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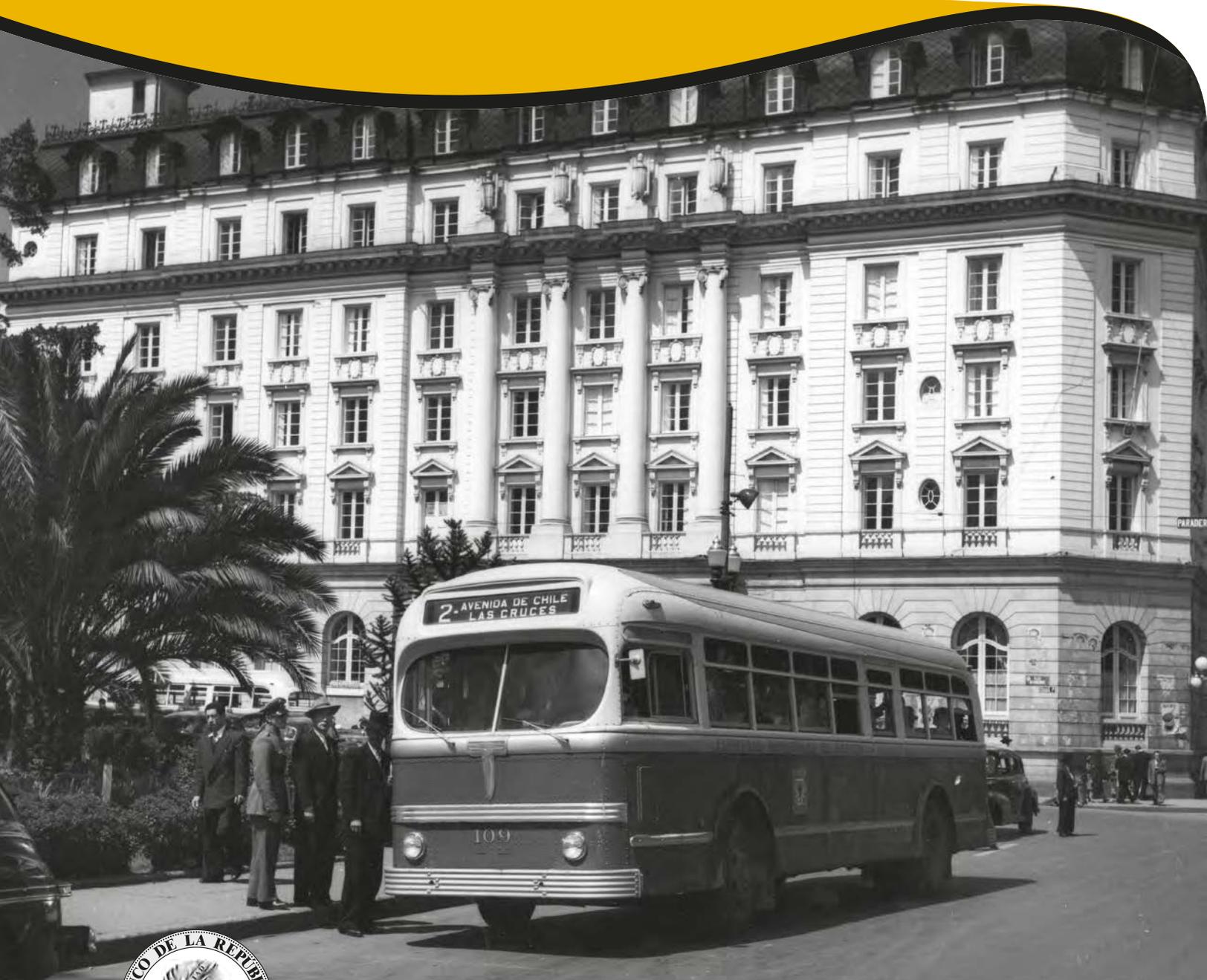
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Abstract

We provide evidence on the long-run impact of vouchers for private secondary schools, evidence collected twenty years after students applied for the vouchers. Prior to the voucher lottery, students applied to either an academic or vocational secondary school, an important mediating factor in the vouchers' impacts. We find strong tertiary education and labor market effects for those students who applied to vocational schools with almost no impact on those who applied to academic schools. The labor market gains for vocational students are strongest at the top of the distribution and null at the bottom of the distribution. We find additional long-run impacts on consumption, and teen-age fertility. The expected net present value of benefits to participants and to taxpayers was large and positive implying that the program was welfare improving unless net externalities were large and negative.

JEL Codes: E51, H24, I22, I23, I26, J13

Keywords: school choice, scholarships, formal earnings, access to higher education, access to consumer credit, fertility.

