations using SENA and PILA information. Estimations using 246 courses.

outside of the labor market, we cannot test if women prefer informality or leaving the labor market in order to take care of their children.

5.5 Job quality

Thus far, we have shown strong evidence regarding the effect of SENAS's education on the formal labor market participation of men. What is more, we show evidence that the increase in SENAS's enrollment was due to the reduction in the liquidity constraints for individuals with large expected returns to education. However, do these individuals get access to better jobs? As explained before, we have no access to income data; however, we have some information about the type of contract and firm the individual is working for.

In Table 4 we showed for men that applied to two year courses, enrollment in SENA increases their probability of having a job in the last semester of our sample (last semester of 2017). In this section, we focus on what types of jobs better explain this effect.

First, Table 6 shows the RD-IV estimates of the effect of enrollment in SENA on working in the last semester by the size of the firm the person works in. According to our results, individuals who enrolled in SENA because of financial aid eligibility are more likely to be working in very small firms (1 to 10 workers) or very large firms (more than 500 employees). Following Attanasio et al. (2017) one can assume that working in large firms can imply higher quality jobs.

Table 6: RD-IV estimates of the effect of SENA enrollment on men formal labor market participation in the last semester 2017 by firm size.

	Firm size				
	1-10	11-50	51-200	201-500	500 or more
Enrolled	0.467^{+}	-0.088	0.231	0.160	0.340*
	(0.254)	(0.226)	(0.348)	(0.179)	(0.151)
F test	30.39	51.12	55.90	52.18	50.65
R^2	-0.24	0.02	-0.02	-0.01	0.00
Bandwidth	8.20	13.04	13.42	12.78	12.87
N	9403	14851	15292	14592	14674

Notes: Estimations only for individuals who applied to two-years courses. Enrollment was instrumented with the eligibility for YIA by SISBEN score discontinuity. Other notes as per Table 2.

In addition, we estimate the RD-IV by different types of contracts (Table 7). Columns 1 and 2 compare having a job in the private or public sector. Columns 3 and 4 differentiate who works as an employee or is self-employed. Finally, Columns 5 and 6 distinguish between full time and part time contracts. According to our results, SENA education increases the chances of working in the private sector and as an employee. However, the results are not different with respect to having a part or full-time job.

Table 7: RD-IV estimates of the effect of SENA enrollment on men formal labor market participation in the last semester 2017 by contract and job type.

	Sector of employment		Worker type		Job type	
	Public	Private	Employee	Independent	Full time	Part time
	(1)	(2)	(3)	(4)	(5)	(6)
Enrolled	0.094	0.879**	0.645*	0.127	0.594*	0.523*
	(0.070)	(0.310)	(0.270)	(0.104)	(0.253)	(0.215)
F test	42.11	41.65	57.71	55.83	46.10	35.68
R^2	-0.02	-0.24	-0.07	-0.04	-0.03	-0.18
Bandwidth	11.81	11.37	12.55	13.40	11.53	9.07
N	13382	12846	14306	15286	13044	10404

Notes: As per Table 6.

5.6 Other possible heterogeneous effects

Lastly, we study how our results may change for different types of individuals. Our focus is to further understand the role of liquidity constraints and determine if our estimates change when the economic environment is more or less likely to have higher constraints to post-secondary education. First, we separate individuals according to the age at which they applied to SENA in two groups, individuals from 18 to 20 years old and individuals from 21 to 24 years old. The objective of this separation is to test if there are differences when considering the time passed since high school graduation. On the one hand, older individuals may already have some labor market experience, thereby increasing their opportunity cost. On the other hand, younger individuals who already applied for SENA may have a greater preference for more education after high school.

Second, we compare individuals who were assessed for SISBEN in Area Type 1 (main urban areas) with individuals from Area Types 2 and 3 (which are more rural). This comparison does not only provide information on where individuals lived when they applied, it also gives information on the town of origin and the chances of accessing credit or other educational supplies. Third, we divide the population into individuals who studied in a departmental capital city and individuals who studied in other municipalities. In some cases we modify the delimitation of capital city adding it's surrounding municipalities following DANE's administrative definition of metropolitan area. Capital cities are usually cities where labor markets are more dynamic and the availability of tertiary education is greater.

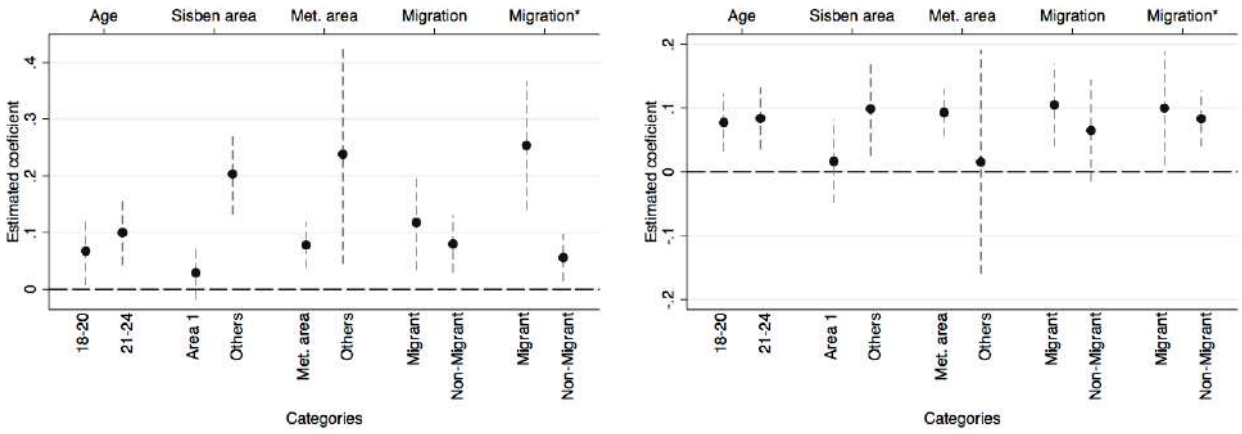
Finally, we analyze individuals using two proxies for migration. The first defines a migrant as anyone who studied in a different city than where they had their SISBEN assessment. The second follows the logic of the first definition but does not consider as migrant individuals who studied and were assessed for SISBEN in the same metropolitan area. We continue focusing our analysis on individuals who applied to two-years courses, where, according to our previous results, liquidity constraints are more important.

Figure 8 shows the estimate coefficient of the SISBEN discontinuity by gender (β_1 from equation 4). There were once again gender differences. On the one hand, for men (Panel B), we do not see a significant difference between groups; however, we lose precision for some of the estimations. On the other hand, women who were assessed in rural areas and migrants seem more responsive to the opportunity of access to aid (Panel A).

We then estimate the second stage by group to assess the difference between OLS and IV estimators. Table 8 summarizes the results.[17] Again, Panel A shows no evidence of liquidity constraints nor positive returns to education for women around the SISBEN cutoff. For men (Panel B), the analysis is more complicated because we lose precision in the first stage of some estimations; thus, sometimes the instrument is weak. Taking into account this limitation, our estimations seem to show that liquidity constrains are stronger for younger men, men assessed and studying in urban areas, and men that did not migrate (only when we exclude migration within metropolitan areas). Studying and living in urban areas may indicate greater living costs that, with imperfect credit markets, imply liquidity constraints play a more important role in the decision of whether to acquire more education or not. Nevertheless, the estimates are not different from one another between different groups, so the evidence is inconclusive.

[17] Similar results are found for estimations on other outcome variables such as the probability of having a formal job at the end of the period, the longest period of employment and the longest period of unemployment. These results are summarized in Table 13 for women and Table 14 for men in Appendix C.

Figure 8: Estimated RD coefficient on enrollment for the SISBEN discontinuity - β_1 - for each category. By gender for two-years courses



(a) Women (b) Men

Notes: Estimated β_1 from equation 4. Control variables as per Table 2. 95% coefficients intervals in dashed lines.
* Excluding migration within metropolitan areas.

Table 8: Effect of enrollment in SENA by gender for applicants to two-year courses on formal labor market participation. OLS vs IV estimates for different groups using SISBEN discontinuities as instrument.

