THE LEARNING AND EARLY LABOR MARKET EFFECTS OF COLLEGE QUALITY: A REGRESSION DISCONTINUITY ANALYSIS

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Abstract

National college *entry* test-scores determine admission to Colombian universities, creating peer and resource quality variation near admission cutoffs. One RD approach utilizes applicant lists for Los Andes University, a top-ranked college. Relative to applicants below the cutoff, those just above score 0.2 standard deviations higher on a national college *exit* test, and are 16% more likely to be employed one year after college, with the strongest effects for low-income applicants. In the second RD approach I infer *entry* test-score cutoffs for 25 nationwide selective universities, generating a range of end-of-college learning effects that I relate to input differences.

KEYWORDS: College Quality, College Learning, Returns to College Quality, Regression Discontinuity.
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Introduction

Despite growing evidence of the economic returns to attending a more selective university, little is known about whether such returns represent true human capital gains or simply the potential signaling value of a selective college´s diploma. [1] This knowledge gap stems from two main difficulties. The first challenge is to uniformly measure end-of-college skills across colleges. The second challenge is to credibly isolate the influence of colleges' student body, financial and faculty resources from individual attributes that also affect outcomes.

This paper's first contribution is to provide evidence on the effect of college quality on students' end-of-college skills, as well as on employment and earnings after college in Colombia. Colombia provides a good setting to empirically examine the human capital returns to college quality because, unlike the U.S. for example, Colombian students in their last year of college take a centrally-graded, standardized, field-specific college *exit* test that allows me to look at impacts on end-of-college skills. Holding other student attributes constant, the *exit* test is a strong predictor of employment and earnings early after college.

Another important appeal of the Colombian setting to examine whether there are skills and labor market returns to college quality is that admission into many selective Colombian universities is determined solely by whether students' standardized college *entry* scores are above an ex-ante unknown cutoff. This single-index admission policy allows me to credibly isolate the effect of college peers and resource quality from students' ability because it creates large exogenous variation in peers and resource quality near admission cutoffs.

[1] In one strand of literature, some evidence suggests positive economic returns to college quality but it is not clear whether returns represent actual skill improvements of the fact that selective colleges are very good at screening applicants who would have done equally well in the absence of such education. See, for example, Hoekstra (forthcoming), Black and Smith (2004), Dale and Krueger (2002), Brewer, Eide and Ehrenberg (1999). A different line of research suggests that, at particular institutions, initial professor quality measures predict students' subsequent course achievement. See, for example, Hoffmann and Oreopoulos (forthcoming) and Carrell and West (2008).

The localness of treatment is a well-known limitation of regression discontinuity (RD) designs. The RD approaches based on identification at the cutoff only yield internally valid local estimates of the combined effect of better peers and resources for marginal admits to selective colleges.[2] In Colombia, however, admission cutoffs vary by college, field and entry cohort so that the estimates at different cutoffs allow me to make stronger statements about the average returns to college quality in this population than would otherwise be possible with a unique cutoff.

Two different RD approaches identify a nationwide range of local effects of better peers and resources on student outcomes. In the first RD approach I use applicant lists for Los Andes University, a top-ranked selective university in Bogotá, and compare *exit* scores, employment and earnings outcomes for applicants just above and below the admission cutoff. In the second RD approach I infer the *entry* test-score cutoffs for 25 nationwide selective universities and compare end-of-college learning based on *exit* test scores for students in the same city and field just above and below the cutoff.

Based on the first RD approach using Los Andes University applicant lists, I find that relative to applicants just below the admission cutoff, those who score just above are exposed to better peers who score on average 0.5 standard deviations higher on the *entry* test. Relative to applicants just below the cutoff, those who score just above also benefit from expenditures per student that are 40% higher.

[2] Recent papers use an RD approach to study the effects of school quality on student outcomes. In the most related paper, Hoekstra (forthcoming) shows that male students above the admission cutoff of a flagship public university in the U.S. earn 20% more five to ten years after graduation relative to those below the cutoff. Pop-Eleches and Urquiola (2008) show that students above selective Romanian high-schools' cutoffs score 0.05 standard deviations higher on a college entry exam. Clark (2008) finds that in the UK, students above high-achieving public secondary schools' cutoffs are more likely to attend college. Jackson (2009) finds that in Trinidad and Tobago students above selective secondary schools' cutoffs are more likely to take and pass a college entry test.

Relative to applicants just below, I find that applicants to Los Andes just above the cutoff score 0.2 standard deviations higher on the *exit* exam. Based on social security records, applicants above the cutoff are also 16% more likely to be formally employed one year after graduation and, as a consequence the employment effect, earn 20% more. These effects should be thought of as intent-to-treat effects local to the population near the cutoff. Using admission status above and below the cutoff as an instrument for attending Los Andes University in a two-stage least squares (TSLS) setup yields treatment-on-treated *exit* scores, employment and earnings local effects that are roughly 60% larger than the reduced-form just above/below cutoff comparison.

Based on the second RD approach where I infer the *entry* test-score cutoffs for 25 nationwide selective universities, I find that the average peer quality difference at the cutoff is 0.4 *entry* test score standard deviations and the average expenditure per student difference is about 20%. In turn, the average intent-to-treat *exit* test-score difference for students in the same city and field just above and below the cutoff is 0.25 standard deviations.

The second contribution of this paper is that, as indicated by results from both RD approaches, students from low socioeconomic (SES) backgrounds benefit the most from attending Colombian universities with better peers and resources in terms of the end-of-college skills measured by the *exit* test. Low-SES students attending universities with better peers and resources graduate with *exit* scores comparable to their high-SES peers, suggesting that college quality 'levels the playing field'. This finding has a potentially important equity implication considering that in today's globalized and technologically changing work environments, above and beyond a college degree, skill levels largely determine an increasingly unequal income distribution (Autor, Katz and Kearney 2008; Murnane and Levy 1996).

Finally, the third contribution of this paper is to disentangle the correlation between peers and *exit* test-scores from the correlation between resources and *exit* test-scores. Separating these two correlations is partially possible given the range of local treatment *exit* test-score effects that I estimate although, in my sample, peers and resource quality measures are highly collinear. I find that peer quality (measured by average college entry tests) and the fraction of full-time faculty relate positively and significantly to *exit* scores. Overall expenditures per student and the fraction of PhD-credentialed faculty are not economically or statistically significantly related to students' *exit* scores.

II. Context: Higher Education in Colombia

1. Access to College, College Hierarchy and Geography

In recent years the gap between secondary and tertiary enrollment in Latin America narrowed considerably. In Colombia the gap has remained constant suggesting, relative to the region, a growing disparity in college access (Figure A.1, appendix A). In 2006, 30% of 18 to 24 year old Colombians were enrolled in college. The 2006 college enrollment rate represents a 50% increase over the rate in 1999.

However, the college-bound share of population in Colombia remains below the Latin American average (44%). Like in the average Latin American country, about sixty percent of 12-17 year old Colombians are enrolled in secondary school, many of which do not graduate from high-school. For every hundred students that finish elementary school in Colombia, forty graduate from high-school; of the forty high-school graduates twenty go on to college and eight finish college. Like in many countries, a larger fraction of low-income Colombian students do not have access to college: 40% of 18 to 24 year olds from the wealthiest income quintiles and 6% from the poorest income are enrolled in college at a point in time.

There are 177 colleges and universities in Colombia, two-thirds (69%) of which are privately owned and operated (Table A.1, appendix A).[3] By law, all private Higher Education Institutions (HEI) are not-for-profit. About 47% percent of college students are enrolled in private institutions, suggesting that private colleges and universities are smaller that public ones. Of all HEI, 36% are technological institutes which are roughly equivalent to two-year colleges in the U.S.

All colleges charge tuition, some at flat rates and others at rates that vary by family income or major. Average college tuition is approximately US$1000/semester, with large differences by ownership (public: US$600/semester; private US$1200). As reference, the average Colombian salary of a recent college graduate is US$5400/year, and Colombian GDP per capita is US$2,200.

The most selective colleges and universities in Colombia (those with the largest applicant pools relative to capacity) have a higher fraction of full time and PhD faculty, greater expenditures per student and higher admission standards (Table A.2, appendix A). Colleges and universities are also geographically concentrated: 73% are located in Colombia's ten largest cities; and 50% are located in Colombia's three largest cities, which concentrate 26% of the Colombian population. Bogotá, the capital city, is home to 31% of all colleges and universities and 16% of the population. About 75% of the college going population attends college in the city of their birth.

[3] In comparison, according to the National Center for Education Statistics (2006), 74% of all 4-year colleges in the U.S are private.

2. The College Admission Process

The college admission process begins with the ICFES test, Colombia's centralized college entrance exam. The test is a compulsory requirement for students intending to enroll in college and serves as the primary college admission criteria (ICFES 1999). Given that college admission policies are mostly determined by the ICFES test, a high ICFES score is the gateway to selective universities and major like engineering.[4]

Each year, approximately 430,000 students (92% of high school graduates) take the ICFES test. The ICFES test is given, and college applications take place twice every year because there are two high school-graduating cohorts (fall and spring). The exam tests multiple subject areas including: math, chemistry, physics, biology, social science, philosophy, and Spanish language and electives including foreign language (English, French or German) and abstract reasoning. All colleges and universities use the ICFES test in the process of selecting applicants. Some use it as their only admission criterion while others also consider personal interviews and/or high school transcripts. Of the 59 selective schools (see Table A.2, appendix A) 25 use only the ICFES test for admission. These 25 universities are the focus of my nationwide analysis. Applications to college and admission cutoffs are major-specific: students apply to a college/major pair.

3. College Exit Exams

In 2003, as part of an initiative to improve quality, transparency and accountability in Colombian higher education, the National Education Ministry introduced a college field-specific exit exam (ECAES) with considerable publicity The ECAES exit test is intended to i) evaluate colleges' performance in different fields of study, and ii) assess senior students' field-specific

[4] The ICFES score is reflective of previous human capital investments and student socio-demographic characteristics. Family income, maternal and paternal education are all positively correlated with ICFES scores.

competencies of senior students. In 2003, 27 fields of study were tested; in 2004 and 2005 43 and 50 fields were tested, respectively (a few fields including political science, anthropology, history and philosophy have never been tested).[5] The exit test is, holding other student attributes constant, a strong predictor of employment and learning outcomes after college (Table B.3, appendix B).

The exam is compulsory and a graduation requirement in a few universities, though not at the majority. Students have other incentives to take the test. A growing number of students list the ECAES score on their resume. Students also report whether they obtained a top score nationally, or their score in comparison to the university or the national average.[6] Some universities use ECAES results in admissions to certain graduate programs.[7] In addition, every year the Colombian President and Education Minister publicly recognize the accomplishments of the best ten nationwide scorers in each field. Anecdotal evidence suggests that the best scorers receive job offers based on public knowledge of their test scores.[8] Finally, the Colombian Student Loan Institute (ICETEX) offers a postgraduate study credit-line exclusively to the best ten nationwide scorers of up to US$ 16,000.[9]

The exit test is not a graduation requirement at many universities but about 82% of graduates in fields with a test take it. Given that taking the exit test is not compulsory, I devote a

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[5] Professional associations and university consortiums write each field's exam. See appendix B for tested fields and economics example questions.
[6] http://www.computrabajo.com.co/em-cvslistado.htm?BqdPalabras=ecaes&BqdComienzo=1&Bqd= (Accessed April 9, 2008.)
[7] Some examples are:
Masters in Physics http://campus.unicesar.edu.co/suefisica/article.php3?id_article=17. (Accessed April 9, 2008.)
Medicine Specializations http://www.unisabana.edu.co/especializaciones/medicina/pediatria/index.html. (Accessed April 9, 2008.)
and http://www.unisinucartagena.edu.co/programas/docpos/reglamentopos.pdf. (Accessed April 9, 2008.)
Masters in Psychology http://www.humanas.unal.edu.co/maestriaps/admisiones.html. (Accessed April 9, 2008.)
PhD in Mechanical Engineering http://www.uninorte.edu.co/eventos/convocatoria_doctorado_mecanica.html. (Accessed April 9, 2008.)
[8] http://www.mineducacion.gov.co/cvn/1665/article-106772.html. (Accessed April 9, 2008.)
[9] http://www.icetex.gov.co/portal/Default.aspx?tabid=410. (Accessed May 28, 2008.)

central part of the empirical analysis looking for evidence of selection into taking the test. I find no such evidence of differential selection into taking the test by college selectivity.

III. Data

The data comes from four different sources. The first source is applicant lists to Los Andes University, a private selective university in Bogota, for 1998-2001 application cohorts (excluding the 1998 second-semester cohort which is not available). I omit from the analysis applicants from the 1999 first-semester cohort because the only way to link applicant records to outcomes is based on names (first last name, second last name, first name, middle name) which are missing from this particular cohort. The applicant lists contain information on applicants' full name, gender, entry score, program applied to and cohort of application, the field/cohort admission cutoff, whether the student was admitted and whether she enrolled. Los Andes sample statistics are shown in Table C.1 of appendix C.

The second data source is administrative records for all students in Colombia taking the exit test in 2004 and 2005. These data contain information on students' exit and entry scores, the field in which they take the exit test, the semester when they take it, the university in which they are enrolled at the time they take the test, and demographic information regarding students' parental education, socioeconomic stratum and the type of high-school from which they graduated (academic or vocational).[10]

The third data source is national administrative records for all Colombian college graduates from 2001 up to the first semester of 2007. These records are maintained by Colombia's Ministry of Education. In addition, for every graduating cohort, the Ministry of Education and

[10] Socioeconomic stratum is a six-category (one lowest, six highest) income proxy based on residential location. Utilities and property taxes, for example, are stratified based on this categorization.

the social security administration internally link graduates' records to administrative social security records on employment and earnings one year out of college.

The fourth data source is La Nota Económica (2006), a yearly Colombian publication that features information about university resources, like ownership, student population, percent of full-time and PhD faculty and expenditures per student. I link university inputs' data to the university students report being enrolled in at the time they take the exit test.