Becas Escolares, Mercados Laborales y Educación Vocacional

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Resumen

En este trabajo estudiamos los impactos de largo plazo del programa de becas PACES para educación secundaria privada, para alumnos de bajos recursos, utilizando información recolectada veinte años después de que los estudiantes aplicaran a la beca. Previo a la asignación aleatoria, los estudiantes debían escoger entre un colegio académico o vocacional, factor importante en el impacto de las becas. Encontramos fuertes efectos sobre la educación superior y el mercado laboral para aquellos estudiantes que aplicaron a colegios vocacionales y casi ningún impacto sobre aquellos que aplicaron a un colegio académico. Las ganancias laborales de los estudiantes vocacionales son más fuertes en la parte superior de la distribución y nulas en la parte inferior. Se encuentran impactos adicionales de largo plazo sobre consumo y embarazo adolescente. El valor presente neto esperado de los beneficios de los participantes y los contribuyentes fue positivo y de gran magnitud, lo que significaría mejoras sustancialmente en el bienestar social, a menos de que existieran externalidades netas grandes y negativas.

Clasificación JEL: E51, H24, I22, I23, I26, J13

Palabras clave: elección de colegio, becas, ingresos formales, acceso a educación superior, acceso a crédito de consumo, fertilidad.

1. Introduction

Educational vouchers have been hotly contested throughout both low- and high-income countries. While evidence on educational vouchers has shown minimal impact in high-income countries, the evidence in low-income countries has been more mixed (see reviews by Epple et al. 2017, Bettinger and Zimmer 2014). Two puzzles persist in the educational voucher literature. First, little is known as to why impacts appear in some locales but not others and whether specific design features might be scalable. Second, little is known about the impact of voucher programs on social mobility, often the stated goal of voucher programs.

We provide new evidence on these puzzles. The evidence comes from Colombia's PACES voucher program. In the 1990s, Colombia's PACES program sought to expand secondary school access for socioeconomically disadvantaged students by awarding them vouchers to attend private schools. Prior to the lottery, students applied to either an academic or vocational secondary school, and this decision is an important mediating factor for the program's impacts. We take advantage of an oversubscription lottery to estimate the impacts of the voucher.

We make three distinct contributions to the voucher literature. First, we present evidence on the long-run impacts. We have longitudinally tracked voucher applicants using a variety of survey and administrative data for over twenty years since the initial voucher award. We show that PACES beneficiaries greatly increased their chance of transitioning to the middle

class, as defined by increased tertiary education, greater formal sector earnings, a higher fraction of formal earners above a middle-class earnings threshold, and access to credit for consumption typically associated with the middle class. Voucher awardees also had a lower incidence of teen childbearing without changes in total fertility by age 30.

Voucher winners who had applied to vocational schools prior to the voucher lottery entirely drive the results. Among these vocational school applicants voucher lottery winners are seven percentage points more likely to have ever enrolled in tertiary education, whereas among applicants to academic schools, we do not find evidence that winning the lottery affects tertiary enrollment. Similarly, vocational lottery winners have 17 percent greater formal sector earnings at around age 33 than vocational lottery losers, but we see no voucher impact on formal earnings among academic school applicants. These gains were largely at the top of the earnings distribution.

Our second significant contribution is to demonstrate the long-run fiscal impact of the voucher program. We show that these long-run gains in tertiary education and labor markets in this population occur at a low or possibly negative cost to taxpayers. Unless there are large, negative externalities, the program more than pays for itself as a result of the extra taxes collected as a result of the increased formal sector incomes.

Our third contribution is to shed light on why impacts in Colombia have been so positive relative to other programs. Like in earlier work (Bettinger, Kremer, Saavedra 2010), we find

that the impacts were larger among students who, prior to the lottery, had applied to vocational schools than they were for students who had applied to academic schools. The concentration of effects among vocational school applicants in the PACES program sheds light on what mechanisms may or may not be at work. For example, among vocational applicants, lottery winners attend schools with peers who are less desirable on observables than the schools attended by losers, casting doubt on the role of peer quality as a driving mechanism (Bettinger, Kremer, Saavedra 2010). We also find little evidence that vocational applicants were more likely to "trade-up" and attend schools with larger gross school fees. Similarly, the long run effects on tertiary education and the labor market cast doubt on the possibility of participating schools lowering the academic bar for voucher winners. Perhaps the most suggestive evidence is the impact of the program on students' access to particular curriculum. Academic schools offer a similar curriculum whether they are public or private. The key advantage of the secondary school market may be in offering a more differentiated product that is more responsive to labor market and advanced training opportunities than public education. Private vocational schools are more likely to offer education in commercial, service-oriented subjects, rather than industrial subjects, and among vocational school applicants, point estimates of earnings effects are particularly strong for applicants to schools with a commercial focus.