	Age		SISBEN area		Met. area		Migration		Migration[1]	
	18-20	21-24	Area 1	Others	Met. area	others	Migrant	Non-migrant	Migrant	Non-migrant
Panel A: Women										
OLS	0.018	0.011	-0.001	0.024	0.012	0.035	0.024	0.021**	0.040	0.016
	(0.015)	(0.015)	(0.018)	(0.023)	(0.014)	(0.027)	(0.021)	(0.007)	(0.025)	(0.011)
IV	0.835	-0.227	0.316	0.044	0.265	0.243	0.559	-0.209	0.393	0.178
	(0.619)	(0.567)	(2.087)	(0.287)	(0.503)	(0.447)	(0.463)	(0.624)	(0.304)	(0.791)
IV - OLS	0.817	-0.239	0.317	0.020	0.253	0.210	0.537	-0.230	0.356	0.163
	(0.620)	(0.561)	(2.088)	(0.284)	(0.498)	(0.444)	(0.465)	(0.623)	(0.307)	(0.788)
F test	4.94	12.12	1.56	32.59	15.29	6.41	7.92	9.89	19.96	7.11
Bandwidth	11.39	9.85	8.71	8.62	10.35	9.85	10.98	14.08	8.03	12.19
N	5920	5239	4841	4229	9575	1210	4384	9225	1975	9820
Panel B: Men										
OLS	0.055**	0.016	0.043**	0.060**	0.045**	0.065**	0.058**	0.051**	0.068**	0.038**
	(0.007)	(0.010)	(0.008)	(0.009)	(0.006)	(0.022)	(0.010)	(0.012)	(0.012)	(0.006)
IV	1.850**	0.615	7.825**	1.105*	1.504**	0.119	1.289*	1.847*	0.803	1.505**
	(0.516)	(0.443)	(2.906)	(0.433)	(0.291)	(5.331)	(0.505)	(0.785)	(0.605)	(0.406)
IV - OLS	1.796**	0.599	7.782**	1.046*	1.461**	0.054	1.232*	1.797*	0.736	1.468**
	(0.516)	(0.449)	(2.908)	(0.436)	(0.294)	(5.330)	(0.505)	(0.793)	(0.603)	(0.409)
F test	11.31	12.25	0.26	7.13	25.33	0.03	10.18	2.62	5.01	14.32
Bandwidth	9.89	14.29	8.06	12.64	9.72	11.38	11.97	7.97	11.86	10.21
N	5346	8196	5143	6323	9777	1328	4812	5789	3229	8621

Notes: As per Table 2.
[1] Excluding migration within metropolitan areas.

5.7 Possible flaws and caveats

According to Carneiro and Heckman (2002), comparing IV and OLS estimates has some important weaknesses. First, instruments in the literature are usually invalid or weak. We have already shown that both discontinuities are strong instruments of enrollment. Furthermore, the RD environment supports the validity of our instruments. According to Lee and Lemieux (2010), if there is both no manipulation of the forcing variable by the cutoff, and observable and unobservable variables are continuous around the cutoff, then RD estimations represent an experiment by the cutoff. Appendix A contains the evidence supporting the validity of both RD estimations. Hence, both our instruments are strong and valid.

Second, the difference between the IV and OLS can be explained by differences in an individuals' comparative advantage in the labor market. This drawback is common when instruments come from regional variations in the cost of education. In our estimations we control for each SENA venue and program type fixed effects. Therefore, applicants on both sides of each cutoff are likely to be facing the same labor markets. In addition, following the assumption of continuity of observable and unobservable factors around the cutoff, one can argue that an individual's comparative advantage in the labor market does not radically change around the cutoffs.

Finally, the OLS and IV comparison ignores the choice of school quality. In our analysis all individuals applied to the same institution (SENA), and the use of fixed effects allows us to compare individuals who applied to the same course at the same venue. Furthermore, we show that eligibility for financial aid did not increase the application for two-year courses. Hence, the quality argument does not apply.

In addition, according to Griliches (1977) and Angrist and Krueger (1991), another reason why the IV estimates are larger than the OLS estimates could be due to measurement error, which could overcome the effect of the ability bias. In our case, we can argue that the possibility of measurement error is coming from alternatives to post-secondary education aside from SENA. Individuals above SISBEN's cutoff (or below the exam's cutoff) may be more likely to look for other types of post-secondary education aside from SENA, college for example. There are some results in our estimations that support that our estimates are capturing the effect of liquidity constraints instead of the effect of measurement error.

For all individuals in our analysis, we observe their decision to enter or not enter SENA, but we do not observe if the they accessed other sources of post-secondary education. Although, there is no reason why the probability of using other sources of post-secondary education should be different for different instruments (SISBEN or exam), different course types (one or two-year), or even by gender. Why then, do we only find that IV estimates are larger than OLS estimates for the SISBEN instrument for men who applied to two-year courses? If measurement error was driving our results, we could expect to find some other examples of IV estimates larger than those of OLS; however, we only find one case where IV estimates are larger than OLS estimates. Additionally, the MRD estimations also support the hypothesis of liquidity constraints for men that applied to two-year courses. Therefore, we do not believe that the differences between IV and OLS are coming from measurement error.

6 Discussion and final remarks

Reducing tuition fees is important if you want to make post-secondary education available to individuals from low-income households. Therefore, it is intriguing why some people do not enroll in free vocational education even when there are some monetary incentives to attend. High school graduates may not attain more education because they perceive low returns to post-secondary education, they do not want more education (low preferences), or because they may still face liquidity constraints. Our results show new evidence that even when education is free, low-income individuals face liquidity constraints.

Our results align with the evidence shown by Attanasio et al. (2017), Kugler et al. (2020) and Londoño-Vélez et al. (2020) in Colombia. For example, by the time YIA offered a grant to study in SENA, the program *Ser Pilo Paga (SPP)* also offered a substantial grant, including complete coverage of tuition fees, to support high achieving individuals to study in college. Londoño-Vélez et al. (2020) show that SPP increased enrollment in post secondary education by 27.5 percentage points (a 48% increase). We show that in the case of free education, eligibility for financial aid increased enrollment in SENA by 11 percentage points (a 47% increase). Even though the compliers in both cases may not be comparable, policies that support students with non direct costs have comparable impacts with policies that cover tuition fees.

We do know that liquidity constraints matter in the case of free education. However, when tuition fees are

removed, which costs are driving continuing education decisions. Is it the opportunity cost or the cost of maintenance? In section 5.6 we tested our hypothesis in different scenarios aiming to disentangle the opportunity cost from the maintenance cost. Unfortunately our results were inconclusive. For this reason we complement our analysis using information from survey data of a sample of beneficiaries of *YIA* in order to understand how they spend the cash transfer from the program (Econometría-S.A. and SEI, 2017). According to the data, 74% use part of the transfer in transportation, which is clearly part of the maintenance costs. Furthermore, 65% use part of the transfer for household cleaning expenses, which could be understood as helping at home (opportunity cost). According to the survey, *YIA* beneficiaries use about 30% of the transfer on direct maintenance expenses (transport, food outside the home and educational expenses) and about 70% of the expenses for home support which is similar to an opportunity cost. In the case of migrants, home support can also be seen as maintenance costs and the share of the expenditure increases to 66%. Once again the evidence is inconclusive so we cannot argue that only one cost explains our results.

In addition, our work borrows from previous works such as Cameron and Taber (2004) using the comparison between IV and OLS estimates to test the existence of liquidity constraints. However, Cameron and Taber (2004) based the identification of liquidity constraints on the claim that direct costs (tuition fees) and indirect costs (opportunity cost) affect constrained and unconstrained individuals differently. Hence, IV estimates are larger than OLS estimates when the instrument affects the direct costs only. In that sense, our strategy would not work because our analysis does not include tuition fees.