IV. Empirical Strategy

1. Identification

In the returns to college quality literature, researchers typically estimate an equation of the form:

(1) $Y_{ij} = \pi_0 + \pi_1 CollegeQuality_j + \pi_2 X_i + \xi_i$

Where Y_{ij} is the outcome for student *i* attending college *j*, (traditionally log wages), $CollegeQuality_j$ is a vector of college characteristics which might include average SAT score of students attending college *j*, expenditures per student, average faculty salary or tuition, and X_i is a vector of student characteristics, like college entry test and socioeconomic indicators. In general, admissions to selective colleges in the U.S are based on multiple student dimensions, some of which - including SAT scores and high school grades – are observable to researchers, and others of which - such as letters of recommendation, essays and participation in extra-curricular activities -- are never observed by the researcher. To the extent that these characteristics also affect individual outcomes, estimates of π_1 will be biased, most likely upward.

In contrast, admissions to many selective Colombian universities and to Los Andes University in particular are solely determined by whether the ICFES entry test is above the admission cutoff. The cutoff is unknown to students at the time of application and reflects the university's capacity constraints.

I use two RD approaches to identify the local effect of peers and resources on student outcomes. The first approach is based on Los Andes University applicant lists. At Los Andes the admission policy creates sharp discontinuity in the probability of admission as a function of applicants' entry score. Figure I.A illustrates this relationship. I have normalized all field-cohort specific cutoffs to zero so that entry scores are expressed in points from the admission cutoff. For reference, 45 entry score points is about one third of a standard deviation in the entry score distribution of applicants. The few applicants who were admitted with scores slightly below the cutoff applied to programs that were not oversubscribed in the corresponding year, like Philosophy, Anthropology and Biology. At Los Andes, 60% of admitted applicants enroll (Figure I.B).

Relative to applicants who score below the admission cutoff, those just above are exposed to college peers who score on average 0.5 standard deviations higher on the entry test. Those who score just above also benefit from expenditures per student that are 40% higher and from more than twice the fraction of faculty with Ph.D., relative to those just below (Figure II). (These resource measures are based on the college at which they are enrolled at the time they take the exit test). Consequently, as the admission policy at Los Andes illustrates, there is a highly non-linear relationship between students' entry score and the college peers and resources they experience near the admission cutoff. Importantly, since peer quality and resources vary discontinuously near the cutoff, the RD strategy identifies the local combined effect of better college peers and resources for marginal college applicants.

The key identification assumption in regression discontinuity analyses is that at the discontinuity point, all determinants of the outcome vary smoothly. Therefore, one validity test of the research design is to look for discontinuities in covariates at the admission cutoff, which I show graphically in Figure III. There are no differences in any of the observable covariates (i.e. gender percent belonging to top socioeconomic strata, parental education and the type of high-school applicants' graduate from) around the admission cutoff.

A potential violation of the identification assumption is gaming of the cutoff by applicants or their parents. As noted earlier, the cutoffs are unknown to applicants before they apply and reflect capacity constraints, so in theory gaming should not be an issue. To address this concern more formally, I show the smooth kernel density plot of the entry score around the admission cutoff in Figure IV.

2. Estimation

Given the admission policy at Los Andes and the variation in peers and resources it induces near the admission cutoff – *c*- , the average causal effect of peers and resources on outcomes for applicants near the cutoff can be written as follows:

(2) $\lim_{x \downarrow c} \mu(x) - \lim_{x \uparrow c} \mu(x)$

Where $\mu(x) = E[Y_i \mid X_i = x]$ and X is entry score. Equation (2) corresponds to the average causal effect of being admitted to Los Andes, at the admission cutoff c:

(3) $\pi_1^{admit} = E[Y_{i1} - Y_{i0} \mid X_i = c]$

I estimate (3) by fitting linear regression functions at each side of the admission cutoff, to observations within distance *h* of admission cutoff *c* (Imbens and Lemieux 2008). This can be done in a single regression framework by solving:

$$(4)\quad \min_{\pi_0,\pi_1,\pi_2,\pi_3,\Pi} \sum_{i=1}^{N} 1\{-h \le X_i \le h\} \cdot (Y_i - \pi_0 - \pi_1 \cdot A_i - \pi_2 \cdot X_i - \pi_3 \cdot X_i \cdot A_i - \Pi \cdot W_i)^2$$

Where $A_i = 1\{X_i \ge c\}$ and X_i is student *i's* entry score defined as points from the admission cutoffs since these are normalized to zero. Because applications and cutoffs are field and cohort specific, the vector W_i contains a full set of field and cohort fixed effects, as well as a gender indicator. Thus, the reduced form regression is:[11]

$$(4a)\quad Y_i = \pi_0 + \pi_1 A_i + \pi_2 X_i + \pi_3 (X_i \cdot A_i) + \Pi W_i + \varepsilon_i$$

Since not all admitted applicants to Los Andes enroll (Figure I.B), equation (4a) identifies an intent-to-treat effect local to *c*. To recover the average causal effect (at *c*) of attending Los Andes, I scale-up (4a) by the difference in the probability of enrolling, conditional on being admitted:

$$(5)\quad \pi_1^{IV,Wald} = \frac{E[Y_{i1} - Y_{i0} \mid X_i = c]}{P[Enroll_{i1} - Enroll_{i0} \mid X_i = c]}$$

Equation (5) is a standard Wald estimate evaluated at cutoff *c*. With covariates W_i, it is equivalent to an instrumental variable setup where $Enroll_i$ is instrumented with A_i. The first stage and IV regressions are:

$$(5a)\quad Enroll_i = \alpha_0 + \alpha_1 A_i + \alpha_2 X_i + \alpha_3 (X_i \cdot A_i) + \mathrm{A} W_i + \varsigma_i$$

$$(5b)\quad Y_i = \pi_0^{IV} + \pi_1^{IV} \widehat{Enroll}_i + \pi_2^{IV} X_i + \pi_3^{IV} (X_i \cdot A_i) + \Pi^{IV} W_i + \zeta_i$$

[11] In all specifications, standard errors are heteroskedasticity-robust. Lee and Card (2008) argue that when the forcing variable is discrete, standard errors should be clustered, in this case, at the point-level. Such adjustment makes no difference in this context.

An important decision in implementing (4-5b) is the choice of smoothing parameter *h*. In this paper, I follow Imbens and Lemieux (2008) and Chiang (2008) by using a cross-validation approach. Note that the linear regression functions to the left and to the right of *c* estimated by (4) yield estimates of $\lim_{x \uparrow c} \mu(x)$ and $\lim_{x \downarrow c} \mu(x)$. The goal of the cross-validation approach is to find the *h* that minimizes the mean prediction error of these two limits at *c*. Formally, for observations to the left (*L*) and right (*R*) of *c*:

$$h_{cv}^{A} = \arg\min \frac{1}{N^{A}} \sum_{i=1}^{N^{A}} [Y_i - \hat{\mu}(X_i)]^2, A = L, R$$

In practice, I estimate h_{cv}^{L} and h_{cv}^{R} by using only the 50% of observations that are closest to the cutoff on each side. The preferred bandwidth obtained from the cross-validation approach is 45 points. As an additional robustness I check the sensitivity of results to different bandwidth choices. For this reason, in all tables, in addition to the estimates within 45 points of the admission cutoff, I include estimates using bandwidths of 80, 60 and 20 points.

3. Potential Selection into Taking the Exit Test

In my analysis, a key outcome is end-of-college learning, as measured by the college exit test. A reasonable concern about using the exit test to measure end-of-college learning is that taking the test is potentially endogenous. If around the admission cutoff students not taking the test look like missing at random, learning outcomes conditional on taking the test are unbiased. If students admitted to the more selective college are more likely to take the exit test, learning outcomes will be biased. Importantly, this bias concern is not related to graduation, employment and earnings outcomes because they are not conditional on taking the test.

My approach to addressing the issue of potential differential selection into taking the exit test is empirical. I will show that there are no differences in the probability of taking the exit test around the entry score cutoff, for the entire applicant sample and by field of application. I will show for Los Andes University that the entry test-score distribution for admitted applicants who take the exit test is indistinguishable from the entry test-score distribution for the population of admitted applicants. I will further show for Los Andes University that there are no differences in graduation rates and time to degree around the entry score cutoff.

4. Learning-Input Correlations

In the second RD approach I infer admission cutoffs for 25 nationwide selective universities and compare end-of-college learning for students in the same city and field above and below the cutoff. The cutoffs in this approach correspond to the college entry score of the last student among all exit test-takers attending the corresponding selective university in each field and cohort. As before, I normalize all cutoffs to zero.

The only assumptions required in this procedure are (a) the actual cut-score is not dramatically below the one observed, which is plausible as the data is the population of exit test-takers; (b) students with entrance exam scores just below a university's cut-off that might have been interested in attending that university would not have been disqualified from attending for other reasons, which is also plausible.

Figure V shows among all students in the same city as the treatment university the probability of attending each of 25 selective universities (that only use ICFES for admission) near the estimated cutoff. As Figure V shows, there is a discontinuity in the probability of attending each selective school as a function of entry score. As in the Los Andes main approach, these 25 plots correspond to the first stage graphs. Similarly, the reduced form estimates are obtained by comparing end-of-college learning for all students from a city in a field just above and just below the cutoff point. In practice, I estimate the exit score reduced-form effect at the cutoff of each of the 25 selective universities using specification (4a). I relate these 25 reduced-form exit test-score effects to differences in educational inputs (peer quality, expenditures per student, share of faculty with PhD and share full-time faculty) above and below the cutoff of each of the 25 treatment universities.

V. Results at Los Andes Cutoff

1. Selection into Taking the Exit Test at Los Andes

Since the exit test is not a graduation requirement, there might be non-random test-taking selection around the cutoff. To rule out this possibility, I begin by examining four outcomes for Los Andes applicants: i) enrollment for all applicants and for applicants who take the exit test; ii) probability of taking the exit test; iii) graduation, and iv) time to degree.

1.1 Enrollment

The estimates of enrollment at the Los Andes admission cutoff are shown in Table I. Columns (1)-(4) show enrollment estimates for all applicants in the sample at four different bandwidth choices. Columns (5)-(8) report corresponding enrollment estimates for the sample of applicants that take the exit test. In both cases, near the cutoff about 58% of applicants enroll. To the extent that the same unobserved factors that determine endogenous enrollment decisions also affect whether students take the exit test, enrollment estimates for all applicants and for applicants taking the exit test should differ. The estimates in Table I suggest, however, that at any given bandwidth, enrollment at the cutoff is very similar.

1.2 Taking the Exit Test at Los Andes Admission Cutoff

Figure VI, Panel A plots 5-point entry score averages of the probability of an applicant taking the exit test, to the left and right of the admission cutoff with a linear fit on each side. [12] This visual evidence suggests that the probability of taking the exit test is similar on both sides of the admission cutoff. It also suggests that there is no relationship between entry scores and the probability of taking the exit test.

Panel A of Table II shows regression analogs to Panel A of Figure VI using specification (4). Highlighted in grey in column (3) is the preferred cross-validation bandwidth choice of 45 points. The coefficient on *admitted* is small and statistically insignificant, confirming that there is no discontinuity in the probability of taking the test at the admission cutoff. As columns (1)-(2) and (4) of Table II show, this conclusion is robust to different bandwidth choices. Further, I find no difference in the probability of taking the exit test at the admission cutoff by field of application (Table C.3, appendix C).

It is possible that applicants that do and do not take the exit test are different even though there are no differences in the probability of taking the test at each side of the admission cutoff. For this reason in Panel B of Figure VI I show the ICFES entry score distributions for all admitted applicants and for admitted applicants that take the exit test. To the extent that unobserved differences driving the test-taking decision are correlated to student's individual motivation or academic ability, part of which is measured by the ICFES entry test, then the two distributions should look dissimilar. As Figure VI, Panel B suggests, the sample of admitted students taking the exit test looks like drawn at random from the sample of admitted students. Further, a Kolmogorov-Smirnoff test for equality of the distributions cannot reject at

[12] I examine potential selection into taking the exit test at other selective schools when I present nationwide estimates in section VI.

conventional statistical levels the null hypothesis that entry score distributions for admitted students and for admitted students taking the exit test are the same.

1.3 Graduation and Time to Degree at Los Andes Cutoff

Graduation and time to degree results are relevant in their own right because they are important academic outcomes. In the context of this paper, they are important for two additional reasons. The first reason it that they provide additional evidence on potential selection into taking the exit test. The second reason is that due to the nature of the data, all labor market outcomes are conditional on graduation. In this section I show that there are no significant differences in graduation and time to degree around the Los Andes admission cutoff.

Graduates are the applicants matched to the administrative database of all Colombian graduates, which in my data covers the period up to fall of 2006. Figure VI, Panel C shows no difference in graduation probabilities around the admission cutoff.

Regression results in Panel B of Table II, columns (1)-(4) confirm the visual evidence. The graduation effects for applicants above the cutoff are small and insignificant, although consistently negative for all bandwidths, suggesting the possibility that marginal applicants at Los Andes struggle to get through graduation relative to rejected applicants who attend less selective university.[13]

Similarly, Figure VI, Panel D, shows time to degree averages around the Los Andes cutoff. Time to degree is the difference between year finished and cohort year, for graduated applicants. Figure VI, Panel D shows no differences in time to degree around the cutoff. Panel C of Table II

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[13] The 'mismatch' hypothesis argues that marginal admits to a more selective university might be better-off attending a less selective university (Alon and Tienda 2005, Bowen and Bok 2000). Being the least prepared in the more selective university, marginal admits will be poorly matched with its standards, expectations and demands. The negative pattern of graduation effects in columns (1)-(4) of Table II, Panel B provides partial support for the 'mismatch' hypothesis: students just above the admission cutoff are, in fact, slightly less likely to graduate. The support for the 'mismatch' hypothesis is only partial, however, because as I show, conditional on getting to the exit exam students just above the admission cutoff learn more.

shows regression estimates confirming that near the admission cutoff there are no differences in time to degree.

Although none of the separate pieces of evidence – enrollment conditional and unconditional on taking the exit test, probability of taking the exit test at the admission cutoff, entry score distributions for admitted applicants and for admitted applicants taking the test, and graduation and time to degree outcomes – definitely proves that there is no selection into taking the exit test, together they provide consistent evidence of little or no selection into who takes the exit test around the Los Andes admission cutoff.