Besides the educational voucher literature[1], this paper builds on other threads of research including the long-term consequences of educational interventions,[2] the economic returns to interventions that target socially disadvantaged children,[3] the impact of vocational education, the effects of education on fertility,[4] and recent developments in public finance employing reduced form causal estimates of labor-market behavioral responses to policy to measure welfare changes.[5] Most specifically, our paper builds on Angrist et al. (2002, 2006) and Bettinger, Kremer and Saavedra (2010) which examine the impact of PACES on secondary school outcomes.

The rest of the paper is organized as follows: Section 2 provides background on the Colombia education system and the PACES program. Section 3 discusses data, empirical strategy, and the framework we use for welfare analysis. Section 4 discusses voucher impacts on educational outcomes. Section 5 discusses labor market outcomes and consumption.

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[1] For example, Helen Ladd 2002; Angrist, Bettinger and Kremer 2006; Hsieh and Urquiola 2006; Wolf, Gutmann, Puma, Kisida, Rizzo, Eissa and Carr 2010; Barrow and Rouse, 2008; Muralidharan and Sundararaman 2013. See also reviews by Epple et al 2017 and Bettinger and Zimmer 2014.

[2] For example, Kemple 2004; Chetty, Friedman, Hilger, Saez, Schanzenbach and Yagan 2011; Deming, Hastings, Kane and Staiger 2011; Dynarski, Hyman and Schanzenbach, 2011; Cowen, Fleming, Witte, Wolf and Kisida 2012.

[3] Some argue that interventions that target socially disadvantaged children have highest returns early in the life cycle, during key child-development windows (Cunha, Heckman, Lochner and Masterov 2006; Heckman and Masterov 2007; Heckman 2008). A stronger claim is that interventions in the teen years are doomed to have small impacts. Our findings demonstrate that secondary schooling interventions that target disadvantaged children have the potential to increase earnings and promote social mobility.

[4] In developing countries, in particular several, studies find a strong causal relationship between educational subsidies and teen fertility (e.g. Breireova and Duflo 2004; Cortés, Gallego and Maldonado 2010; Duflo, Dupas and Kremer 2012).

[5] See, for example, Hendren 2013 and Baird, Hicks, Kremer and Miguel 2013.

Section 6 discusses the impact of vouchers on fertility. Section 7 discusses welfare. Section 8 concludes.

2. Background

Sub-section 2.1 summarizes Colombia's educational context. Sub-section 2.2 discusses the PACES voucher program.

2.1 Colombia's educational context

The Colombian education system comprises three levels: elementary school (grades 1-5), secondary (grades 6-11) and tertiary education. Children typically transition into secondary at around age 12 or 13. Students are legally required to attend school through grade 9. Students who complete secondary school on time typically do so by age 18.

Most secondary schools are academic and traditionally prepare students for five-year universities (which few in our sample will attend). Others are vocational. These offer similar curricula in the lower grades, but in the last two grades of secondary school in addition to teaching core academic subjects, they also prepare students for admission into vocational colleges or for participation in the labor market, through additional school time and specialized curricula in commercial, industrial, agrarian or pedagogical domains.

By 1995, a significant proportion of Colombia's secondary schools were private, and private schools were not just for the elite or the religious. Nationally, 37 percent of primary and secondary school student population attended a private school at the time the PACES voucher

program was put in place; in Bogotá, the focus of our study, 58 percent of students did so (Angrist et al. 2002).

Within the category of vocational schools, public schools are more likely to teach industrial as opposed to commercial subjects. Among public vocational schools in our sample, 25 percent have an industrial curriculum and 62 percent have a commercial curriculum, whereas among private vocational schools only four percent have an industrial curriculum and 92 percent have a commercial focus (Bettinger, Kremer and Saavedra 2010).

Students who wish to continue on to tertiary education can enroll in either vocational colleges or traditional universities. Vocational programs typically last two or three years. University programs —more prestigious, expensive and selective— last typically four or five years. By 2004, the Ministry of National Education reports that seventy-five percent of tertiary education students in Colombia attend a university and 25 percent attend a vocational college. With the exception of a few elite private universities, private tertiary education institutions serve those who do not obtain admission into public universities.

2.2 The PACES voucher program

The PACES voucher program was introduced nationwide by the Colombian government in 1992 to increase secondary school enrollment rates among disadvantaged students. The program aimed at tapping the excess capacity in urban private schools by providing vouchers for private secondary schooling among applicants from public elementary

schools in the poorest two strata of Colombia's major cities (King, Laura Rawlings, Gutierrez, Pardo, and Torres 1997). Colombia divides its population into six strata based on residential location. According to the 1997 Colombian Living Standard and Measurement Survey, roughly 55 percent of Colombia's population (49 percent in Bogotá) make-up the poorest two strata.