According to Cameron and Taber (2004), credit constrained individuals are those who borrow with an interest rate above the market interest rate. Thus, if individuals only borrow when they need to pay tuition, the differences in educational choices between constrained and unconstrained individuals will only appear in the presence of tuition fees. But, without tuition fees, they should obtain the same level of education. This may be the case for college applicants in developed economies. Although, this may not be the case for low-income youths in developing countries. In an impoverished environment, if an individual wants to stay out of the labor market while studying for a period of, for example, two years, she may need to borrow in order to achieve a minimum level of consumption. Therefore, the difference between constrained and unconstrained individuals would be the interest rate at which they could borrow. Following this idea, constrained individuals would be more sensitive to changes in the cost of education (for example when a grant is introduced) than unconstrained individuals, and the logic behind Cameron and Taber (2004) applies to this analysis as well.

To conclude, This paper provided evidence of the existence of liquidity constraints, even in the absence of tuition fees. The discussion on post secondary education has been disregarded by the literature in the past. However, free education is a key component of public policy in many developing and low-income countries. Our results shed light on the limitations of free education policies by quantifying how important other costs are, such as opportunity cost and maintenance cost, in explaining enrollment in post secondary education.

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A Validity of the RD design

In this appendix we show evidence in favor of continuity and manipulation assumptions in our sample, following Lee and Lemieux (2010) for SISBEN and entry exam scores.

Figure 9 shows the continuity in confounding characteristics around SISBEN's cutoff for one-year courses (panels a-e) and two-year courses (panels f-j). There is no evidence of strong changes around the cutoff for all the observable variables. However, it is worthnothing that the SISBEN is also employed to select the beneficiaries for many other social programs in Colombia. Consequently, the same cutoffs are used by YIA as well as by other programs such as subsidized healthcare (RSS, Régimen Subsidiado en Salud in Spanish) which provides access to medical services without paying periodical contributions and reduced co-payments to households with a SISBEN score below the cutoff points we use in this paper (Prosperidad-Social, 2014). Hence, identification could be compromised because individuals just below the cutoff are not only eligible to YIA but also to the RSS. Possible bias comes from the correlation between the decisions of demanding education in SENA and RSS's benefits. On the one hand, correlation may be negative because seeking tertiary education in SENA is a signal of a desire to obtain a job in the formal labor market, but once an individual signs a contract, she losses her RSS benefits. On the other hand, RSS means lower expenditure in healthcare. Therefore, individuals may have less pressure to work after finishing high school and require more income to cover the costs of studying at SENA.

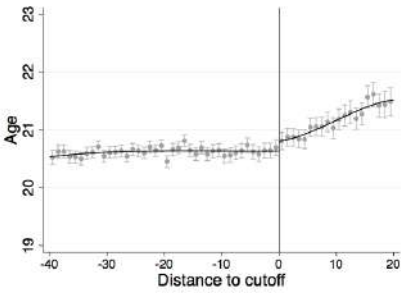
Figure 10 shows the change in enrollment in SENA due to the SISBEN's discontinuity by application semester. As we can see, when we take into account the participants in YIA the coefficients change from a positive sign to a negative sign. This result can support the idea of a negative correlation between eligibility to RSS and YIA. As result, our estimates may underestimate the total impact of being eligible for financial aid.

Regarding on the entry exam, Figure 11 shows that there are not significant jumps around the cutoffs previously obtained by simulating the effect that YIA's affirmative action has on enrollment. The small discontinuities in the SISBEN score are the result of changes in the cutoff due to the affirmative action. However, in appendix B we discuss that these changes only affect a small proportion of our sample and do not change the ability distribution of enrollees.

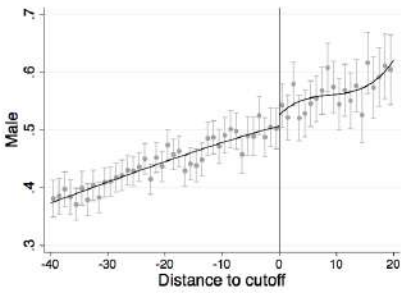
The second assumption for RD estimations means that individuals cannot manipulate their score. Figure 12 shows the distribution of each score around the cutoffs following Cattaneo et al. (2016). Based on the figure and the discontinuity test we reject the hypothesis of manipulation of SISBEN or exam scores by the cutoff.

Figure 9: Continuity in observables around the SISBEN's cutoff

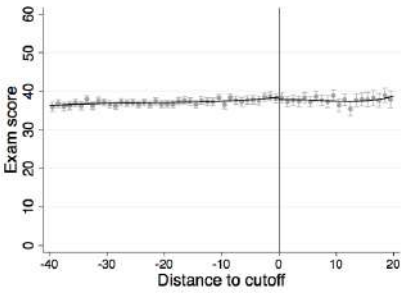
one-year course



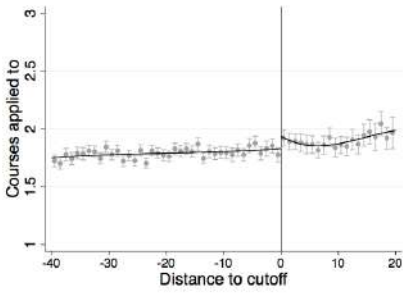
(a) Age



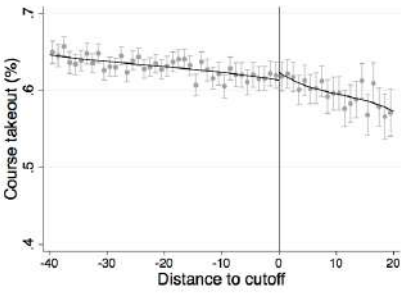
(b) Gender (% male)



(c) Entry exam score

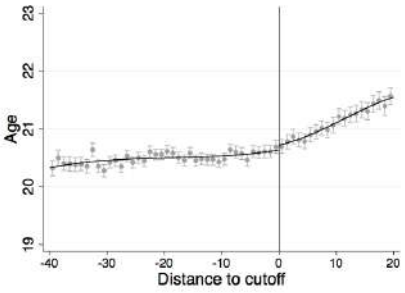


(d) Applications

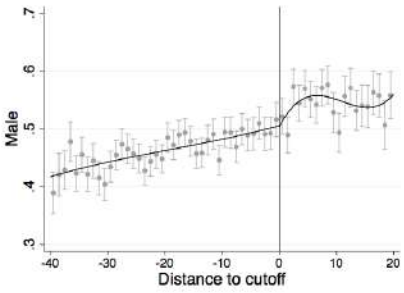


(e) % takeout

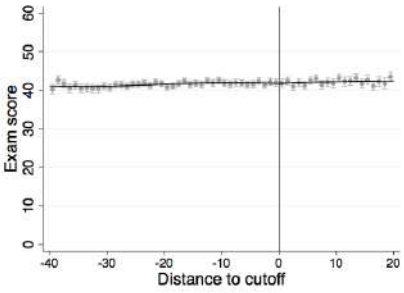
two-year course



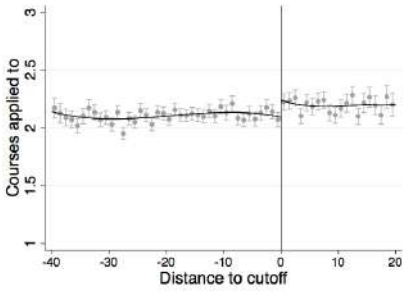
(f) Age



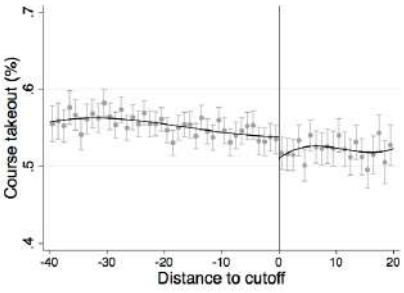
(g) Gender (% male)