2. End-of-college Learning at Los Andes Admission Cutoff

I now turn to analyzing the end-of-college learning effects. Figure VII, Panel A shows average exit scores around the admission cutoff with separate linear fits to the left and right of the cutoff. There is a discontinuity in exit score intercepts at the admission cutoff of about 0.2 standard deviations (exit scores are normalized to have mean zero and standard deviation one).[14] As suggested by the regression estimates in Panel A, Table III, columns (1)-(4) the discontinuity in exit score intercepts at the cutoff is statistically significant and robust to different bandwidth choices. Columns (5)-(8) of Table III show the implied exit score effect for enrollees, which is obtained by scaling-up the effect of admission at the cutoff by the probability of enrolling conditional on admission (from Table I) as in equation (5). The implied effect on enrollees is 0.37 standard deviations, substantive considering that mean exit score for applicants below the admission cutoff (given by the constant term, not shown) is 0.45 standard deviations. In percent terms the treatment on treated at the cutoff represents an 82% exit score increase.

[14] The exit exam originally has mean of 100 points and a standard deviation of 10 points in each field. The standardization was done by cohort and field.

Figure VII also shows a discontinuity in the relationship between entry and exit scores at the admission cutoff: the relationship between entry and exit scores is flat to the left of the admission cutoff and fairly steep to the right.[15]

One important robustness check in the RD framework is to test for zero effects where it is *a priori* known that there should be none. Figure VII, Panel B demonstrates this counterfactual test, showing the t-statistic on the *above cutoff* coefficient, when the cutoff is set at *x* points from the true cutoff point. Panel B of Figure VII shows clearly that the t-statistic is maximized at the true cutoff.

3. End-of college learning heterogeneity at Los Andes Cutoff

There is considerable heterogeneity in end-of-college learning effects by SES, as Figure VIII shows. While the end-of-college learning effect for students from low SES background is considerable, there is no effect for high SES students. To the left of the cutoff low SES applicants score about 0.2 standard deviations lower than high SES applicants. To the right of the cutoff, on the other hand, low and high SES applicants have similar exit scores. This big jump suggests that selective universities 'level the playing field': low SES students in selective universities catch-up with their more privileged peers.

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[15] The graphical evidence is confirmed in the regressions in Table III. The coefficient on the interaction term *Admitted*Points* (not shown) suggests a strong and statistically significant positive relationship between entry and exit scores to the right of the admission cutoff and robust to different bandwidth choices. For the interested reader, there are two ways to understand the upward slope to right of the admission cutoff. First, among admitted applicants and among those who enroll, those with higher entry scores are more likely to persist. Formal evidence of this positive relationship between persistence and entry scores is shown in Table C.2 in appendix C. The dependent variable in Table C.2 is an indicator that equals one if an applicant is attending Los Andes at the time she takes the exit test. In panel A of Table C.2, I show the point estimates on entry score points for enrollees. As the coefficient on Points suggests, enrollees with higher scores are significantly more likely to persist at Los Andes until the ninth or tenth semester when they take the exit test. In panel B of Table C.2, I show estimates for admitted students, which suggests that among admitted applicants, the higher scoring ones are more likely to persist at Los Andes.
A second explanation suggested by the positive relationship between entry and exit scores to the right of the admission cutoff is potential complementarity between college resources and student characteristics. More able students, as measured by their entry scores may benefit more from high quality college resources. The estimates at other selective universities provide suggestive evidence in support of this interpretation.

The regression-analog estimates to Figure VIII are shown in Panels B and C of Table III. Panel B shows learning effects for low SES applicants. Low SES applicants above the admission cutoff score 0.33 standard deviations higher than their counterparts below the cutoff (columns (1)-(4)). The implied end-of-college learning effect for low SES applicants who enroll is about 0.6 standard deviations, (columns (5)-(8)). In marked contrast, there are no learning gains from attending a more selective college for high SES applicants (Panel C, Table III).

One consistent explanation with the heterogeneity in learning by SES is that high and low SES students go into different fields of study and some fields are more effective at improving skills than others. Low SES applicants are more likely to apply to engineering programs than high SES ones: 58% of engineering applicants are low SES, whereas 43% of applicants to all other programs are from low SES backgrounds, and the difference is statistically significant.[16] However, there are no end-of-college learning differences by application field (Table C.4, appendix C), suggesting that heterogeneity in learning by SES is not explained by SES differences in fields of application.

Another explanation for the learning heterogeneity by SES shown in Figure VIII is that universities rejected low SES applicants attend are inferior in quality, compared to Los Andes, while universities rejected high SES applicants attend are not. However, differences in average college resources experienced by admitted and rejected applicants by SES are small, as Table C.5, appendix C indicates.

One potentially important difference for low and high SES applicants is that low SES applicants who just missed the Los Andes cutoff are more likely to end-up with low SES peers than high SES applicants who just missed the Los Andes cutoff (Table C.5, appendix C). If students are sensitive not only to their peers' achievement, as indicated by entry test-scores, but

[16] Engineering programs represent more than half of all applicants.

also their peers' social expectations and cultural beliefs, then ending-up with low SES peers matters: low-SES students might either deprive students from a) social connections that are necessary to make the most of a university education or b) social reinforcement for doing well in university.

The access to financial aid might also differentially affect low SES students' academic performance in college. At Los Andes University, financial aid is based on students' GPA, suggesting that low SES students - who are more likely to need financial support through college- might have a higher incentive to study intensely during college.

4. Labor Market Outcomes one Year after Graduation at Los Andes Cutoff

4.1. Employment

Estimates of the probability of having formal employment for all graduated applicants near the admission cutoff are shown in Panel A of Table IV. Applicants above the admission cutoff are 11 percentage points more likely to have formal employment after graduation. At the dependent variable mean of 61% the point estimate indicates that applicants above the cutoff are 18% more likely to be employed after college. These results are most robust at larger bandwidths due to smaller sample sizes at smaller bandwidths that result from conditioning on graduating.

Enrollees' implied formal employment effect ranges from 18 to 20 percentage points depending on bandwidth choice (Columns 5-8 of Table IV). At the employment mean the effect on applicants who enroll corresponds to a 30% increase in the probability of having a formal job.

In Panel B of Table IV I restrict the sample to graduated applicants who took the exit test. In this sub-group, graduates above the admission cutoff are 14 percentage points more likely to have employment. The effect of admission is about 14 percentage points, statistically significant and indistinguishable from the effect for all graduates in Panel A. The similarity between the employment effects for all graduates and for graduates taking the exit test also provides further evidence in support of no selection into taking the exit test.

Conditional on taking the exit test, I break-up employment effects by SES.[17] At larger bandwidths (columns 1-2), employment effects at the admission cutoff are similar for low and high SES students. Employment effects are strongest for low SES students at smaller bandwidths although in most cases the effects for these two groups are statistically indistinguishable. At the preferred bandwidth of 45 points, low SES students above the admission cutoff are 21 percentage points more likely to have formal employment with an implied effect for enrollees of 41 percentage points. The effect on enrollees translates into a statistically significant 67% employment effect at the mean. For high SES applicants the 10 percentage point effect of admission is smaller and is statistically insignificant (Panel D).

The estimates from Table VIII suggest that admittance to and enrollment in Los Andes positively affect labor force participation early in students' professional career. However, if early employment is displacing post-graduate study the long-term benefit of these initial employment effects is ambiguous.

One way to benchmark the employment effects is by using census data. Based on the Colombian 2005[18] census 60% of college graduates aged 24 to report working, a proportion consistent with the fraction of applicants working in the Los Andes sample. About 18% of graduates report being in school, and 14% reports being unemployed or inactive (see Table C.6, appendix C). Given the census-based evidence, it seems unlikely that the near 40% of Los Andes

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[17] SES is only observed for applicants taking the exit test.

[18] Available from IPUMS international, Minnesota Population Center, https://international.ipums.org/international/, cited September 5, 2008.

graduates who do not work are all unemployed. It is therefore likely than many graduates who are not working among Los Andes applicants are attending graduate school. Since applicants above the Los Andes admission cutoff are more likely to be employed it is possible that they are less likely to enroll in graduate school. An early employment effect in this context is not necessarily a positive outcome.

For this reason I examine postgraduate degree completion. Using the national registry of graduates 2001-2006 I test the hypothesis that graduates from Los Andes are less likely to complete postgraduate study relative to graduates from other universities in Bogotá (where Los Andes and universities rejected applicants attend are located). I test postgraduate degree completion two, three, four and five year after college graduation by comparing raw probabilities of postgraduate degree completion across schools (i.e. not in RD framework).[19]

Table C.7 of appendix C shows (unconditional) postgraduate degree completion probabilities within two, three, four and five years of obtaining a bachelors degree using three alternative comparison groups. Regardless of the comparison group and time span, Los Andes graduates are more likely than graduates from other universities to complete postgraduate study.

The stated evidence on postgraduate degree completion underscores the positive nature of the employment effects reported in Table IV because it suggests that Los Andes graduates are more likely to find employment after graduation but not at the expense of additional formal education.

[19] For postgraduate degree completion two years after graduation I focus on the 2004 college graduates cohort and examine the probability that they complete any postgraduate degree up to 2006, the last year of records available. For degree completion three years after graduation I focus on the 2003 cohort and examine postgraduate completion in the years up to 2006. For degree completion four and five years after graduation I focus on the 2002 and 2001 cohorts, respectively.

4.2 Earnings

Earnings at the start of workers' careers are noisy measures of long-run earnings. Haider and Solon (2006) show young workers' current earnings drastically understate lifetime earnings. With this caveat in mind Figure IX and Table V show graphically and in regression framework unconditional yearly earnings effects of admission to a more selective college.

Figure IX suggests that applicants above the Los Andes cutoff have higher unconditional earnings one year after graduation. Panel A of Table V confirms the visual evidence: applicants above the admission cutoff earn 20% (2.5/12.3) more than applicants below the cutoff. At larger bandwidths (60 and 80 points) the effect is even larger. The implied earnings effect at the preferred bandwidth for applicants who enroll is 35% (4.3/12.3).[20]

Though applicants' position in relation to the cutoff affects their probability of employment, in Panel B of Table XI I show effects for yearly earnings conditional on employment. Conditional on employment, there are no significant earnings differences for applicants above and below the cutoff, suggesting that most of the earnings effect one year after graduation is driven by employment differences.

VI. Nationwide End of College Learning Effects of Attending a Selective University

1. End-of-college learning effects at 25 selective universities

So far I have focused on results from applicants to Los Andes University. In this section I present end-of-college learning results from the second RD approach in which I infer admission

[20] Hoekstra (forthcoming) reports a 20% earnings premium of attending a flagship state university in the U.S. using a similar RD design. However, it is hard to directly compare Hoekstra's estimate with mine. Hoekstra does not observe peer and resource characteristics of the universities that applicants rejected to the flagship attend. It is therefore difficult to scale his and my estimates by a comparable quality metric.

cutoffs for 25 nationwide selective universities and compare end-of-college learning for students in the same city and field above and below the cutoff.

End-of-college learning, as noted, is conditional on students taking the exit test, which is potentially affected by the university students attend. Without applicant information, I cannot test for selection into taking the test as I could with the Los Andes case. Instead, for each university I construct the probability of taking the exit exam as the number of exam takers in each exit exam cohort (2004, 2005) divided by the number of first year students in 2002 - the earliest year these data are available. I then compare university-level test-taking rates for more and less selective colleges. The results in Table D.1 show no evidence in support of differential test-taking rates across more and less selective universities.

End-of-college learning effects for the 25 selective universities are shown in Figure X. These comparisons are for students in the same city and field as those in the treatment university. The different plots show discontinuities in exit scores near many universities' cutoffs. In addition, like in the Los Andes case the slope of the relationship between entry and exit scores changes at the discontinuity too, suggesting a potential complementarity between college inputs and student ability.

A convenient way to summarize the 25 reduced-form effects is by showing the distribution, which I do in Figure XI.A. The mean effect is 0.24 standard deviations, with a standard deviation of 0.23. Figure XI.B shows the precision distribution of these reduced-form estimates. The median t-statistic is 1.71, suggesting that more than half are statistically significant at the 10% level. One way to scale these effects is by relating them to differences in peer quality and resources at the cutoffs, under the caveat that learning effects cannot be causally attributed to any one of the academic inputs. The average peer quality difference at the cutoff in the 25-university approach is 0.4 *entry* test standard deviations and the average expenditure per student difference is about 20%. Therefore, taking peer quality as denominator, a one standard deviation increase in peer quality translates into a 0.6 standard deviation exit score gain. This magnitude is roughly comparable to the end-of-college learning effect associated with a one standard deviation improvement in peer quality at the Los Andes cutoff. In the 25-university approach, the estimated average change in the probability of attendance at the cutoff (Figure V) is 40%. Therefore, scaling-up each exit-score effect by the change in the probability of attending each treatment university in a two-stage least squares (TSLS) setup yields *exit* score effects that are roughly 2.5 times larger than the reduced-form just above/below cutoff comparison.

Like in the case of Los Andes, the academic benefit for low SES students of attending other selective universities across Colombia tends to be higher than for high SES applicants. As I show in Figure D.1 appendix D, the end-of-college learning effects' distribution for low SES students has a higher mean (and also less dispersion) than the one for high SES students.

2. Learning-inputs correlations

The next question I consider is whether the distribution of end-of-college learning effects is related to average input differences above and below each of the 25 treatment universities' cutoffs. This correlational analysis does not necessarily identify causal effects since peers and academic resources and not randomly distributed. Figure XII shows each end-of-college learning reduced-form effect plotted against the corresponding resource difference above and below the cutoff, where resources are peer quality (mean standardized entry score), natural log of expenditures per student, fraction of PhD faculty and the fraction of full-time faculty.[21] Two

[21] Mean change in peer quality is observed for all 25 cutoffs. Mean change in fraction PhD faculty and in fraction full-time faculty is observed for 20 cutoffs as data on resources for some lower quality universities that students below the cutoff in small municipalities attend are not available. Mean change in log expenditures per student is observed for 18 cutoffs for the same reason.

different bivariate regression lines are plotted in each panel: the dashed line, representing the correlation as if all exit-score effects where equally precisely estimated, and the solid line which weighs each exit-score effect by the corresponding precision with which it is estimated. The slope and heteroskedasticity-robust standard error in each panel refer to the precision-weighted bivariate regression coefficient of exit-score treatment effects on the corresponding input difference. Weighting by precision, as each panel of Figure XII shows, is of little practical importance.