Participating private schools served lower-income students and charged lower tuition fees than other urban private schools that chose not to participate. Teacher-pupil ratios were comparable between all public and participating private schools (King et al. 1997). While initially the voucher covered most tuition fees, the government did not increase its monetary value to keep pace with inflation, and by 1998 the voucher only covered about 56 percent of the tuition of the average participating school. Families made up for the difference (Angrist et al. 2002).

In order to apply for an award, students needed to have applied and been accepted (at least conditionally) to a participating private school. This is particularly important in that we can separate those students who prior to the voucher lottery had applied and been accepted at a vocational school (or an academic school).

PACES assigned the vouchers by lottery when demand exceeded supply. Colombian municipalities including Bogotá are responsible for the administration of public education, funded by transfers from the national government (Barrera-Osorio et al. 2011), and local educational officials conducted the voucher lottery. Following Angrist et al. (2002, 2006), we

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limit our analysis to individuals who applied in 1994 to enter, by lottery, a private school in sixth grade in Bogotá in 1995.[6] This lottery and its records are the most complete and accurate of any of the annual voucher lotteries conducted in Colombia between 1992 and 1997.

It was administratively difficult to retain the voucher if one switched schools, so there was considerable stickiness in schools attended by voucher winners. Less than 20 percent of students that transferred after the first year were able to retain their voucher. Renewal of the award through the end of students' secondary schooling was supposed to be contingent upon passing grades although there was imperfect enforcement (Calderón 1996; Ribero and Tenjo 1997).[7]

Vocational private schools were overrepresented among participating private schools. Applicants to vocational schools tend to differ systematically from other applicants; they tend to come from families where the parents are less educated, they are also more likely to be living in the poorest of Colombian neighborhoods, and they typically applied to schools whose students attained lower than average scores on college entrance examinations (Bettinger, Kremer and Saavedra 2010). Among applicants who applied to vocational private schools, voucher lottery winners were more likely to stay in vocational schools whereas applicants who did not win a voucher were more likely to attend academic schools (Table 1)

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[6] Bogotá was chosen because the data were available and because the lottery passes basic randomization checks.
[7] There appears to be significant but not perfect enforcement. After three years, only nine percent of voucher lottery winners who had repeated at least one grade were still using the voucher while 60 percent of voucher lottery winners who had never repeated a grade were still using the voucher.

3. Data, Empirical Strategy, and Welfare Analysis Framework

Sub-section 3.1 below discusses our data. Sub-section 3.1 discusses our overall welfare analysis framework and subsection 3.3 discusses our empirical strategy.

3.1 Data

Our baseline data come from the PACES applications. Covariates available from the PACES application include age, gender, whether the applicant had a phone at the time of application and the school to which the student applied. Bettinger, Kremer and Saavedra (2010) matched 93 percent of applicant school names in the Bogota 1995 lottery to school types (vocational or academic) using data from the ICFES secondary graduation database, which we describe below. In the 1995 voucher lottery, 43 percent of students applied to a private vocational secondary school, with no difference by lottery status (Table 2). In 1995, only 16 percent of secondary school graduates attended vocational schools, which underscores the overrepresentation of vocational schools among private schools participating in the program.

In general, application covariates are balanced across lottery winners and losers in the full sample and separately by type of school applied to, with the exception of age (Panel A, Table 2). Lottery winners are 0.086 years younger than losers in the full sample, (p-value=0.055) and 0.14 years younger among vocational school applicants (p-value=0.035)

(column 6, Table 2). With Bonferroni adjustment for multiple hypotheses, these differences lose significance.

While prior analysis concluded that this age difference was inconsequential (e.g. Bettinger et al. 2002), recent econometric advances in machine learning allow us to examine the pattern of differences more thoroughly to test if assignment was indeed random. To do so, we use a modified strategy from Ludwig, Mullainthan and Spiess (2017). To our knowledge, we are the first to use this methodology for assessing random of assignment in an experiment. To implement, we use our data to train a random forest classifier to predict treatment status from covariates. We then use cross-validation to estimate the accuracy of the machine learning predictions. If assignment is truly random, it should not be predictable from covariates at all. We therefore permute treatment assignment to simulate a random assignment and repeat this process over and over again. This allows us to compare the distribution of potentially observed prediction accuracies to the prediction accuracy that we observe. In our case, this exercise produces a p-value of 0.9 for the pattern of observed differences across all covariates suggesting that randomization was indeed valid.[8]

While our analysis gives us some assurance that the randomization was valid, we present our results with controls for age, gender and having a phone. As we document later, results are robust to alternative age specifications as well as to excluding application controls.