(h) Entry exam score

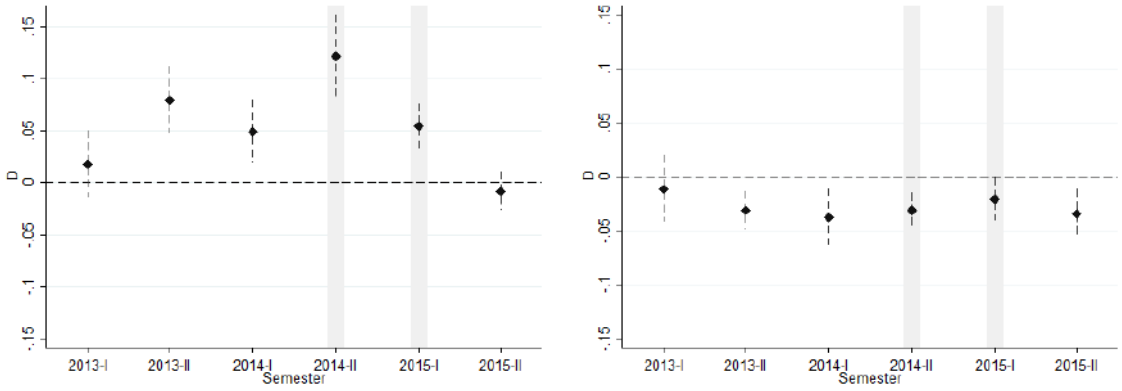


(i) Applications



(j) % takeout

Figure 10: SISBEN discontinuity on enrollment in SENA by enrollment semester. Conditional and unconditional of YIA participation)

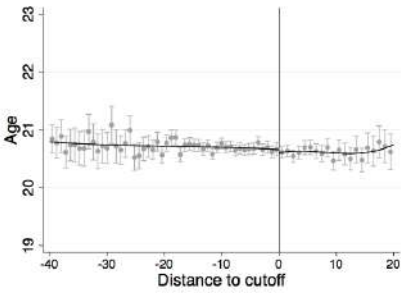


(a) Unconditional (b) Controlling by the effect of participation in YIA

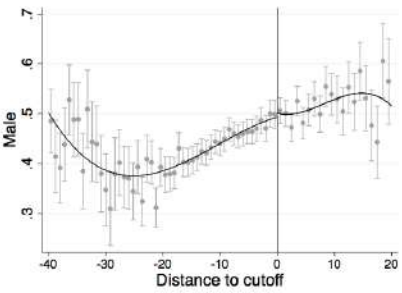
Using all applications from August 2013 to August 2015. The shades represent the period of our analysis. 95% confidence intervals in dashes lines.

Figure 11: Continuity in observables around the entry exam's cutoff

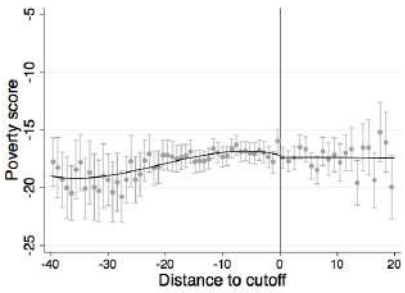
one-year course



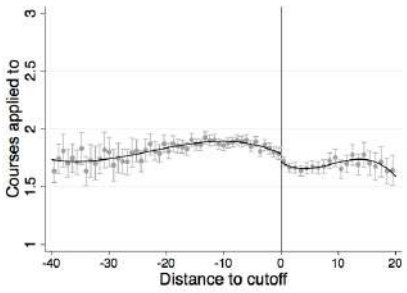
(a) Age



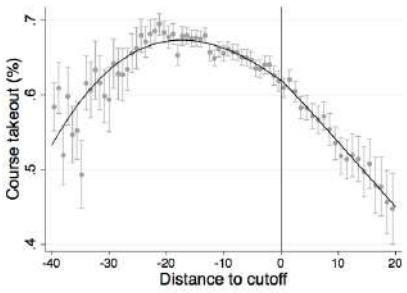
(b) Gender (% male)



(c) SISBEN score

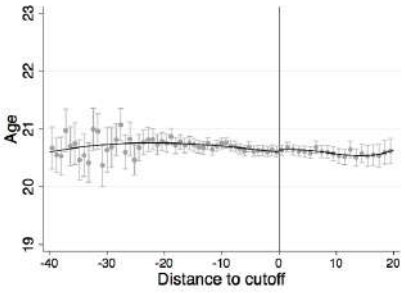


(d) Applications

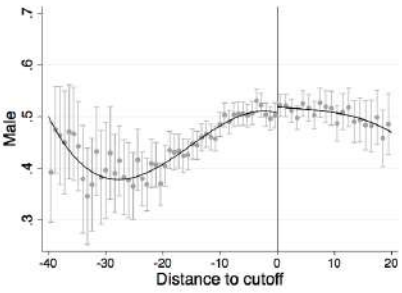


(e) % takeout

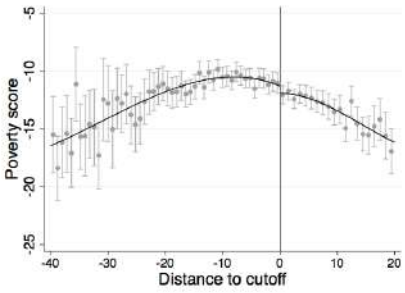
two-year course



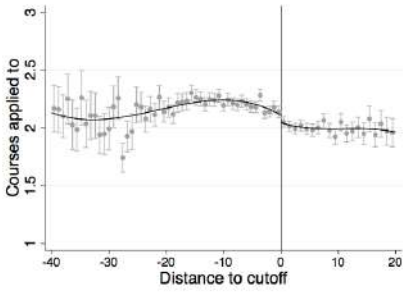
(f) Age



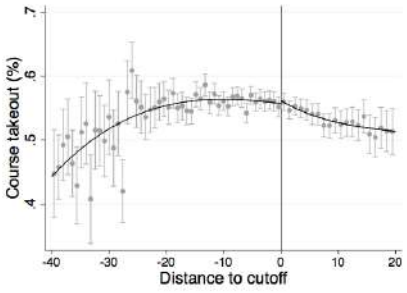
(g) Gender (% male)