As Figure XII shows, exit-score effects are positively and statistically significantly related to differences in peer quality and fraction of full-time faculty. The bivariate correlation between exit-score treatment effects and peer quality difference suggests that a one-standard deviation increase in peer quality as measured by college entry tests is associated with a 0.7 standard deviation exit-score effect. Similarly, the bivariate correlation between exit-score effects and the difference in fraction full-time faculty suggests that a ten percentage point increase in the difference in fraction full-time faculty (roughly doubling the change in full-time faculty at the mean cutoff) is associated with a 4% of a standard deviation increase in exit scores. The correlations between exit score effects and peer quality, and exit score effects and full-time faculty suggest that the quality of the student body and the availability of faculty for consultation and advice outside class time are both associated with improved end-of-college skills.

As Figure XII also shows, there is no statistical relationship between exit score treatment effects at the cutoff and the change in fraction of PhD faculty at the cutoff or the change in expenditures per student. The lack of correlation between exit score treatment effects and differences in expenditures per student possibly reflects the fact that I only observe total university expenditures per student. Total expenditures include instructional spending (i.e.

teacher salaries), research spending, operational outlays and investment. The universities with the highest total expenditures, like the outlier in the bottom-right panel of Figure XII, are research universities. Total expenditures might therefore not accurately reflect spending that is directly associated with student learning. At the same time, the lack of correlation between exit score effects and overall expenditures per student casts doubt on the potential role of across-the-board resource investments in improving college students' learning.

VII. Conclusion

There is rising concern in the U.S. and in many developing countries regarding the level of skills with which many recent graduates are entering the labor force. This concern is grounded on the role that skills play in the creation and distribution of wealth in today's globalized and technologically-oriented work environments. The first of this paper's contributions is to present evidence that college peers and resource quality significantly and practically affect the skills with which graduates enter the labor force, as well as their employment perspectives and earnings after college in Colombia.

To measure end-of-college learning I use a standardized field-specific college *exit* test that is a strong predictor of employment and earnings after college. To isolate the effect of peers and resource quality from students' ability, I exploit the fact admission into many selective Colombian universities is determined solely by whether students' standardized college *entry* scores are above an ex-ante unknown cutoff, which creates large exogenous variation in peers and resource quality near admission cutoffs.

The second contribution of this paper is to suggest that college peers and resource quality 'level the playing field'. As the results indicate, students from low socioeconomic (SES) backgrounds benefit the most from attending Colombian universities with better peers and resources in terms of the end-of-college skills measured by the *exit* test. Low-SES students attending universities with better peers and resources graduate with *exit* scores comparable to their high-SES peers. This finding has a potentially important equity implication considering the role of that skills play in determining the distribution of income.

The third contribution of this paper is to disentangle the correlation between peers and *exit* test-scores from the correlation between resources and *exit* test-scores. Separating these two correlations is possible given the range of local treatment *exit* test-score effects I estimate. Peer quality and the fraction of full-time faculty relate positively and significantly to *exit* scores while overall expenditures per student and the fraction of PhD-credentialed faculty do not.

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Table I
Enrollment at Los Andes Admission Cutoff

Dependent Variable is Enroll	All Applicants Bandwidth (Points)				Applicants Taking Exit Test Bandwidth (Points)			
	80	60	45	20	80	60	45	20
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Admitted	0.569	0.573	0.585	0.573	0.576	0.584	0.591	0.575
	[0.013]	[0.013]	[0.015]	[0.021]	[0.028]	[0.026]	[0.030]	[0.041]
Admitted*Points (x100)	0.057	0.089	0.008	0.001	-0.144	-0.113	-0.070	-0.025
	[0.046]	[0.050]	[0.065]	[0.002]	[0.106]	[0.106]	[0.136]	[0.353]
Points (x100)	-0.055	-0.073	-0.065	-0.020	0.092	0.084	0.042	0.101
	[0.026]	[0.026]	[0.033]	[0.052]	[0.072]	[0.062]	[0.082]	[0.141]
Observations	6419	5946	5161	2802	1766	1645	1426	768
R-squared	0.21	0.21	0.21	0.27	0.21	0.21	0.22	0.31

Notes: Robust standard errors in parentheses. The dependent variable equals one if applicant enrolls. The variable Points is the difference between students score and the program-cohort cutoff to which he applied, since cutoffs are normalized to zero. Each column is a separate linear probability regression for applicants within the specified bandwidth at each side of the admission cutoff. In addition to the reported coefficients, all regressions include a gender indicator, program applied and cohort fixed effects.

Table II
Probability of Taking the Exit Test, Graduation and Time to Degree at Los Andes Admission Cutoff

	Bandwidth (Points) Reduced Form			
	80	60	45	20
	(1)	(2)	(3)	(4)
A. Applicant Took Exit Test (Mean=0.30)				
Admitted	-0.004	0.012	0.007	0.022
	[0.022]	[0.024]	[0.028]	[0.038]
Observations	6419	5946	5161	2802
R-squared	0.12	0.12	0.11	0.09
B. Applicant Graduated (Mean=0.32)				
Admitted	-0.041	-0.039	-0.030	-0.033
	[0.023]	[0.025]	[0.029]	[0.040]
Observations	6355	5885	5113	2774
R-squared	0.06	0.06	0.05	0.05
C. Time to Degree if Graduated (Mean=5.9)				
Admitted	-0.031	0.030	0.014	-0.076
	[0.083]	[0.081]	[0.090]	[0.129]
Observations	2061	1931	1673	890
R-squared	0.48	0.49	0.49	0.44

Notes: Robust standard errors in parentheses. In Panel A the dependent variable equals one for applicants who take the exit test. In Panel B the dependent variable is an indicator that equals one for applicants who are matched to administrative records of all Colombian graduates up to the fall of 2006. Sample in Panels A and B is applicants to Los Andes with entry scores within corresponding bandwidth from admission cutoff, which is normalized to zero. In Panel C the dependent variable is the difference between year applicants finished college minus the entry cohort year, and sample is restricted to graduates only. Admitted equals one if applicants' entry score is greater or equal than the admission cutoff for the corresponding program applied and cohort. Each column is a separate regression for applicants within the specified bandwidth at each side of the admission cutoff. In addition to the reported coefficients, all regressions include: points from the cutoff, and interaction of points with admitted, a gender indicator, program applied and cohort fixed effects.

Table III
End-of-college learning at Los Andes Admission Cutoff

Dependent Variable is Exit Score								
	Reduced Form Bandwidth (Points)				TSLS Bandwidth (Points)			
	80	60	45	20	80	60	45	20
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. All								
Admitted	0.215	0.226	0.216	0.206				
	[0.084]	[0.091]	[0.098]	[0.128]				
Enrolled					0.373	0.388	0.366	0.359
					[0.146]	[0.157]	[0.166]	[0.224]
Observations	1766	1645	1426	768	1766	1645	1426	768
B. Bottom Strata								
Admitted	0.266	0.335	0.316	0.384				
	[0.113]	[0.121]	[0.135]	[0.183]				
Enrolled					0.493	0.593	0.561	0.650
					[0.206]	[0.216]	[0.241]	[0.311]
Observations	986	929	813	441	986	929	813	441
C. Top Strata								
Admitted	0.094	0.064	0.008	-0.053				
	[0.125]	[0.136]	[0.135]	[0.168]				
Enrolled					0.148	0.103	0.013	-0.100
					[0.197]	[0.220]	[0.212]	[0.317]
Observations	780	716	613	327	780	716	613	327

Notes: Robust standard errors in parentheses. The dependent variable is standardized exit score, with mean zero and standard deviation one. Admitted equals one if applicants' entry score is greater or equal than the admission cutoff for the corresponding program applied and cohort. The variable Points is the difference between students score and the program-cohort cutoff to which he applied, since cutoffs are normalized to zero. Each column is a separate regression for applicants within the specified bandwidth at each side of the admission cutoff. In addition to the reported coefficients, all regressions include: points from the cutoff, and interaction of points with admitted, a gender indicator, program applied and cohort fixed effects. In columns 5-8 Enrolled is instrumented with Admitted; the corresponding first stages are reported in columns 5-8 of Table III. Bottom strata equals one if socioeconomic stratum, observed only for applicants taking the exit test equals one, two, three or four. Top strata equals one is socioeconomic stratum equals five or six, the two highest.

Table IV
Probability of Employment One Year After Graduation at Los Andes Cutoff

Outcome is Has Formal Employment one Year after Graduation (Mean=0.61)								
	Reduced Form Bandwidth (Points)				TSLS Bandwidth (Points)			
	80	60	45	20	80	60	45	20
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. All Graduates								
Admitted	0.132	0.113	0.112	0.046				
	[0.045]	[0.048]	[0.053]	[0.071]				
Enrolled					0.231	0.200	0.193	0.083
					[0.078]	[0.085]	[0.092]	[0.128]
Observations	2061	1931	1673	890	2061	1931	1673	890
B. Graduates Taking Exit Test								
Admitted	0.167	0.137	0.140	0.106				
	[0.058]	[0.062]	[0.069]	[0.096]				
Enrolled					0.304	0.251	0.245	0.181
					[0.107]	[0.114]	[0.121]	[0.163]
Observations	1211	1134	982	518	1211	1134	982	518
C. Bottom Strata								
Admitted	0.166	0.154	0.214	0.224				
	[0.074]	[0.080]	[0.090]	[0.125]				
Enrolled					0.331	0.301	0.412	0.353
					[0.151]	[0.159]	[0.178]	[0.202]
Observations	660	620	538	286	660	620	538	286
D. Top Strata								
Admitted	0.186	0.132	0.085	-0.069				
	[0.097]	[0.099]	[0.106]	[0.161]				
Enrolled					0.303	0.220	0.134	-0.132
					[0.157]	[0.164]	[0.165]	[0.314]
Observations	551	514	444	232	551	514	444	232

Notes: Robust standard errors in parentheses. The dependent variable equals one for graduates who report to social security, as dependent or independent workers. Panel B reports results conditional for graduates who took the exit test in 2004 or 2005. Panel C and D report results by socioeconomic strata, see notes to Table VII. Each coefficient is a separate regression for applicants within the specified bandwidth at each side of the admission cutoff. In columns (5)-(8) enrolled is instrumented with admitted. In addition to the reported coefficients, all regressions include: points from the cutoff, and interaction of points with admitted, a gender indicator, program applied and cohort fixed effects.

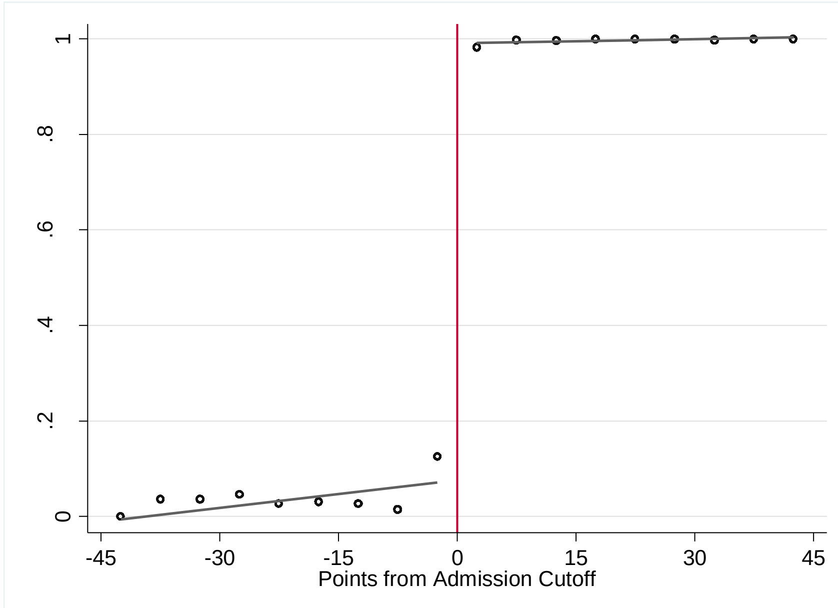
Table V
Earnings One Year After Graduation at Los Andes Cutoff

Yearly Earnings one Year after Graduation (millions of $col)								
	Reduced Form Bandwidth (Points)				TSLS Bandwidth (Points)			
	80	60	45	20	80	60	45	20
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Unconditional on Employment (Mean=12.3)								
Admitted	4.331	2.99	2.482	0.472				
	[1.514]	[1.481]	[1.634]	[2.236]				
Enrolled					7.589	5.273	4.287	0.856
					[2.667]	[2.616]	[2.826]	[4.051]
Observations	2061	1931	1673	890	2061	1931	1673	890
R-squared	0.12	0.13	0.13	0.13	0.1	0.12	0.13	0.13
B. Conditional on Employment (Mean=20.1)								
Admitted	2.852	0.299	0.014	-1.58				
	[2.420]	[2.260]	[2.507]	[3.402]				
Enrolled					4.955	0.514	0.022	-2.551
					[4.223]	[3.886]	[4.124]	[5.495]
Observations	1258	1196	1030	529	1258	1196	1030	529
R-squared	0.12	0.13	0.13	0.13	0.11	0.13	0.13	0.12

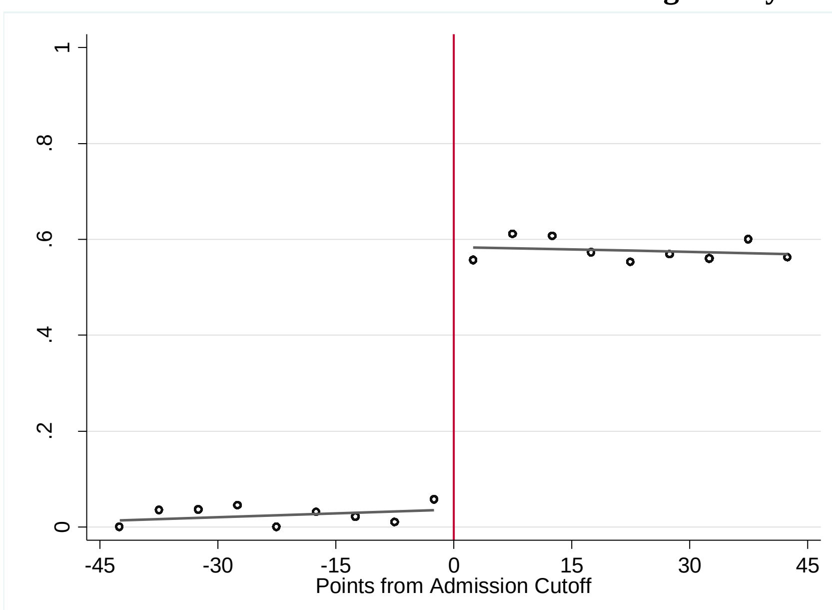
Notes: Robust standard errors in parentheses. In Panel A the dependent variable is reported yearly earnings in million of Col$ for graduates who report to social security and zero for graduates not reporting earnings to social security (Exchange rate is roughly Col$ 2000 per US$). In Panel B sample is restricted to graduates reporting to social security. Each coefficient is a separate regression for applicants within the specified bandwidth at each side of the admission cutoff. In columns (5)-(8) enrolled is instrumented with admitted. In addition to the reported coefficients, all regressions include: points from the cutoff, and interaction of points with admitted, a gender indicator, program applied and cohort fixed effects.