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[8] Appendix Figures A.1 and A.2 plot the p-values from simulations of the predictability of treatment status on basic covariates for the full and vocational samples.

We match the Bogotá 1995 lottery data to five administrative data sources. In the voucher applicant list, all applicants report their full names (typically two first names, two last names) and 97.2 percent report a valid youth identification number, which contains their date of birth embedded in the first six digits. The remaining four digits in the youth identification number include an algorithm for determining the validity of a youth identification number. There is no difference by lottery status in the probability of having a valid youth identifier in the full sample or separately by type of school applied to (Panel B, Table 1).

Tracking long-run outcomes in some datasets —particularly social security records— relies on having students' adult identification numbers, which citizens obtain when they turn 18 years old. 97.1 percent of applicants have valid adult identification number, with no difference in the likelihood of having an adult identification number by win-loss status among all applicants or separately by gender (Panel B, Table 2).[9] Given the high proportion and win-loss balance in identifying information, PACES applicants can be matched to various individual-level national administrative datasets with low overall and differential attrition:

1. *The 2001-2007 ICFES secondary school graduation/tertiary education entry exam database.* Students attending grade 11 take the ICFES exam, and ICFES scores are the primary admission criteria in Colombia's tertiary education institutions. While it is not a binding graduation requirement, most schools enforce test taking and, in practice, over 95 percent of

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[9] Youth and adult identification numbers were linked using administrative data from Colombia's national registrar's office and the Department of National Planning.

students take the test (ICFES 2013), making it a good proxy for secondary school completion. We update and improve the prior match conducted by Angrist et al. (2006) by: i) matching on students' youth identification numbers, adult identification numbers, and names, (Angrist et al. 2006 did not have students' adult identification numbers), and ii) by matching students to the population of test takers through 2007 —7 years after students would have graduated with no grade repetition —whereas Angrist et al. (2006) was only able to match students through 2001. Finding a match in this database, like the others listed in this database, is an outcome in and of itself.

2. *The 2001-2012 (1ˢᵗ semester) tertiary education database.* Colombia's Education Ministry's *Sistema de Prevención y Análisis de la Deserción en Instituciones de Educación Superior (SPADIES)* is an individual-level panel dataset that tracks close to 95 percent of tertiary education students from their first year to their degree receipt. It includes information on the timing and institution of students' tertiary enrollment, as well as whether the institution in which they enrolled was a university or a vocational college and whether it was public or private.

3. Colombia's Social Protection Ministry's 2008-2014 *Sistema Integral de Información de la Protección Social* (*SISPRO)* is an individual-level panel dataset that provides information on formal sector earnings and tax payments.[10] It contains information on

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[10] The SISPRO database only includes people who worked for employers that register their workers or self-employed workers who register themselves. In Colombia and in Bogotá, respectively 50 percent and 55 percent of employment is formally registered (*Secretaría de Desarrollo Económico de Bogotá* 2012).

contributions to government social programs for health, professional risks insurance, and retirement. SISPRO only began to cover the universe of formal sector workers in 2008, eight years after on-time secondary school completion of voucher applicants in the Bogotá 1995 sample.[11] On average, voucher applicants would have been around 33 years old in 2014.

4. Colombia's financial comptroller's (*Superintendencia Financiera*) formal credit census from 2004 to 2014, ten to 20 years after the lottery and four to 14 years after on-time secondary school completion of voucher applicants in the Bogotá 1995 sample. We focus on two indicators of access to middle class consumption, namely access to credit card and car loans. We also analyze credit risk, as measured by interest rates charged on loans.

5. *The 2010 SISBEN Household Census.* SISBEN collects data on Household's covariates used to build an index of quality of life that is used to determining eligibility for various transfer programs.[12] Unlike the other administrative datasets that have national coverage, the SISBEN census surveys only residents from neighborhoods classified in the two

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[11] We compute annual formal sector earnings by adding inflation-adjusted monthly formal sector earnings during the period covered by our formal employment data (July 2008 to December 2014 or 78 months) including zeroes for months without reported formal sector earnings and dividing by the 6.5 years of coverage to get an annual average (Table 6). Since 19 percent of applicants never appear on formal employment records during this period, total formal earnings for them are zero. We report results based on formal earnings reported in health payroll accounts. Results are very similar if we use instead earnings from the pension payroll account.