(h) SISBEN score



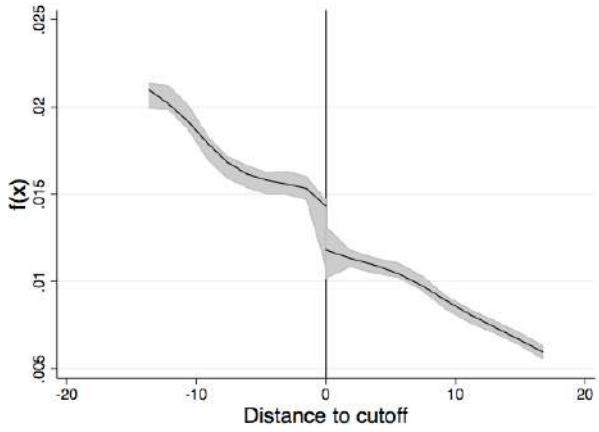
(i) Applications



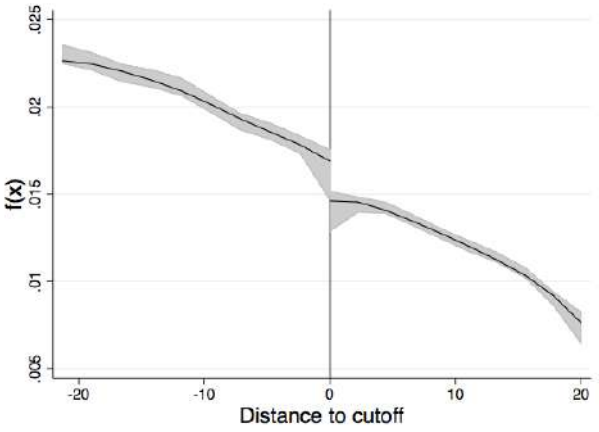
(j) % takeout

Figure 12: Manipulation test - density around the cutoff

SISBEN score

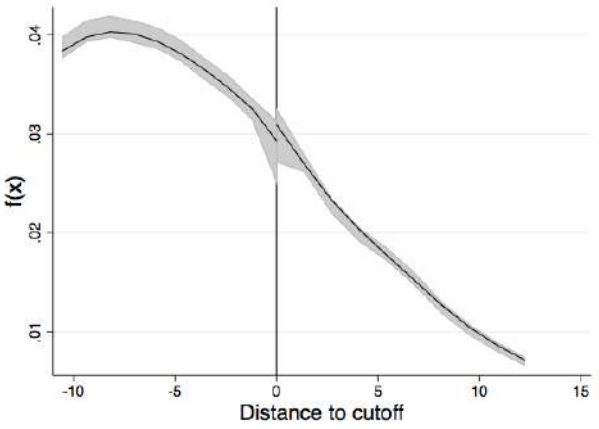


(a) 1y. course

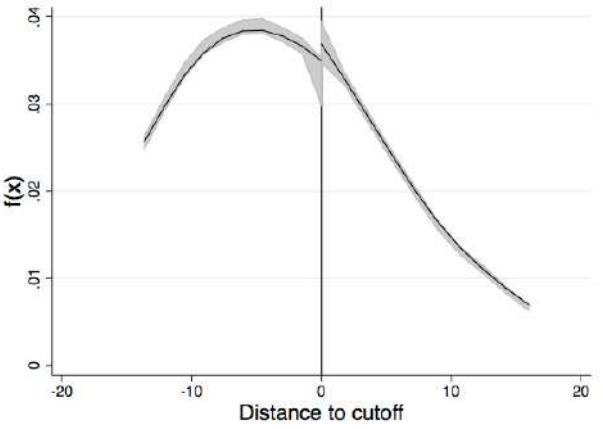


(b) 2y. course

Entry exam

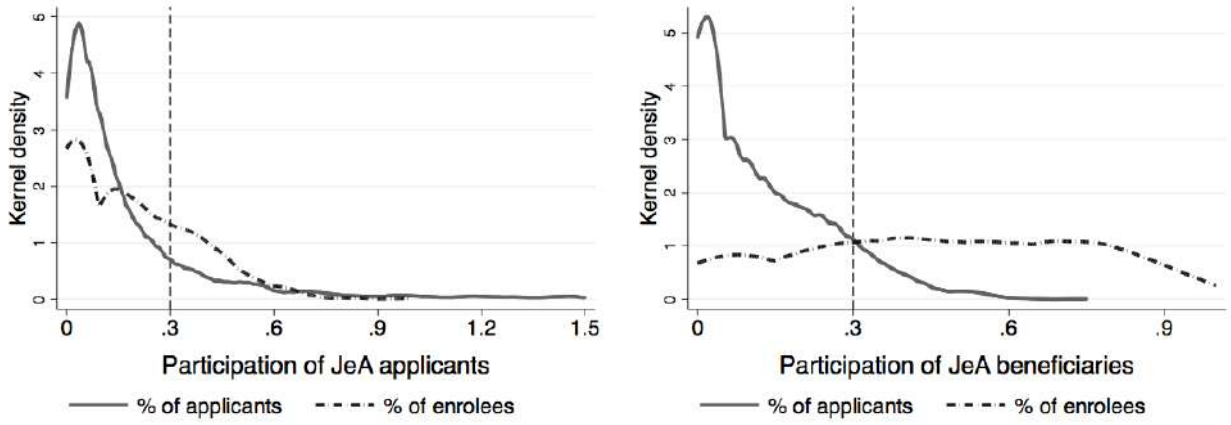


(c) 1y. course



(d) 2y. course

Figure 13: Important of preferential entry. Distribution of the proportion of YIA applicants and YIA enrollees in a given course



(a) YIA applicants

(b) YIA beneficiaries

Notes: Authors' calculations using SENA applicants data.

B Affirmative action vs financial aid

As it was mentioned in section 4, τ_Y includes the effects of all YIA components on Y. Here, we show that, despite preferential entry helping some individuals access SENA, monetary aid does explain most of our results. Table 9 shows the affirmative action's effect on the composition of SENA applicants and enrollees.

Table 9: Preferential entry effect on SENAS's composition

	Never offered first	First offer due to AA	Lost first offer due to AA	Always offered first
Entry exam's score	41.984	43.426	49.292	51.436
	(0.470)	(0.528)	(0.787)	(0.473)
% enrolled	0.072	0.467	0.291	0.505
	(0.008)	(0.026)	(0.025)	(0.017)
Individuals	78222	4799	3032	33736

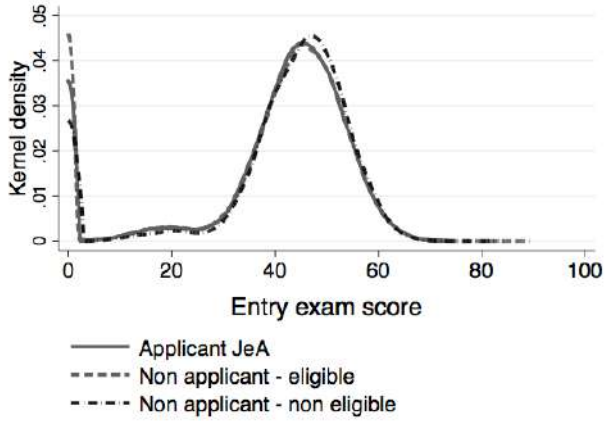
Notes: Authors' calculations using data from SENA. Standard error is parentheses. Simulations based on the entry exam results using only courses with excess of demand and at least one YIA applicant.

As we can see, 4799 individuals gain an offer due to YIA's preferential entry. This means that without being part of YIA, their score would not have been enough to gain a first offer to join a course. Among these individuals 47% enrolled in SENA. Furthermore, 3032 individuals who are not part of YIA did not get the first offer because their exam cutoff increased due to YIA's preferential entry. Nevertheless, 30% did enrolled in SENA. This means the preferential entry affected 6.5% of total applicants.

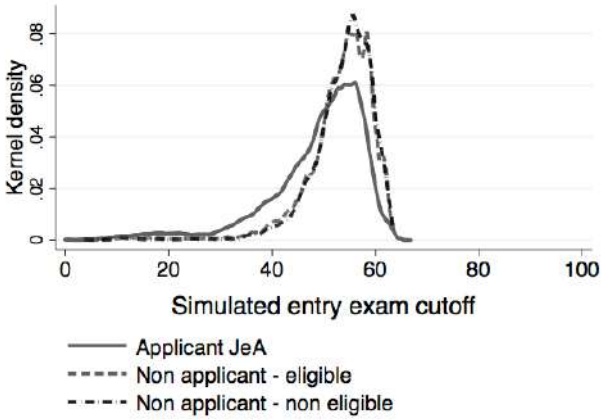
In addition, Figure 13 shows that both the proportion of YIA applicants and beneficiaries among the total number of applicants and enrollees per course. None of these distributions jump around the preferential entry quota. The continuity of around 30% shows that the preferential entry is no more binding than usual, which is evidence of its low importance.

We can also test if the affirmative action changed the abilities distribution among SENAS's applicants and enrollees. Panel a in Figure 14 shows that there is no difference in the exam distribution among YIA applicants and non-applicants (neither eligible or non-eligible ones). Therefore, one can say that YIA does not attract better or worse applicants. However, panel b shoes how the simulated exam entry cutoff distribution for possible beneficiaries of the Program moves left with respect to the distribution of those who did not ask for the benefits of the Program. Nevertheless, when we see the distribution of the individuals that finally enroll in SENA, there are no differences in the exam score of YIA applicants and non-applicants. Then, the distribution of abilities of individuals enrolled in SENA did not depend on the effect that the affirmative action had on enrollment.