Figure I

A. Admission to Los Andes as a Function of College Entry Score

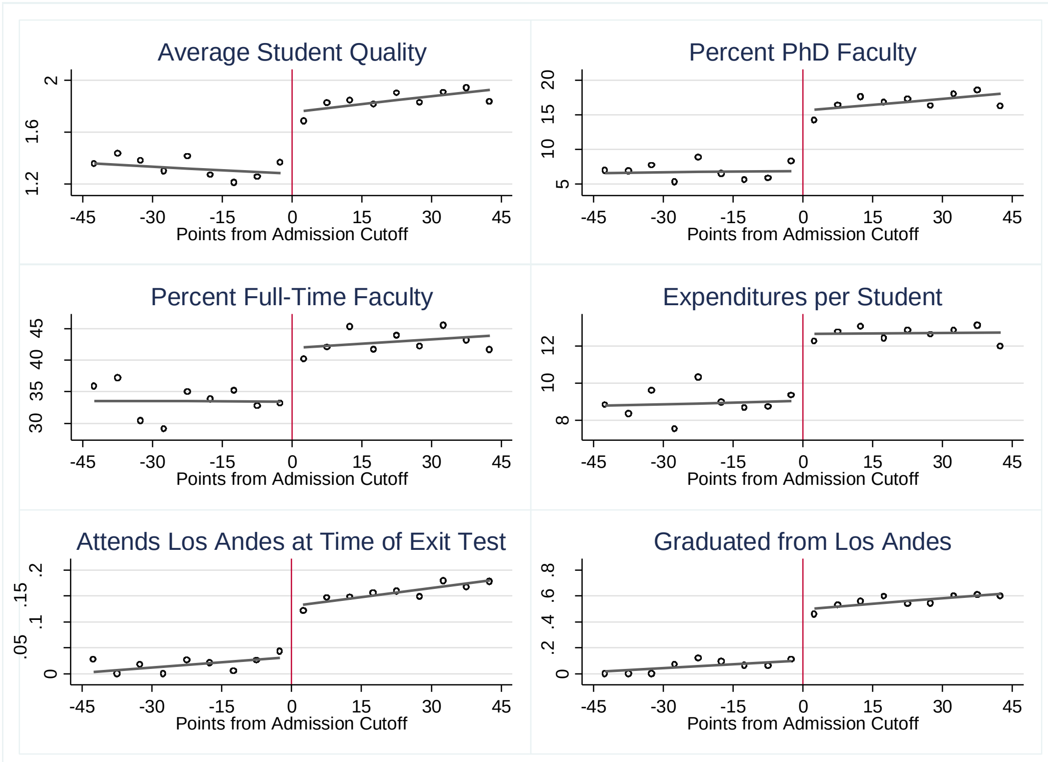


B. Enrollment at Los Andes as a Function of College Entry Score



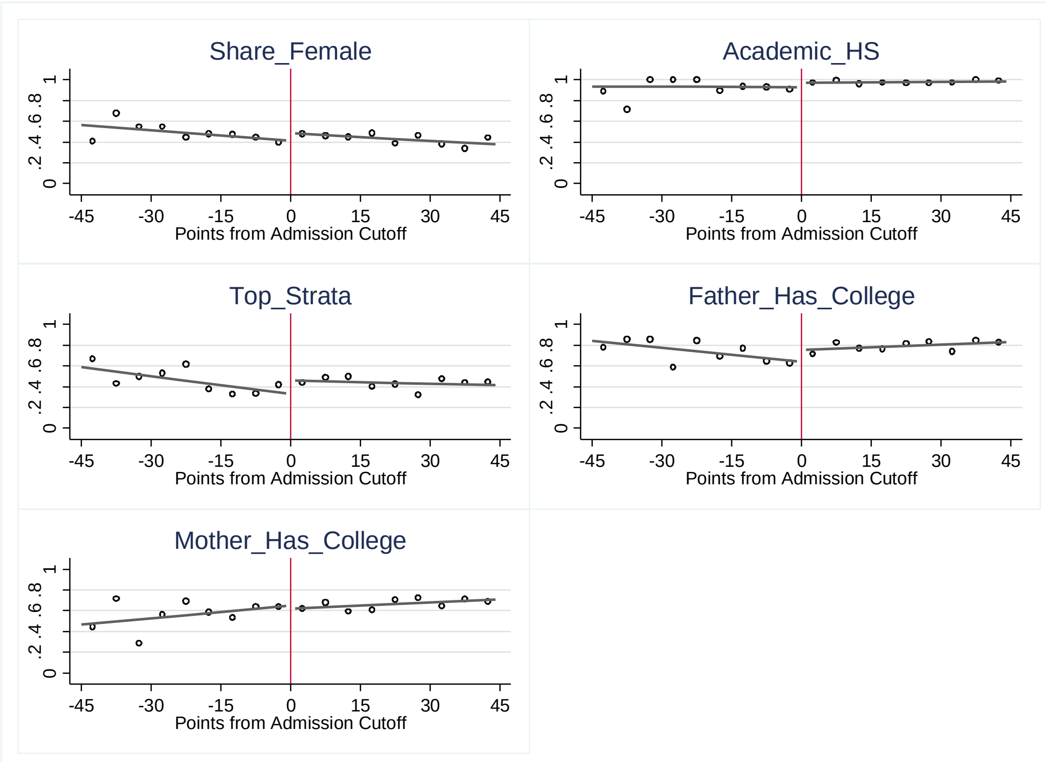
Notes: Figure I.A plots applicants' admission status to Los Andes as a function of entry score in five-point entry score bins. Figure I.B plots the probability of enrolling as a function of entry score in five-point entry score bins. Cutoffs are cohort-field specific and normalized to zero so that entry scores are expressed in terms of points from the cutoff. 45 points corresponds to one third of a standard deviation of the point distribution of applicants.

Figure II
Variation in Peers and Resources at Los Andes Admission Cutoff



Notes: This figure plots five-point averages of college inputs and a linear fit at each side of the Los Andes admission cutoff. College inputs correspond to inputs at the college applicants attend at the time they take the exit test. Average student quality is measured in standard deviations of the college entry test. Expenditures per student are measured in Col$ millions.

Figure III
Covariates at Los Andes Admission Cutoff



Notes: five-point averages and local linear fits around the Los Andes admission cutoff of covariates observed for applicants taking the exit test.

Figure IV
Entry Score Distribution Around Los Andes Cutoff

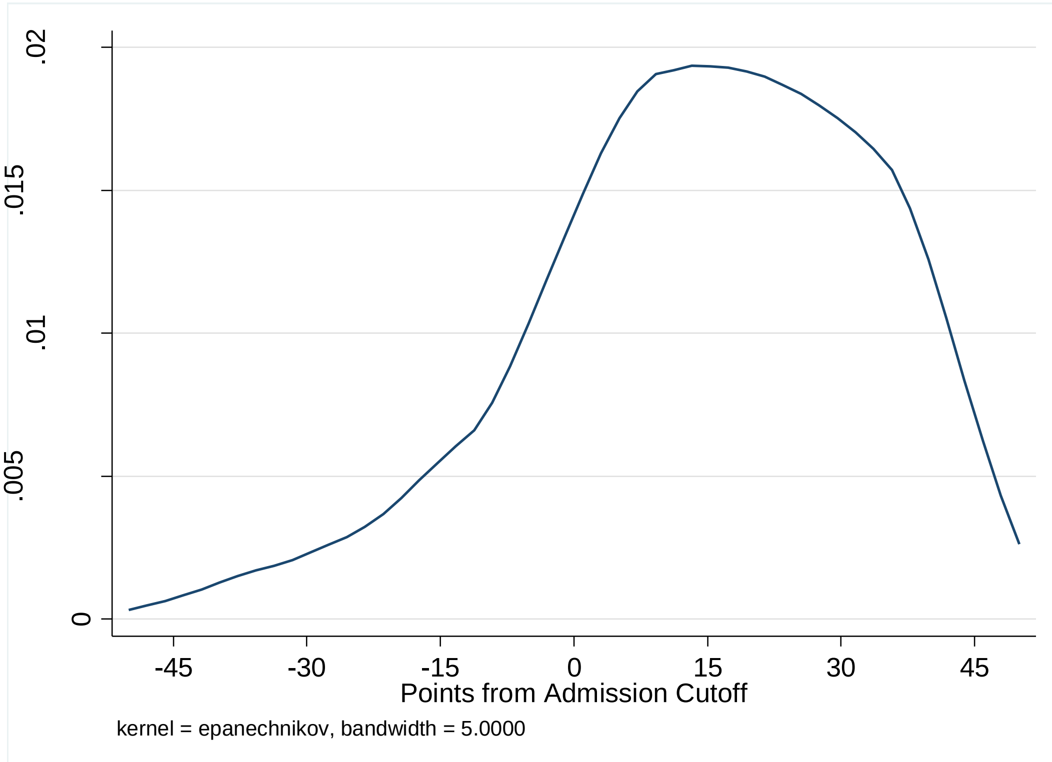
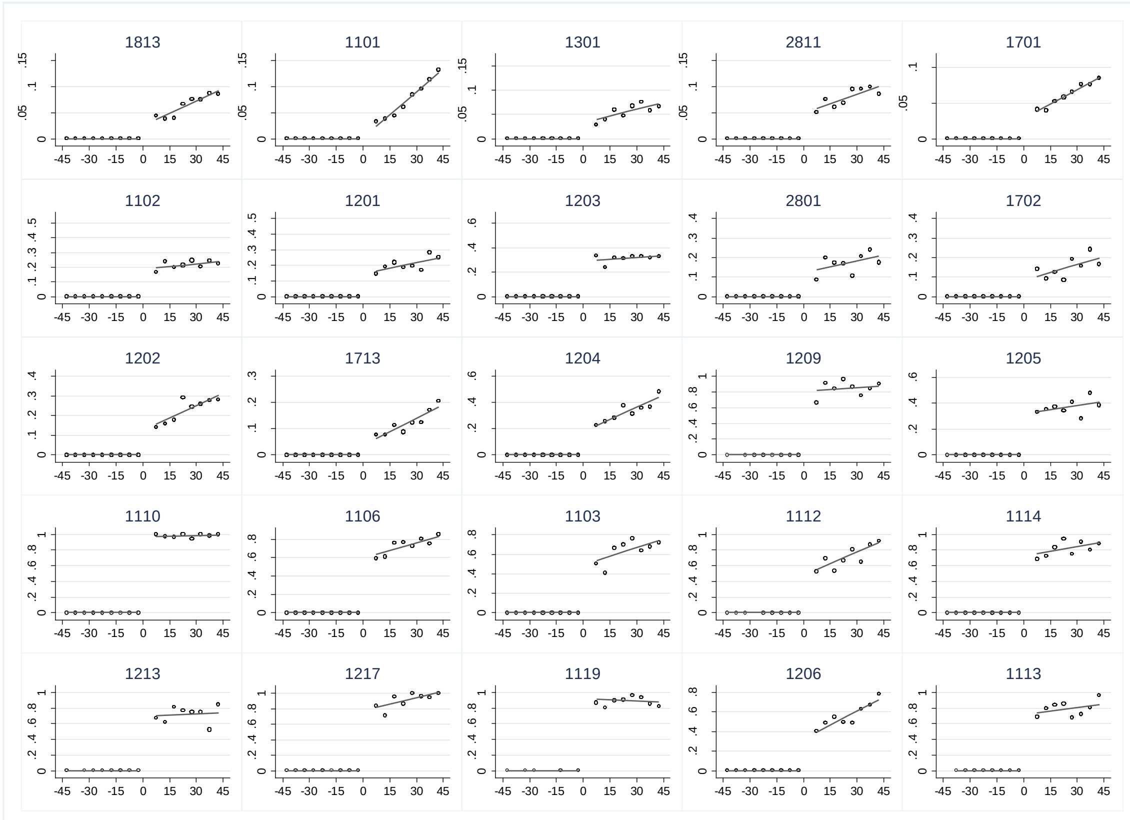


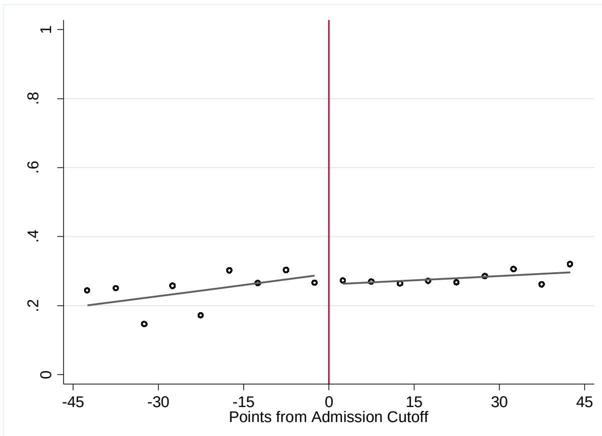
Figure V
First Stage Plots for 25 Nationwide Selective Universities



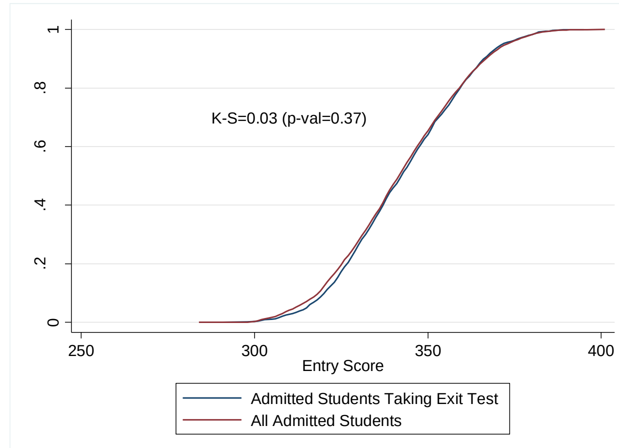
Notes: Each figure shows the probability of being above a selective university's admission cutoff as a function of entry test-scores.