[12] These subsidies include: early childhood care (*primera infancia*), health care (*régimen subsidiado en salud*), tertiary education loan subsidies (*crédito ACCESS*), conditional cash transfers (*familias en acción*) and elderly care (*protección social al adulto mayor*) subsidies. For the healthcare subsidy the only eligibility criterion is SISBEN scores. Eligibility for the remaining subsidies requires additional demographic conditions such as having age-appropriate children, being admitted or attending tertiary education or living with an elderly relative. We observe eligibility for these subsidies but not actual subsidy receipt. We define *Familias en Acción* receipt as whether applicants' SISBEN score is at or below the eligibility cutoff and whether they have children between 0 and 17 years of age. Take up of subsidized health care is nearly one hundred percent among eligible families so for subsidized health care eligibility and receipt is almost identical.

lowest socioeconomic strata. For this reason, SISBEN 2010 covers only 57 percent of households in all of Colombia and 39 percent of households in Bogotá. Given that this score determines eligibility for government subsidy programs, we estimate voucher impacts on the probability of receiving *Familias en Acción* conditional cash transfers and on the probability of being eligible to receive benefits from the other three largest government subsidy programs available for urban households: the two tiers of subsidized health care and early childhood care. Since being surveyed and scored by the SISBEN formula is a requirement for government subsidy eligibility, the outcome of eligibility for various government programs is well defined for the entire population of voucher applicants because those who do not appear in the census are not eligible. However, we are interested in two additional outcomes from the SISBEN survey, namely, teen fertility and self-reported earnings. Since these outcomes are not defined for the full voucher applicant sample, we analyze them using a bounding approach described in subsection 3.3.

3.2 Welfare Analysis Framework

We use a simple framework for understanding the fiscal and welfare impacts of the PACES program. The welfare impact of the PACES program B is the sum of impacts on students who received vouchers (B_s), on taxpayers (B_t), and on others (B_o):

$$B = B_s + B_t + B_o.$$

We separately estimate impacts on participants (B_s) and taxpayers (B_t), allowing us to determine how large negative externalities (B_o) would need to be in order to change welfare conclusions.

One approach to assessing welfare impacts on participants (B_s) is to measure the net present value of extra earnings net of increased household school expenditures, increased public expenditure on education, and foregone earnings. Household school expenditures accrue in the short run while earnings accrue in the long run. This calculation will be a lower bound on welfare gains if the non-financial utility gains are positive. Second, we can also use a revealed-preference methodology to estimate an even more conservative lower bound on the welfare impact on participants, in which financial benefits are fully offset by increased effort costs of attending private school among those induced to attend private school by PACES, so the only benefits to participants consisted of the financial transfer to those infra-marginal applicants who would have gone to private school in the absence of the program. (This is a worst-case analysis

by revealed preference, since lottery winners always had the option of turning down the voucher.)[13]

For taxpayers, the welfare impact (B_t) is the net present value of additional future tax revenues due to the program minus the fiscal cost of the program and of any additional expenditure it induced, for example, on publicly funded tertiary education. Fiscal costs of the program primarily accrue in the short run while fiscal revenue accrues in the long run. The key outcome to estimate this is the additional contribution of participants to government revenue through increased payroll taxes, which are only levied on formal sector employment, and which we observe for the universe of applicants through administrative social security records.

Besides the impacts on participants and taxpayers, there may be other externalities (B_o), which may influence welfare calculations. We do not attempt to quantify these externalities directly. Instead, we calculate how large the negative externalities would have to be to offset the positive impacts we find elsewhere.

The design of the PACES program and the Colombian context included several features that likely reduced its fiscal cost. First, vouchers cost less than per pupil expenditure in public schools. Second, vouchers could be augmented with household funds. To the extent that the program "crowded in" household funds for education, increasing winners' human capital and

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[13] One limitation of this revealed preference approach is that it neglects other non-financial utility consequences of winning a voucher, many of which are plausibly positive (e.g. lower risks of teen pregnancy), but some may be costly in welfare terms (e.g. greater effort in secondary school.)

future taxable earnings, the government budget constraint improves. Allowing "top-ups" also avoids creating incentives for some families to trade down from higher cost private schools to private schools with fees at or below the value of the voucher, which could have reduced human capital accumulation and future taxable income. Third, as is fairly standard in many voucher programs, program rules made retention in the program conditional on satisfactory grade completion. Indeed, we find that on-time secondary graduation increased and grade retention fell as a result of the voucher offers. To the extent that reduced repetition led to fewer years of schooling taking place in public schools, public expenditure in education fell. Fourth, vouchers were targeted to the poor, reducing the extent to which the program simply subsidized students who would have gone to private school anyway.