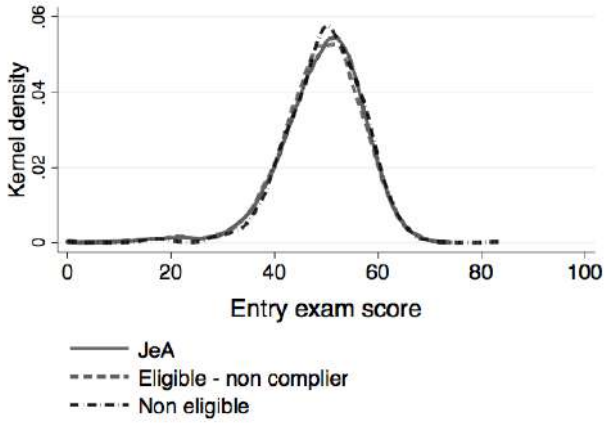
Figure 14: SENA entry exam and distribution of entry cutoffs for YIA applicants and non-applicants and enrollees



(a) Applicants



(b) Entry cutoff

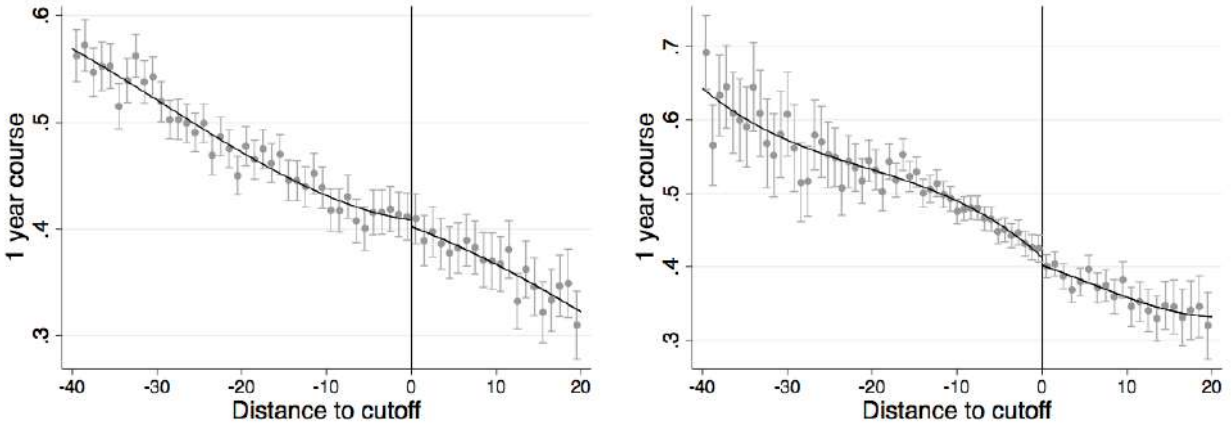


(c) Enrolled

Notes: Authors' calculations using SENA applicants data.

C Supplementary tables and figures

Figure 15: Probability of applying to a one-year course by SISBEN score and entry exam



(a) SISBEN score

(b) Entry exam

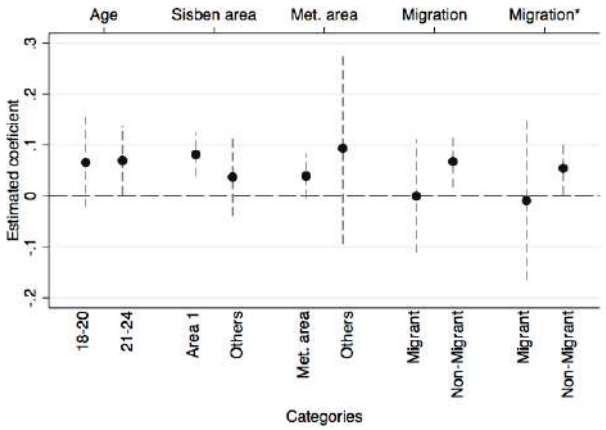
Table 10: Effect of enrollment in SENA on formal labor market participation for applicants to one-year course. OLS vs IV estimates using SISBEN and entry exam discontinuities as instruments.

	Work at least 1 month				Proportion of months working				Work in the last semester			
	SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Panel B: Women												
Enrolled	0.144**	1.288	0.130**	0.323	0.076**	0.863	0.062**	0.071	0.062**	2.502	0.025*	0.144
	(0.033)	(1.050)	(0.029)	(0.303)	(0.017)	(0.710)	(0.015)	(0.194)	(0.018)	(1.729)	(0.010)	(0.192)
Control function		1.144		0.194		0.788		0.009		2.440		0.120
		(1.060)		(0.305)		(0.712)		(0.194)		(1.719)		(0.191)
F test		2.639		21.135		2.153		19.356		1.006		26.198
R^2	0.16	0.16	0.15	0.15	0.14	0.14	0.15	0.15	0.10	0.11	0.10	0.10
Bandwidth		8.12		6.68		9.66		6.25		7.25		8.99
N	5933	5933	11066	11066	7001	7001	10410	10410	5286	5286	14460	14460
Panel C: Men												
Enrolled	0.075**	1.105	0.060**	0.608*	0.036**	1.649*	0.036**	0.590**	0.014	1.868*	0.014	0.767**
	(0.013)	(0.859)	(0.011)	(0.280)	(0.011)	(0.803)	(0.008)	(0.176)	(0.018)	(0.807)	(0.010)	(0.248)
Control function		1.030		0.548^{+}		1.613*		0.555**		1.856*		0.754**
		(0.856)		(0.279)		(0.801)		(0.177)		(0.809)		(0.246)
F test		8.205		17.618		5.149		13.763		8.249		19.755
R^2	0.22	0.22	0.21	0.21	0.19	0.20	0.20	0.20	0.15	0.15	0.15	0.15
Bandwidth		10.73		6.31		9.08		5.51		10.76		6.23
N	8310	8310	9884	9884	7031	7031	8693	8693	8324	8324	9733	9733

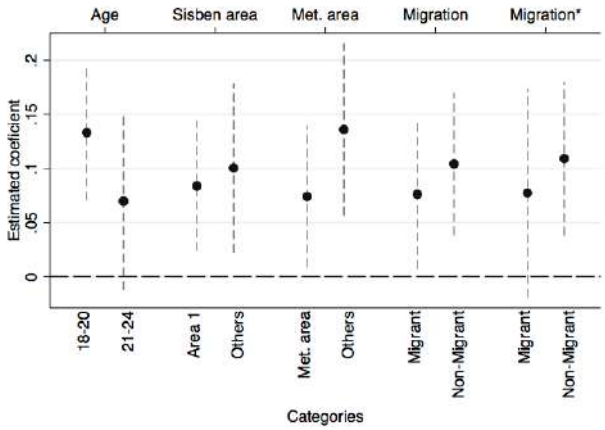
Notes: As per Table 4.

Figure 16: Estimated RD coefficients on enrollment for each discontinuity by categories - men