Figure VI
Probability of Taking Exit Test, Composition of Test-Takers, Graduation and Time to Degree at Los Andes Admission Cutoff

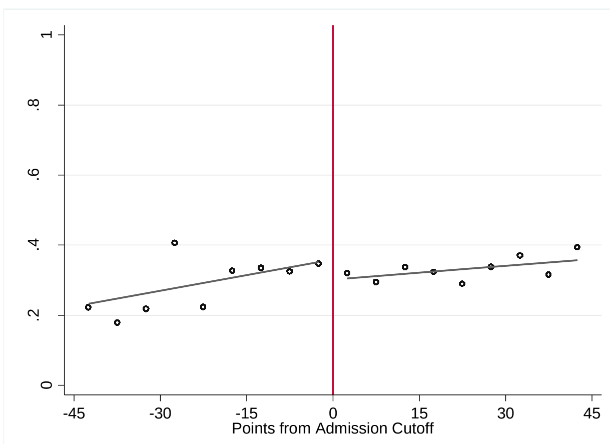
A.



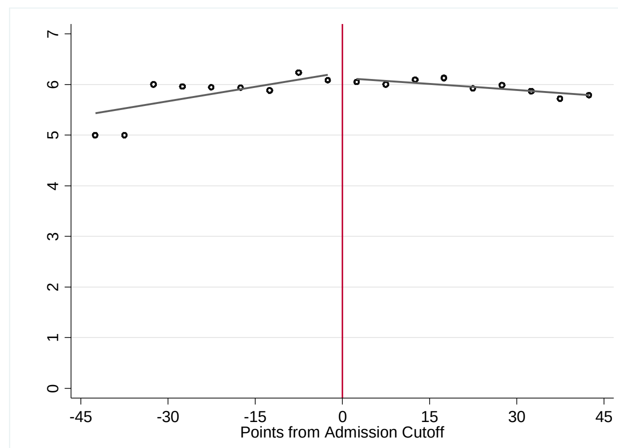
B.



C.

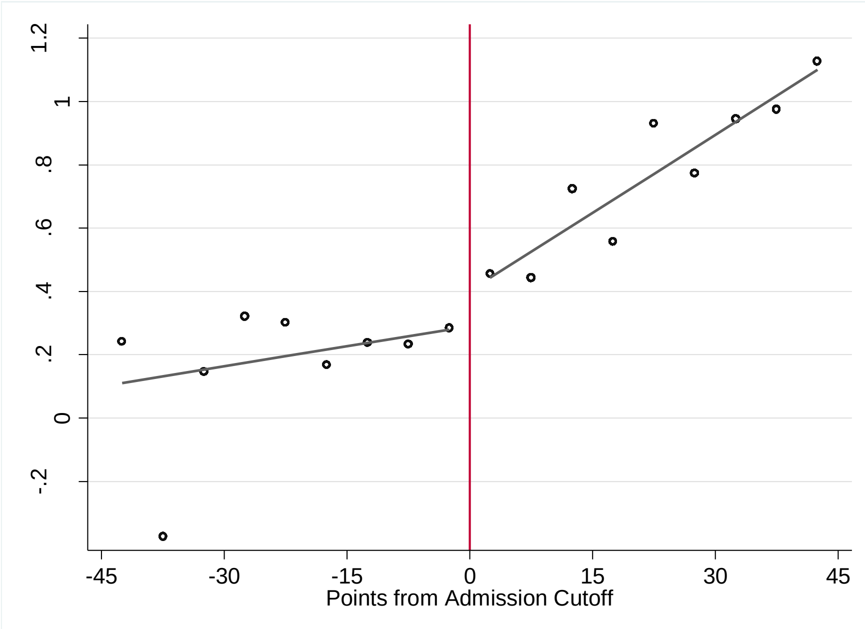


D.

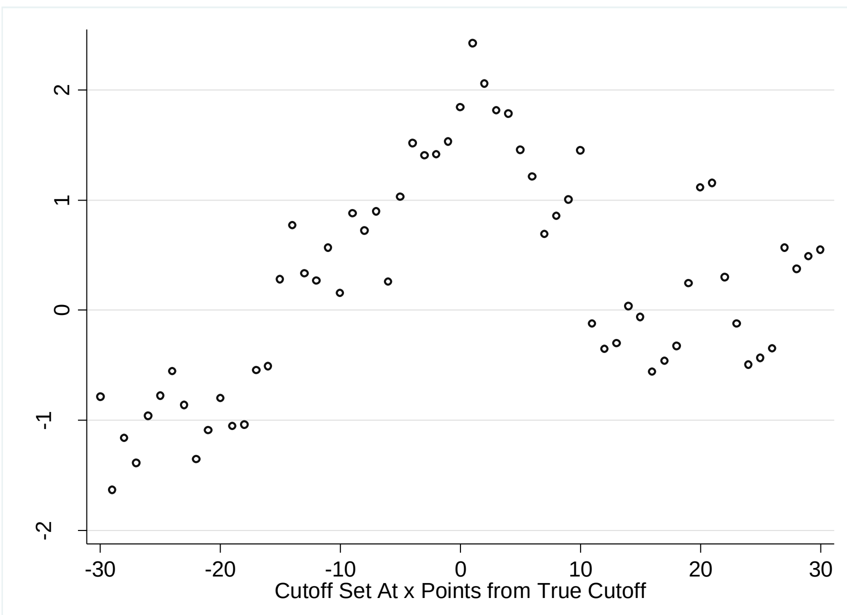


Notes: Panels A, C and D show five-point averages and local linear fits for the corresponding outcome around the Los Andes admission cutoff. Panel B shows cumulative entry score distributions.

Figure VII
End-of-College Learning at Los Andes Admission Cutoff
A. Learning Effects

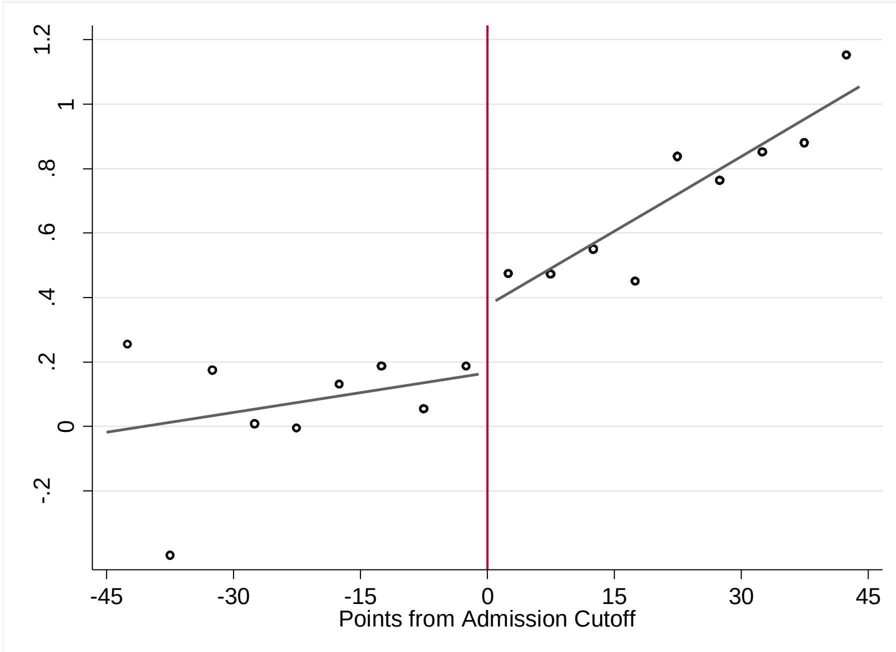


B. t-statistic of Learning Effects as a Function of Different Fake Cutoffs

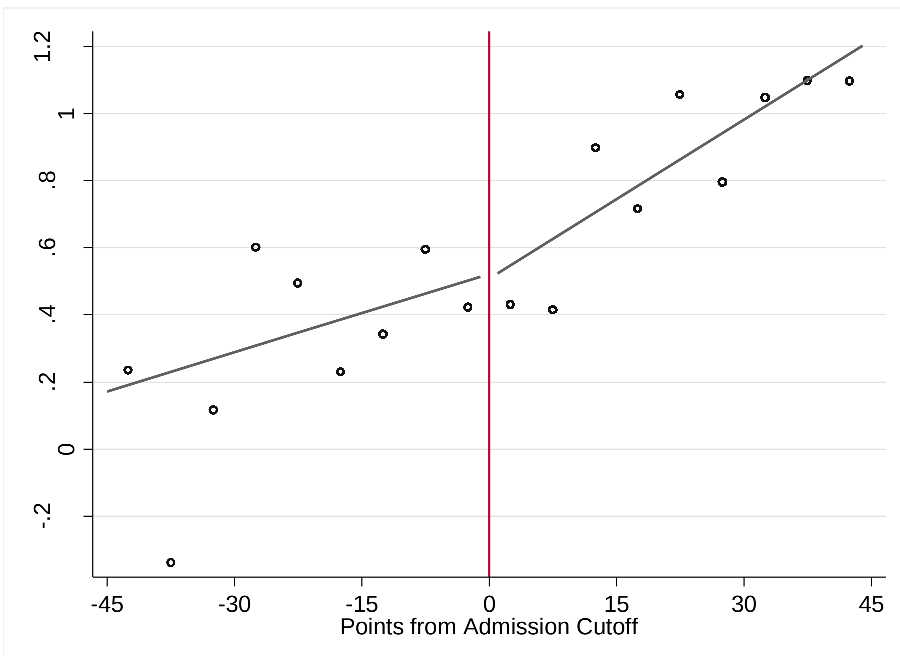


Notes: Outcome is standardized exit score. Panel A plot five-point averages and local linear fits around the Los Andes admission cutoff. Panel B plots t-statistic of above cutoff dummy when cutoff is set at different fake cutoff values from the true cutoff at Los Andes. Cutoff equals zero is actual cutoff. Bandwidth is 45 points. Regression also includes: points from the cutoff, and interaction of points with admitted, a gender indicator, program applied and cohort fixed effects.

Figure VIII
End-of-college learning at Los Andes by SES
A. Low SES

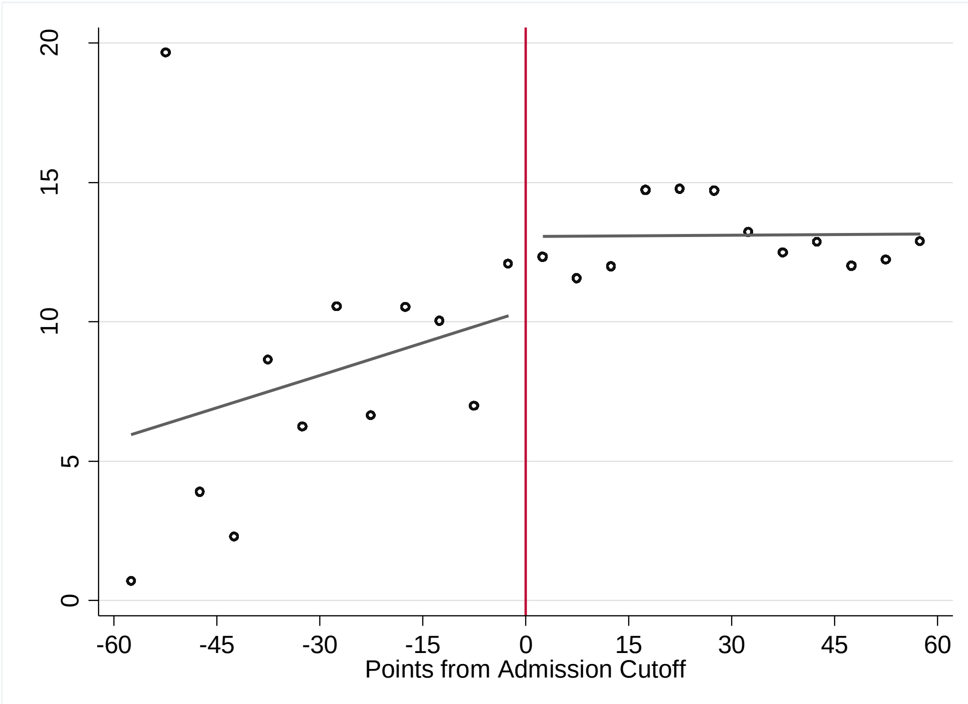


B. High SES



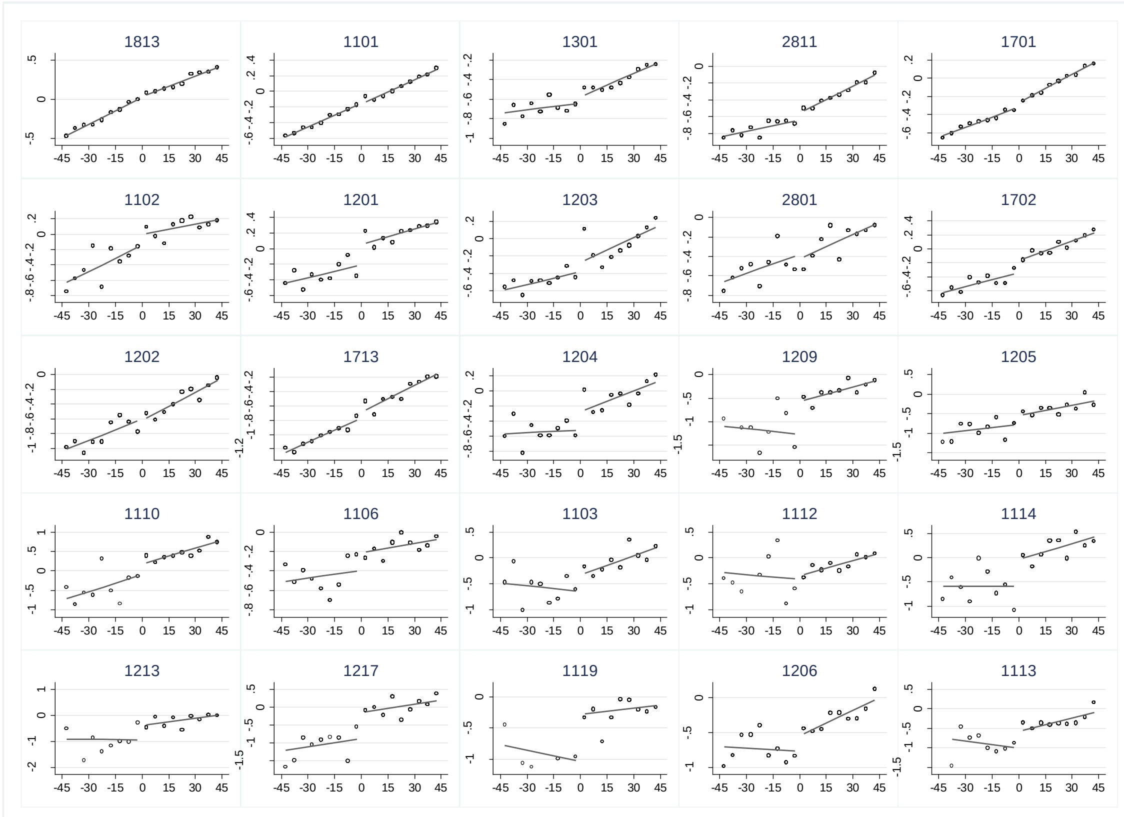
Notes: SES is based on socioeconomic strata which takes values from 1 (lowest) to 6 (highest). Socioeconomic stratum is only observed for applicants who take the exit test. Low SES corresponds to applicants from strata 1 to 4. High SES is applicants from strata 5 and 6.