3.3 Empirical strategy

Our main empirical strategy is based on an intent-to-treat (ITT) analysis that compares outcomes between voucher lottery winners and losers, as follows:

$$Y_i = \alpha + \gamma Z_i + \beta X_i + \varepsilon_i$$

where Y_i is an outcome variable for voucher applicant i, Z_i is an indicator variable for whether applicant i was awarded a private school voucher through the lottery, X_i is a vector of baseline controls from the voucher application form that includes age, gender and whether the applicant had a phone number at the time of application, and ε_i is an error term.

Because students applied to private schools prior to the lottery, we also estimate the

main regression equation separately by the type of school to which they applied. The lottery could be viewed as two separate lotteries – a lottery for students who had applied to vocational schools and a lottery for students who applied to other schools.

Some of our outcomes are conditional on other endogenous outcomes. For example, self-reported earnings and fertility are only observed if a person appears in the SISBEN. A student only appears in the SISBEN if they live in a poor neighborhood, and lottery winners are less likely to appear in the SISBEN data. To account for such conditionality, we construct bounds on treatment effect estimates. Assuming that those winners who moved out of strata one and two neighborhoods due to receiving the voucher had better outcomes than those who remained in those neighborhoods, the raw difference between SISBEN outcomes among winners and losers will be a lower bound on the voucher effect. We estimate an upper bound by trimming the corresponding proportion among losers (Angrist, Bettinger, Kremer, 2006).

4. Voucher Impacts on Long Run Educational Outcomes

4.1 Secondary education completion outcomes

Voucher lottery winners are 17 percent (7.6 percentage points) more likely to complete secondary school on time relative to losers' on-schedule completion rate of 45.2 percent (Panel

A, Table 3).[14] Point estimates of voucher effects are slightly larger (both in percent and percentage point terms) among applicants to vocational schools, but differences between the two are not statistically significant. Voucher lottery winners are 10 percent (5.4 percentage points) more likely to complete secondary school within six years after on-schedule completion relative to a base rate of 56.5 percent. During the six years following on-schedule completion, the difference between the proportion of voucher lottery winners and losers who have completed secondary school declines with each year.

As discussed in Angrist et al. (2002), voucher winners were not only more likely to attend private schools, but also traded up to more expensive private schools, but paid less out of pocket for school fees than losers. In Appendix Table A1, we show that the pattern observed by Angrist et al. (2002) also occurs among academic and vocational applicants respectively. In both cases, voucher winners pay more in gross fees but less out of pocket fees. There is no difference in the extent to which each subsample "trades up" to more expensive schools.

4.2 Tertiary education outcomes

Effects on tertiary education outcomes are concentrated among students who applied to vocational schools. In this population, the base rate of ever enrollment in tertiary education is 19 percent and this increases by 7 percentage points (37 percent) among voucher lottery winners

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[14] We define on-schedule secondary school completion as having taken the tertiary education entry test no later than six years after applying for the voucher, that is to say by 2001. With our updated matching strategy including adult identification numbers, we obtain substantially higher match rates than Angrist et al. (2006). Impact estimates in percentage points are similar.

(Panel B, Table 3). The voucher impact difference across academic and vocational applicants in the probability of ever enrolling in tertiary education is statistically significant (Panel B, Column 7, Table 3). Within this group the effects are particularly driven by males, for whom there is a 10 percentage-point gain in ever enrollment in tertiary education on a base of approximately 16 percent (see Table A2).

Among vocational school applicants there is also evidence of gains in tertiary graduation rates and in total years of tertiary education.[15] Vocational voucher winners are 2.4 percentage points more likely to graduate from tertiary education from a base rate of 4.9 percent among vocational voucher losers. In this population, winners complete 0.19 additional years of tertiary education, which corresponds to a 45 percent increase relative to the base rate of 0.42 years among losers. The difference on tertiary graduation and years of education in voucher impact between academic and vocational applicants is statistically significant (Column 7, Table 3).

Among applicants to academic secondary schools, there is no evidence that vouchers increase the rate of ever enrolling in tertiary education. There is evidence, however, that among academic school applicants, voucher winners were more likely to be enrolled as of 2012—our last year of tertiary education data—by approximately 3 percentage points on a base of 3 percent.   This is also true to a lesser extent among vocational applicants and we cannot reject equality across academic and vocational samples (Column 7, Panel B, Table 3).

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[15] Tertiary graduation and tertiary years of schooling are defined as zero for those who never enroll.

5. Voucher Impacts on Labor Market Outcomes and Middle Class Consumption

In this section, we first show that winning a PACES voucher did not affect the intensive or extensive margin of formal sector labor participation, but that it nonetheless increased formal labor market earnings, and payroll taxes, with this effect concentrated among those applying to vocational schools (subsection 5.1). Subsection 5.2 discusses informal earnings. Since data on informal income are only available through a census of residents of these neighborhoods, we can only bound—and not point estimate— differences in informal income, but accounting for informal income does not change the overall picture. Subsection 5.3 discusses impacts on middle class consumption.