one-year courses

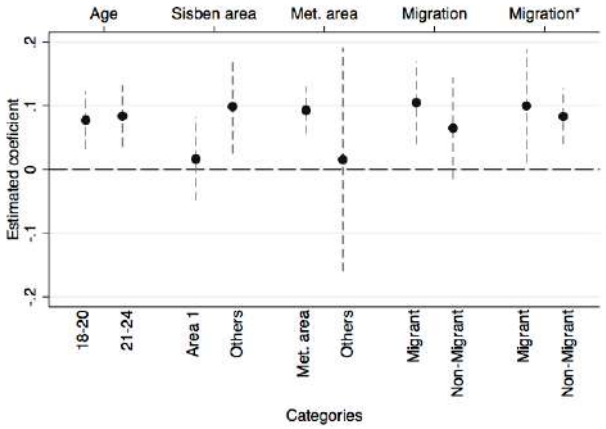


(a) SISBEN discontinuity - β_1

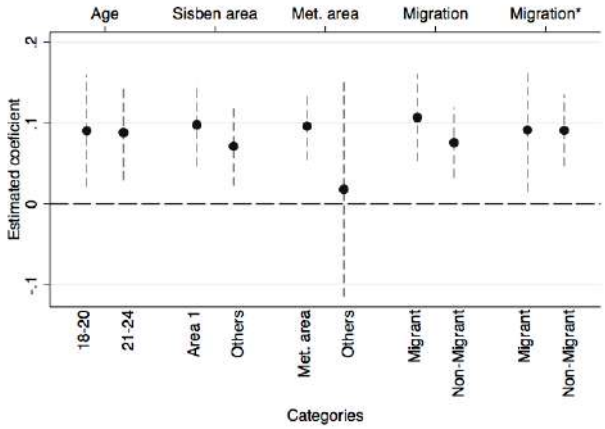


(b) Exam discontinuity - ρ_1

two-year courses



(c) SISBEN discontinuity - β_1

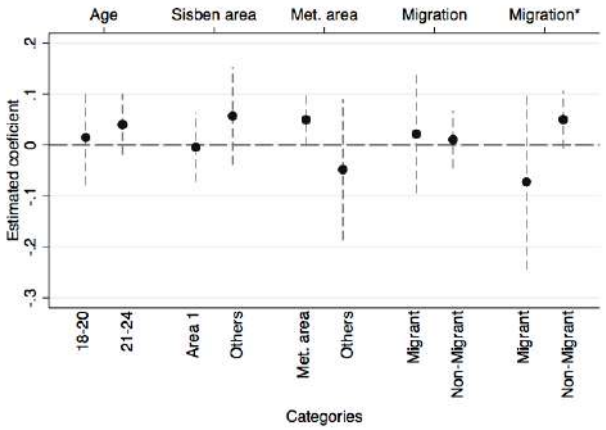


(d) Exam discontinuity - ρ_1

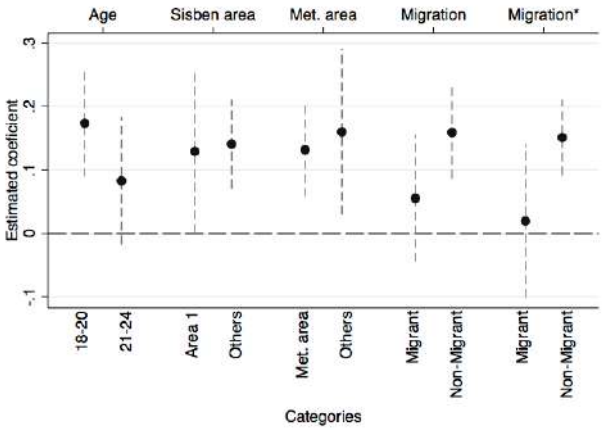
Notes: Following equations 4 and 5. Control variables as per Table 2. 95% coefficients intervals.

Figure 17: Estimated RD coefficients on enrollment for each discontinuity by categories - women

one-year courses

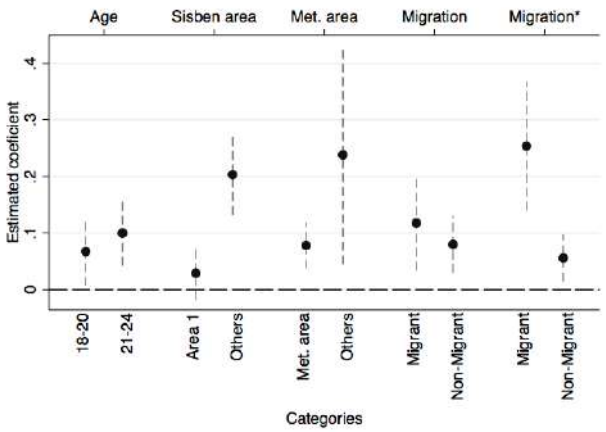


(a) SISBEN discontinuity - β_1

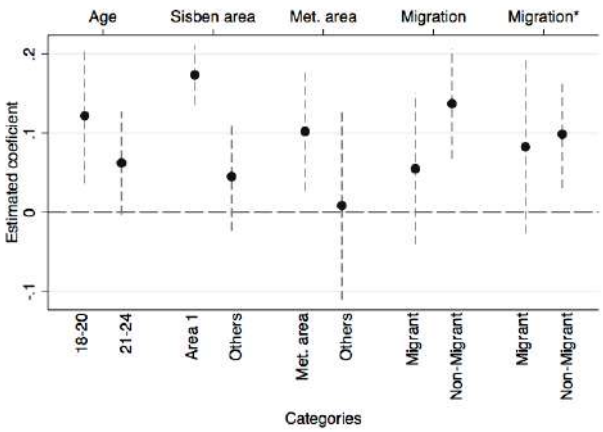


(b) Exam discontinuity - ρ_1

two-year courses



(c) SISBEN discontinuity - β_1



(d) Exam discontinuity - ρ_1

Notes: Following equations 4 and 5. Control variables as per Table 2. 95% coefficients intervals.

Table 11: Effect of enrollment in SENA on formal labor market stability for applicants to two-year courses. OLS vs IV estimates using SISBEN and entry exam discontinuities as instruments.

	Longest employment spell				Longest employment spell[1]				Longest unemployment spell			
	SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.		SISBEN disc.		Exam disc.	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Panel B: Women												
Enrolled	1.503**	11.845	1.204**	0.103	0.458	9.105	0.124	-6.243	-1.927**	-24.042	-1.551**	-4.076
	(0.308)	(16.648)	(0.284)	(3.670)	(0.406)	(17.305)	(0.253)	(3.974)	(0.479)	(21.406)	(0.499)	(6.410)
Control function		10.345		-1.104		8.652		-6.383		-22.121		-2.532
		(16.684)		(3.685)		(17.254)		(3.951)		(21.394)		(6.389)
F test		1.786		22.042		2.075		24.028		2.010		18.648
R^2	0.13	0.13	0.14	0.14	0.10	0.10	0.08	0.08	0.13	0.13	0.14	0.14
Bandwidth		8.68		6.73		7.99		7.08		8.75		4.90
N	6294	6294	11111	11111	3146	3146	6084	6084	6343	6343	8318	8318
Panel C: Men												
Enrolled	0.547*	32.006^{+}	0.645**	12.536**	-0.173	39.281*	-0.079	12.925*	-0.825**	-41.763^{+}	-0.887**	-16.715**
	(0.210)	(18.254)	(0.167)	(3.695)	(0.291)	(19.573)	(0.241)	(5.094)	(0.266)	(23.439)	(0.230)	(5.047)
Control function		31.470^{+}		11.910**		39.472*		13.026*		-40.950^{+}		-15.847**
		(18.225)		(3.751)		(19.591)		(5.017)		(23.382)		(5.045)
F test		5.327		16.486		4.523		26.279		4.362		13.192
R^2	0.20	0.20	0.19	0.19	0.11	0.12	0.11	0.11	0.17	0.17	0.17	0.17
Bandwidth		9.67		5.98		9.23		7.78		10.23		4.82
N	7480	7480	9381	9381	4472	4472	7164	7164	7938	7938	7724	7724

Notes: As per Table 4. [1] Conditional on having work at least one month.

Table 12: IV estimates of the effect of enrollment in SENA on formal labor market participation and stability. Two-year courses by gender and discontinuity

	Participation			Stability		
	Work at least 1 month	Proportion of months working	Work in the last semester	Longest employment spell	Longest employment spell[1]	Longest unemployment spell
Instrument = SISBEN discontinuity						
Panel A: Women						
Enrolled	0.066	0.260	0.077	2.008	5.114	-2.748
	(0.383)	(0.296)	(0.350)	(3.691)	(3.861)	(4.087)
F test	23.721	30.388	28.095	34.108	31.115	31.426
R^2	0.17	0.11	0.12	0.15	-0.02	0.12
Bandwidth	9.82	10.10	11.69	10.55	8.19	12.96
N	10537	10863	12640	11362	5913	14080
Panel B: Men						
Enrolled	0.854**	1.046**	0.889**	20.866**	13.383*	-15.431**
	(0.234)	(0.283)	(0.234)	(6.506)	(5.453)	(4.626)
F test	37.035	35.037	37.035	47.545	84.781	38.909
R^2	-0.18	-0.67	-0.25	-1.09	-0.65	-0.57
Bandwidth	12.06	11.24	12.05	9.95	15.36	10.21
N	13672	12737	13672	11389	11981	11638
Instrument = Entry exam discontinuity						
Panel C: Women						
Enrolled	0.041	-0.170	-0.172	-1.506	-2.631	5.074*
	(0.270)	(0.173)	(0.201)	(2.268)	(3.719)	(2.426)
F test	11.952	12.832	11.707	17.921	16.643	9.249
R^2	0.18	0.12	0.10	0.16	0.05	0.04
Bandwidth	6.81	6.97	6.80	11.44	8.44	6.35
N	14712	15018	14651	22282	11299	13820
Panel D: Men						
Enrolled	0.623*	0.135	0.372	4.602	-6.274+	-5.851
	(0.279)	(0.211)	(0.318)	(3.849)	(3.390)	(3.915)
F test	24.731	24.150	25.903	21.774	22.599	14.807
R^2	-0.03	0.18	0.08	0.13	-0.07	0.04
Bandwidth	6.17	6.17	5.47	5.28	7.10	4.99
N	13962	14007	12624	12237	10560	11634

Notes: As per Table 4. [1] Conditional on having work at least one month.