Figure IX
Yearly Earnings One Year after Graduation at Los Andes Cutoff



Notes: Five-point averages of yearly earnings in millions of $Col and local linear fits around the Los Andes admission cutoff. Earnings are only observed for college graduates. Zero earnings for graduates not reporting to social security included.

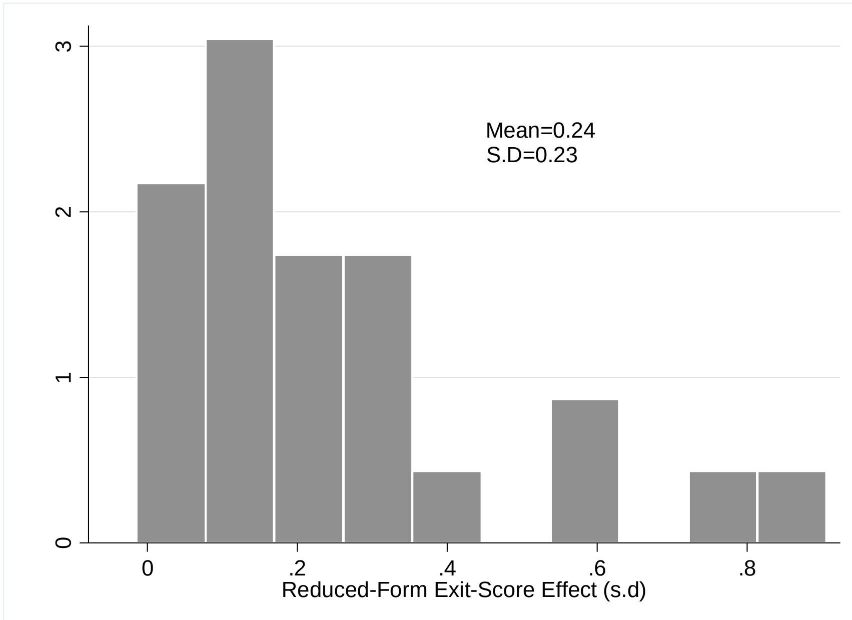
Figure X
End-of-college learning – 25 Universities



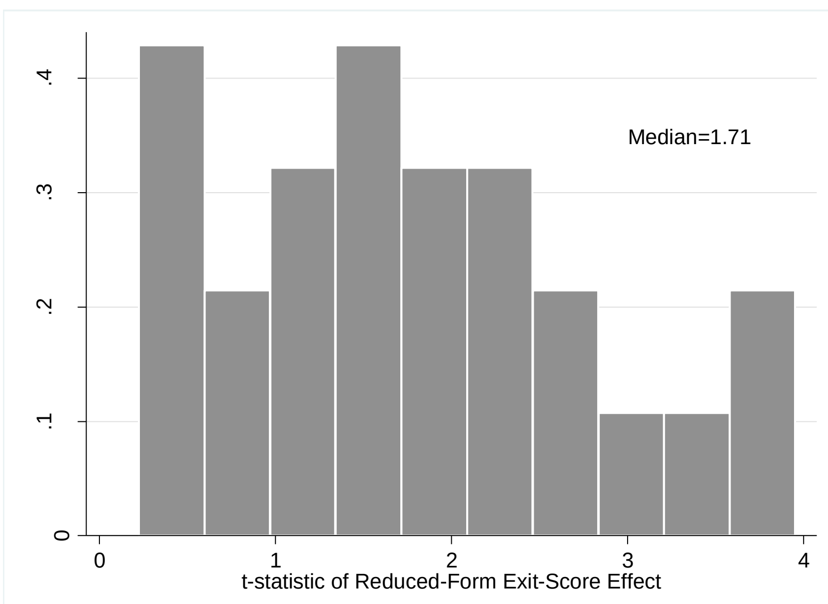
Notes: Each figure shows five-point averages of exit test around each of 25 nationwide selective university's admission cutoff, which is normalized to zero.

Figure XI

A. End-of-college learning distribution – 25 Nationwide Universities

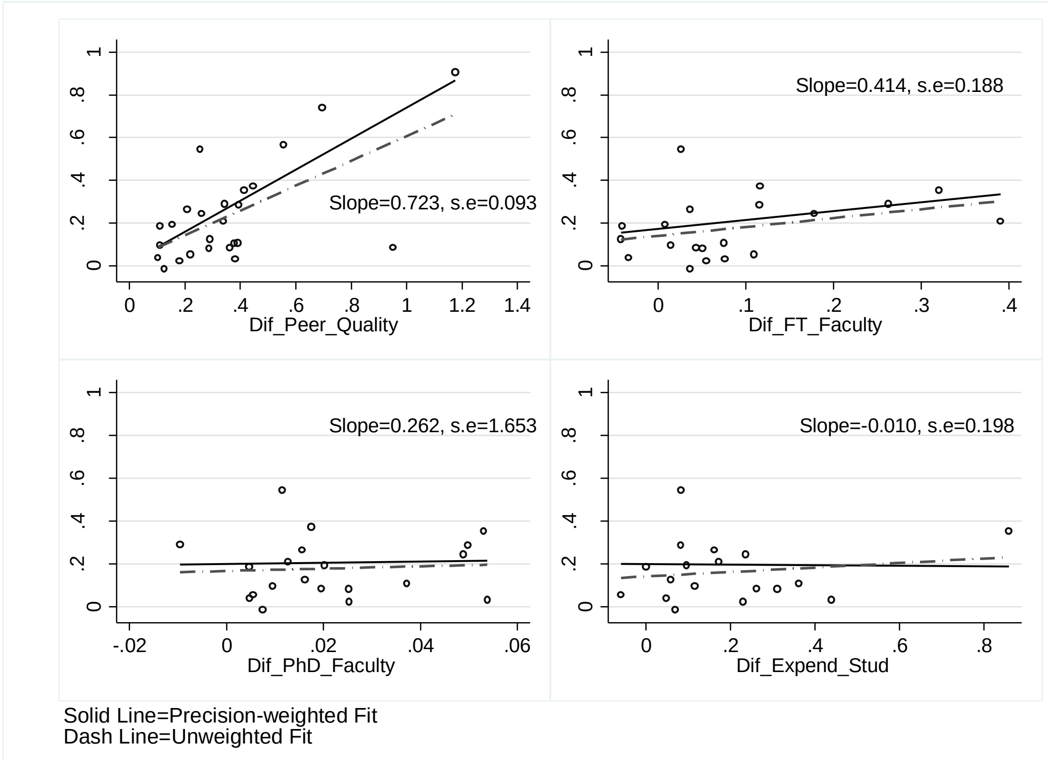


B. Precision Distribution of Reduced-Form Estimates of 25 Nationwide Universities



Notes: Panel A shows histogram of end-of-college learning reduced-form effects at 25 nationwide selective universities from Figure X. Panel B shows histogram of t-statistic of end-of-college learning reduced-effects at 25 nationwide selective universities from Figure X.

Figure XII
End-of-college Learning and College Input Correlations- 25 Nationwide Universities



Notes: Graphs plot end-of-college learning reduced form estimates (see Figures XIII and XIV) against average input difference above and below each estimated cutoff. Peer quality (25 observations) is measured in standard deviation units of entry test. Full-Time (FT) faculty is fraction of full-time faculty (20 observations). Faculty with PhD (20 observations) is fraction of faculty with PhD. Expenditures per student are natural logarithm of expenditures per student in $col millions (18 observations). Slope and heteroskedasticity-robust standard error refer to precision-weighted bivariate regression coefficient.

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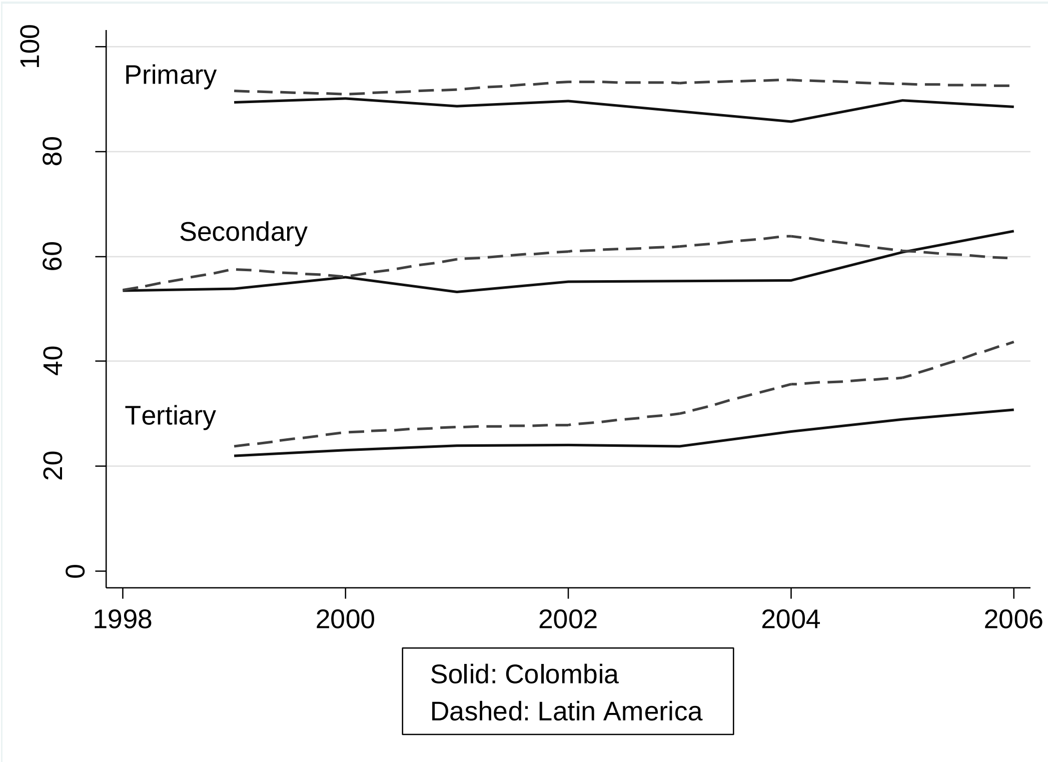
Appendix A: Access to College and College Market Structure in Colombia

Figure A.1
Enrollment Trends in Colombia



Source: World Bank Development Indicators (2008).

Table A.1
Colombian Higher Education Market Structure

Institutions	**Public**	**Private**	**Total**
Colleges & Universities	55	122	177
	20%	44%	64%
Technological Institutes	28	72	100
	10%	26%	36%
Total	83	194	277
	30%	70%	100%
Enrollment			
Colleges & Universities	558,271	479,137	1,028,627
	44%	38%	82%
Technological Institutes	100,871	126,089	232,259
	8%	10%	18%
Total	659,142	601,744	1,260,886
	52%	48%	100%

Notes: calculations based on the Colombian national higher education information system (SNIES 2007), Education Ministry.

Table A.2
Hierarchy of Colleges in Colombia

	Most Selective	Selective	Non-Selective
Mean Entry Score (s.d)	1.21	0.81	0.41
Percent Full Time Faculty	50.34	39.32	26.7
Percent PhD Faculty	6.34	5.92	1.8
Expenditures per student (million $ col)	7.07	7.06	5.25
Universities	29	30	109

Notes: Selectivity is defined as slots over applicants. This variable is constructed from ICFES (2002) annual higher education statistical summary. Most selective are 50% most selective universities among those with more applicants than slots. Selective are 50% less selective universities among those with more applicants than slots. Non-selective universities are those that have more slots than applicants. Mean entry score is universities' standardized mean entry score, constructed from students in the administrative exit score database. The source of percent full time faculty, percent PhD faculty and expenditures per student is La Nota Económica (2007).

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Appendix B: Exit exam fields, economics exam sample questions and the correlation between exit scores and employment and earnings outcomes.