Table 13: Effect of enrollment in SENA for female applicants to two-year courses on formal labor market outcomes. OLS vs IV estimates for different groups using SISBEN discontinuities as instrument.

	Age		SISBEN area		Met. area		Migration		Migration[1]	
	18-20	21-24	Area 1	Others	Met. area	others	Migrant	Non-migrant	Migrant	Non-migrant
Panel A: Working last semester										
OLS	-0.002	0.005	-0.017	0.012	0.002	0.003	0.010	0.018	0.008	0.009
	(0.020)	(0.019)	(0.025)	(0.027)	(0.018)	(0.037)	(0.024)	(0.013)	(0.025)	(0.018)
IV	-0.199	0.341	-0.629	0.155	-0.113	0.776	0.637	-0.141	0.133	0.100
	(0.919)	(0.643)	(2.295)	(0.425)	(0.641)	(0.576)	(0.661)	(0.562)	(0.441)	(0.701)
IV - OLS	-0.198	0.337	-0.612	0.144	-0.115	0.777	0.628	-0.160	0.126	0.091
	(0.928)	(0.637)	(2.296)	(0.431)	(0.639)	(0.586)	(0.663)	(0.561)	(0.446)	(0.699)
F test	4.94	12.12	1.56	32.59	15.29	6.41	7.92	9.89	19.96	7.11
Bandwidth	11.39	9.85	8.71	8.62	10.35	9.85	10.98	14.08	8.03	12.19
N	5920	5239	4841	4229	9575	1210	4384	9225	1975	9820
Panel B: Longest employment spell										
OLS	-0.799**	-0.574**	-0.612**	-0.776*	-0.656**	-0.447	-0.984**	-0.529**	-0.224	-0.735**
	(0.181)	(0.203)	(0.179)	(0.297)	(0.139)	(0.673)	(0.306)	(0.138)	(0.541)	(0.184)
IV	29.966*	-8.496^{+}	29.090	2.707	9.358^{+}	-0.653	23.837**	-15.767	13.135*	-1.721
	(12.996)	(4.386)	(21.804)	(6.714)	(5.552)	(12.146)	(7.210)	(9.616)	(6.453)	(8.608)
IV - OLS	30.792*	-7.929^{+}	29.705	3.502	10.020^{+}	-0.208	24.876**	-15.250	13.479*	-0.986
	(12.930)	(4.348)	(21.813)	(6.628)	(5.519)	(11.932)	(7.143)	(9.645)	(6.465)	(8.599)
F test	4.94	12.12	1.56	32.59	15.29	6.41	7.92	9.89	19.96	7.11
Bandwidth	11.39	9.85	8.71	8.62	10.35	9.85	10.98	14.08	8.03	12.19
N	3470	3863	3462	2594	6557	613	2804	6258	1187	6766
Panel C: Longest unemployment spell										
OLS	-0.452	-0.270	-0.261	-0.408	-0.386	-0.520	-0.335	-0.576**	-0.250	-0.440^{+}
	(0.366)	(0.257)	(0.371)	(0.375)	(0.266)	(0.454)	(0.362)	(0.179)	(0.393)	(0.223)
IV	-9.785	-5.792	-22.141	-2.281	-9.330	-3.219	-6.331	-2.784	-3.924	-8.903
	(11.330)	(10.045)	(33.152)	(5.242)	(9.537)	(7.965)	(8.458)	(10.124)	(5.679)	(12.880)
IV - OLS	-9.338	-5.530	-21.883	-1.882	-8.951	-2.714	-6.007	-2.209	-3.701	-8.467
	(11.356)	(9.948)	(33.124)	(5.265)	(9.446)	(8.015)	(8.521)	(10.064)	(5.745)	(12.810)
F test	4.94	12.12	1.56	32.59	15.29	6.41	7.92	9.89	19.96	7.11
Bandwidth	11.39	9.85	8.71	8.62	10.35	9.85	10.98	14.08	8.03	12.19
N	5920	5239	4841	4229	9575	1210	4384	9225	1975	9820

Notes: As per Table 8.
[1] Excluding migration within metropolitan areas.

Table 14: Effect of enrollment in SENA for male applicants to two-year courses on formal labor market outcomes. OLS vs IV estimates for different groups using SISBEN discontinuities as instrument.

	Age		SISBEN area		Met. area		Migration		Migration[1]	
	18-20	21-24	Area 1	Others	Met. area	others	Migrant	Non-migrant	Migrant	Non-migrant
Panel A: Working last semester										
OLS	0.050**	0.019	0.030**	0.056**	0.038**	0.081*	0.044**	0.040**	0.054**	0.031**
	(0.010)	(0.014)	(0.008)	(0.011)	(0.007)	(0.029)	(0.011)	(0.012)	(0.015)	(0.007)
IV	2.170**	0.469	4.966+	1.902**	1.513**	-0.433	1.996**	1.491*	2.016*	0.869+
	(0.703)	(0.365)	(2.554)	(0.538)	(0.466)	(5.760)	(0.633)	(0.652)	(0.822)	(0.483)
IV - OLS	2.122**	0.451	4.937+	1.848**	1.476**	-0.514	1.954**	1.452*	1.964*	0.839+
	(0.701)	(0.372)	(2.552)	(0.543)	(0.466)	(5.769)	(0.633)	(0.652)	(0.821)	(0.483)
F test	11.31	12.25	0.26	7.13	25.33	0.03	10.18	2.62	5.01	14.32
Bandwidth	9.89	14.29	8.06	12.64	9.72	11.38	11.97	7.97	11.86	10.21
N	5346	8196	5143	6323	9777	1328	4812	5789	3229	8621
Panel B: Longest employment spell										
OLS	-0.091	-0.520**	-0.030	-0.208	-0.200+	0.111	-0.030	-0.101	-0.358	-0.102
	(0.172)	(0.126)	(0.155)	(0.205)	(0.107)	(0.441)	(0.307)	(0.141)	(0.317)	(0.149)
IV	34.402**	15.791	151.521**	13.529+	21.657**	66.104	16.336+	33.811*	14.676	27.296**
	(5.407)	(11.354)	(58.163)	(7.886)	(6.352)	(158.529)	(9.310)	(16.620)	(17.060)	(9.517)
IV - OLS	34.529**	16.318	151.554**	13.750+	21.878**	65.983	16.387+	33.926*	15.046	27.418**
	(5.391)	(11.395)	(58.226)	(7.872)	(6.374)	(158.532)	(9.180)	(16.680)	(17.010)	(9.558)
F test	11.31	12.25	0.26	7.13	25.33	0.03	10.18	2.62	5.01	14.32
Bandwidth	9.89	14.29	8.06	12.64	9.72	11.38	11.97	7.97	11.86	10.21
N	3202	6362	3803	3945	6937	678	3094	4126	1959	6162
Panel C: Longest unemployment spell										
OLS	-0.797**	-0.350+	-0.682**	-0.951**	-0.768**	-0.886*	-0.889**	-0.849**	-1.066**	-0.656**
	(0.105)	(0.185)	(0.158)	(0.163)	(0.142)	(0.356)	(0.180)	(0.240)	(0.213)	(0.127)
IV	-23.691**	-10.758	-97.152+	-16.146**	-21.418**	32.427	-19.478**	-25.194+	-13.052	-20.268**
	(8.302)	(8.223)	(58.096)	(6.199)	(4.591)	(89.755)	(6.845)	(13.547)	(8.256)	(7.349)
IV - OLS	-22.910**	-10.415	-96.473+	-15.210*	-20.671**	33.314	-18.609**	-24.357+	-11.998	-19.629**
	(8.313)	(8.339)	(58.137)	(6.218)	(4.666)	(89.699)	(6.860)	(13.662)	(8.240)	(7.417)
F test	11.31	12.25	0.26	7.13	25.33	0.03	10.18	2.62	5.01	14.32
Bandwidth	9.89	14.29	8.06	12.64	9.72	11.38	11.97	7.97	11.86	10.21
N	5346	8196	5143	6323	9777	1328	4812	5789	3229	8621

Notes: As per Table 8.
[1] Excluding migration within metropolitan areas.