Table B.1
Exit Exam Fields

Accounting	Engineering- Industrial
Arquitecture	Engineering- Mechanic
Biology	Engineering- Systems
Business	Engineering- Telecomm
Chemistry	Geology
Dentistry	Law
Economics	Math
Education	Medicine
Engineering- Agricultural	Nursing
Engineering- Chemical	Physics
Engineering- Civil	Psychology
Engineering- Electrical	Systems Technician
Engineering- Electronic	Veterinary

Notes: medicine and law are undergraduate degrees in Colombia

Economics Exam Sample Questions

1. Under which circumstance does a country with free capital markets have monetary autonomy?

a. Fixed exchange rate
b. Independent central bank
c. Flexible exchange rate
d. Nominal anchor exchange rate

2. Given a Cobb-Douglas production function $Q = AL^{\beta}K^{\alpha}$, the marginal product of labor is given by

a. A β / L
b. β Q / L
c. A
d. αQ / K

3. Consider the following wage function:
$\ln W = 2.38 + 0.4$ Schooling $+ 0.1$ Experience
A one-year experience increase is associated with ___ wage increase
a. $ 1
b. $ 10
c. 10%

d. 1%

Table B.3
The exit test predicts employment and earnings after college

	Formal Employment Dep. Var. Mean=0.61			Yearly Earnings (col$000 - Unconditional) Dep. Var. Mean=7,624		
	(1)	(2)	(3)	(4)	(5)	(6)
Exit Score (s.d.)	0.030	0.018	0.018	1,026	543	436
	[0.008]	[0.007]	[0.003]	[195]	[150]	[81]
Entry Score (s.d)		0.025	0.022		984	726
		[0.007]	[0.005]		[179]	[115]
From Top Strata	-0.002	-0.007	-0.020	1,667	1,473	249
	[0.013]	[0.013]	[0.007]	[540]	[502]	[288]
Female	0.046	0.047	0.044	78	103	44
	[0.006]	[0.006]	[0.006]	[150]	[148]	[142]
Father College Grad	0.008	0.005	0.005	504	386	144
	[0.007]	[0.007]	[0.006]	[184]	[170]	[119]
Mother College Grad	0.019	0.017	0.012	392	321	62
	[0.007]	[0.007]	[0.006]	[138]	[132]	[117]
University Fixed Effects	No	No	Yes	No	No	Yes
Observations			38742			
R-squared	0.08	0.08	0.19	0.10	0.10	0.16

Notes: Sample is exit test takers in 2004 and 2005 matched to Education ministry's college graduation records. Formal employment equals one for graduates who report earnings to social security. Yearly earnings are in thousands of $col, zeros for graduates who do not report included. In addition to covariates in the table, all columns include college entry test cohort, field, department of birth fixed effects and an indicator that equals one if students graduated from an academic high-school.

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Appendix C: Sample Descriptive Statistics, Persistence, Heterogeneity by Field, Differences in College Quality by SES and Post-Graduate Study at Los Andes

Table C.1
Summary Statistics of Los Andes Applicant Sample

Characteristics from Application Lists	Mean	Standard Deviation
Female	0.447	0.497
Admitted	0.844	0.363
Enroll if Admitted	0.560	0.496
Characteristics from Exit Test Administrative Records		
Took Exit Test in 2004 or 2005	0.292	0.455
Semesters to Exit Test Since Applied	9.347	0.944
Father Has College Degree	0.867	0.339
Mother Has College Degree	0.765	0.424
From Top Two Socioeconomic Strata (out of six possible)	0.491	0.500
Graduated from Academic High School	0.977	0.148
Characteristics from Graduation and Social Security Administrative Records		
Has Graduated	0.291	0.454
Percent of Graduates who Took Exit Test	0.627	0.482
By entry cohort:		
1998	0.348	0.477
1999	0.510	0.500
2000	0.748	0.434
2001	0.680	0.467
Percent of Test Takers who Have Graduated	0.636	0.481
By exit test year:		
2004	0.855	0.352
2005	0.471	0.499
Years to Degree if Graduated	5.643	0.991
Has Formal Employment One Year After Graduation	0.590	0.492
Number of Observations	10180	

Table C.2
Persistence and Academic Qualifications of Enrollees to Los Andes

Dependent Variable equals one if applicant attends Los Andes at Time Take Exit Test				
	Bandwidth (Points)			
	80	60	45	20
	(1)	(2)	(3)	(4)
A. Enrollees				
Points from Cutoff (x100)	0.148	0.147	0.266	0.173
	[0.073]	[0.086]	[0.119]	[0.366]
Observations	874	817	701	350
R-squared	0.14	0.16	0.17	0.19
B. Admittees				
Points from Cutoff (x100)	0.109	0.137	0.207	0.431
	[0.071]	[0.084]	[0.111]	[0.314]
Observations	1474	1377	1183	579
R-squared	0.07	0.07	0.08	0.13

Notes: Robust standard errors in parentheses. The dependent variable equals one for applicants attending Los Andes at the time they take the exit test. The variable Points from Cutoff is the difference between students score and the program-cohort cutoff to which she applied, since cutoffs are normalized to zero. Reported coefficients correspond to separate linear probability regressions within the specified bandwidth at each side of the admission cutoff and sample restriction. In Panel A, the sample is restricted to enrollees who take the exit test. In Panel B sample is restricted to admittees who take the exit test. In addition to the reported coefficients, all regressions include a gender indicator, program applied and cohort fixed effects.

Table C.3
Probability of Taking the Exit Test at Los Andes Cutoff by Field of Application

Dependent Variable is Applicant Takes Exit Test (Mean=0.30)				
	Bandwidth (Points)			
	Reduced Form			
	80	60	45	20
	(1)	(2)	(3)	(4)
A. Engineering Applicants				
Admittted	-0.018	-0.011	-0.029	0.030
	[0.032]	[0.036]	[0.039]	[0.056]
Observations	3088	2884	2530	1360
R-squared	0.10	0.10	0.09	0.07
B. Applicants to All Other Majors				
Admitted	0.011	0.037	0.052	0.027
	[0.031]	[0.033]	[0.038]	[0.052]
Observations	3331	3062	2631	1442
R-squared	0.15	0.16	0.15	0.13

Notes: Robust standard errors in parentheses. The dependent variable equals one for applicants who take the exit test. Sample is applicants to Los Andes with entry scores within corresponding bandwidth from admission cutoff, which is normalized to zero. Admitted equals one if applicants' entry score is greater or equal than the admission cutoff for the corresponding program applied and cohort. Each column is a separate regression for applicants within the specified bandwidth at each side of the admission cutoff. In addition to the reported coefficients, all regressions include: points from the cutoff, and interaction of points with admitted, a gender indicator, program applied and cohort fixed effects.

Table C.3
End-of-college Learning Heterogeneity at Los Andes Cutoff by Field of Application

Outcome is Exit Score								
	Reduced Form				TSLS			
	80	60	45	20	80	60	45	20
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Engineering Programs								
Enrolled					0.354	0.283	0.300	0.54
					[0.190]	[0.196]	[0.217]	[0.326]
Admitted	0.226	0.183	0.196	0.339				
	[0.121]	[0.127]	[0.142]	[0.204]				
Observations	970	910	787	415	970	910	787	415
B. All Other								
Enrolled					0.455	0.443	0.374	-0.089
					[0.246]	[0.293]	[0.309]	[0.439]
Admitted	0.235	0.215	0.180	-0.04				
	[0.125]	[0.139]	[0.146]	[0.197]				
Observations	789	728	631	345	789	728	631	345

Notes: Robust standard errors in parentheses. The dependent variable is standardized exit score, with mean zero and standard deviation one. Admitted equals one if applicants' entry score is greater or equal than the admission cutoff for the corresponding program applied and cohort. Each column is a separate regression for applicants within the specified bandwidth at each side of the admission cutoff. In addition to the reported coefficients, all regressions include: points from the cutoff, and interaction of points with admitted, a gender indicator, program applied and cohort fixed effects. In columns 5-8 Enrolled is instrumented with Admitted. Panel A corresponds to exit score estimates for applicants to engineering programs. Panel B for all other programs.

Table C.4
College Quality Differences by SES around Los Andes Cutoff

Input Differences At Admission Cutoff By Income		
	Bottom Strata	Top Strata
Peer Quality	0.53	0.52
Percent Top Strata	13.48	9.69
Expenditure/Student	3.80	3.53
Percent PhD Faculty	9.92	10.23
Percent F.T Faculty	8.80	9.58

Notes: Each number in the table is the mean college input difference between admitted and rejected applicants who take the exit test, separately for bottom and top strata. Inputs correspond to the university applicants are attending at the time they take the exit test.

Table C.5
Employment of College Graduates – Colombian Census 2005

Activity Last Week College Graduates Age 24-26	
At Work	60.4%
In School	18.3%
Unemployed	5.1%
Inactive	9.0%
Housework	5.8%
Other	1.4%

Notes: Data source is Colombian census 2005 from IPUMS international. Table shows detailed version of individual employment status among college graduates age 24-26 (tab empstatd if edattand=400 & 24≤age≤26). Observations=15,456. Other includes: permanent disability, living on rent and missing.

Table C.6
Mean Differences in Postgraduate Degree Completion:
Los Andes Graduates versus Graduates from Other Colleges

Dependent Variable is College Graduate Completes Any Postcollege Degree

	After 2 Years		After 3 Years		After 4 Years		After 5 years	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Control Mean	Los Andes Coefficient	Control Mean	Los Andes Coefficient	Control Mean	Los Andes Coefficient	Control Mean	Los Andes Coefficient
A. Los Andes v. All Other Colleges in Bogota								
	0.045	0.067	0.071	0.110	0.106	0.098	0.133	0.075
	[0.001]	[0.009]	[0.001]	[0.012]	[0.002]	[0.012]	[0.002]	[0.012]
	31487		33637		31838		32996	
B. Los Andes v. All Colleges in Applicant Sample								
	0.047	0.065	0.076	0.106	0.114	0.091	0.142	0.067
	[0.001]	[0.009]	[0.002]	[0.012]	[0.002]	[0.012]	[0.002]	[0.012]
	27566		28836		27228		27470	
C. Los Andes v. Five most Popular Colleges in Applicant Sample								
	0.057	0.055	0.096	0.086	0.153	0.052	0.183	0.026
	[0.003]	[0.009]	[0.004]	[0.012]	[0.005]	[0.013]	[0.005]	[0.013]
	8116		8144		7571		7224	

Notes: Table shows unconditional probability of completing any postgraduate degree in specified time frame. Sample is all college graduates from colleges and universities in Bogota. Los Andes Coefficient equals one if graduated from (undergraduate) college from Los Andes. In Panel A control group is all other colleges in Bogota; in Panel B control group is all colleges that applicants to Los Andes attend at the time they take the exit test; in Panel C control group is five most popular schools from applicant sample. Robust standard errors in parentheses.

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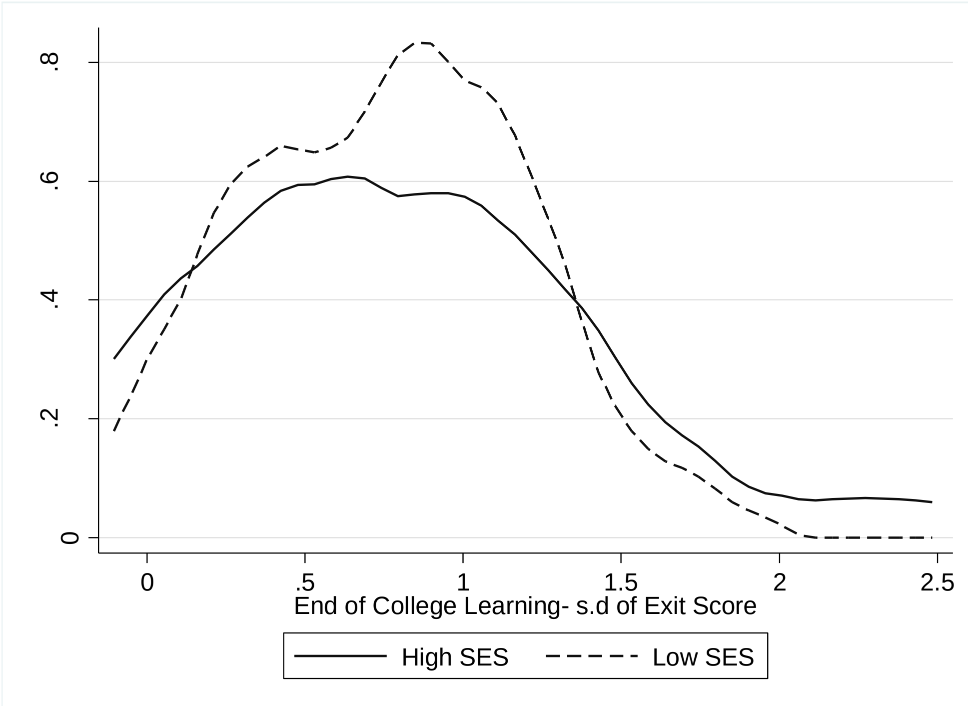
Appendix D: Probability of Taking Exit Test by University Selectivity (All Universities) and End-of-college-learning Differences by SES in 25-University Approach

Table D.1
Probability of Taking College Exit Exam by Institution Selectivity

	(1) 2004	(2) 2005	(3) Stacked
Dependent Var. Mean	0.348	0.326	0.337
A. Selectivity (N=149)			
Selective=1 Coefficient	0.027	-0.024	0.001
	(0.034)	(0.029)	(0.022)
B. Share of Full-Time Faculty (N=102)	-0.015	-0.009	-0.012
Above Median Coefficient	(0.037)	(0.027)	(0.023)
C. Share of Faculty with PhD (N=102)			
Above Median Coefficient	0.048	0.032	0.039
	(0.037)	(0.027)	(0.023)
D. Expenditure per Student (N=83)			
Above Median Coefficient	0.026	0.022	0.024
	(0.041)	(0.032)	(0.026)

Notes: Robust Standard Errors in parentheses. In Panel A, selective is defined as having a ratio of students accepted over applicants lower than one. In Panel B, median share of full-time faculty is 31%. In Panel C, median share of faculty with PhD is 2%. In Panel D, median expenditure per student is 4.9 millions of pesos. Columns 1 and 2 report results for 2004 and 2005 exit exam cohorts. In Column 3 I stack both cohorts so that there are 2 observations per institution. N corresponds to the number of institutions in each regression with both valid probabilities of taking the exit exam (valid data on first year students) and selectivity information based on ratio of admitted to applicants (panel A), share of faculty with PhD (panel B) and expenditures per student (panel C).

Figure D.1
End-of-college Learning, by SES – 25 Nationwide Universities



Notes: kernel density distributions of end-of-college learning Wald estimates for 25 nationwide selective universities, estimated separately for low and high socioeconomic strata.