5.1 Formal-sector participation, intensity and earnings

There are no significant differences between lottery winners and losers in time spent in formal employment on either the intensive or extensive margin. Eighty percent of voucher lottery losers appear in the SISPRO government records as having been in formal sector employment sometime between 2008 and 2014. Point estimates suggest that lottery winners are about one percent (0.8 percentage points) more likely to appear in formal employment records during this period. However, this difference is not statistically significant (Top Row, Table 4).

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Extensive formal employment rates do not systematically differ between winners and losers in the full applicant sample or separately by vocational/academic school application status (Table A3). Similarly, we find no differences in the intensity of formal labor market involvement as measured by time spent in formal employment. On average voucher lottery losers participated in the formal sector for 5.5 months/year in 2008-2014. Voucher lottery winners participated roughly one-fourth of a month more; however, this difference is not significant. The point estimates are virtually identical across the academic and vocational samples.

Current annual formal earnings for voucher lottery losers are, on average, $2,470 (including zeros). Voucher lottery winners earn an additional $196 in formal annual earnings, an 8 percent increase (Panel A, Table 4). The p-value on this difference is 0.06.

Earning effects are driven by those who applied to vocational schools. Current annual formal earnings for voucher lottery losers who applied to vocational schools are, on average, $ 2,568 (including zeros). Voucher lottery winners from applicants to vocational schools earn an additional $427 in formal annual earnings, a 17 percent increase (column 6, Table 4). The voucher impact difference across academic and vocational applicants for annual formal earnings has a p-value of 0.08 (Panel A, Column 7, Table 4). The effects among vocational school applicants are particularly strong for men. Male lottery losers earn $2,743 while winners earn $535.3 more per year, a 20 percent increase. For males, the voucher impact difference across academic and vocational applicants for annual formal earnings has a p-value of 0.07

(Panel C, Column 7, Table 4). These results are robust to alternative approaches to controlling

for age as well as to excluding application controls (Table A4).[16]

As discussed further below, much of the effect of the voucher seems to be not in

improving outcomes at the bottom of the distribution, but in increasing the odds that winners

make it into the middle-class. In Colombia, the threshold for being considered middle-class is

PPP\$10/day (PPP\$3,600/year, Angulo et al. 2013). Near age 33, 44 percent of voucher lottery

losers have annual formal earnings at or above the middle-class threshold. Voucher lottery

winners are 3.7 percentage points (8.4 percent) more likely than losers to have earnings at or

above the middle-class threshold. (Panel A of Table 4). If we consider people to be middle class

either if they are earning more than PPP\$10/day or if ever enrolled in tertiary education, 51

percent of voucher lottery losers have access the middle class. Voucher lottery winners are 3

percentage points (6 percent) more likely than losers to have entered the middle class, a

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[16] This analysis may understate formal earnings' voucher impacts to the extent that, in the full sample, lottery winners are about two percentage points more likely to be enrolled in tertiary education in 2012—our last year of tertiary education data, which overlaps with the period of formal sector earnings data. This may limit winners' current earnings while increasing their future earnings. To bound what the future earnings difference is likely to be between winners and losers once the former complete tertiary education, we can assume that in the absence of a voucher, earnings of applicants who attend and complete tertiary education are at the top of the earnings distribution. Under this assumption, we can bound the estimate for the effect of winning a voucher on future earnings by trimming the top two to three percent of formal earners in the voucher loser group. Table A5 shows results for this bounding approach. An upper bound estimate on voucher lottery winners' future earnings is \$490, a 23 percent increase (Column 2, Panel A, Table A5). Among academic applicants the bound on the voucher effect on future winner earnings is \$396, a 19 percent increase (Column 4, Panel A, Table A5). Among vocational applicants the bound on the voucher effect on future winner earnings is \$702, a 31 percent increase (Column 6, Panel A, Table A5). An alternative assumption, which to us seems conservative, is that future earnings of lottery winners still enrolled in tertiary education would be equal to the current average earnings of lottery losers who obtained some tertiary education but are no longer enrolled in tertiary education. Under this assumption, lottery winners' future earnings will exceed those of losers by \$206, for an 8 percent increase, statistically significant at the 5 percent level (Column 2, Panel A, Table A6). Among vocational applicants, under this assumption the voucher effect on future winner earnings is \$442.4, a 17 percent increase (Column 6, Panel A, Table A6).

difference that is significant at the 10 percent (Panel A of Table 4). Among vocational applicants, voucher winners are 6 percentage points (12 percent) more likely than losers to have entered the middle class by age 33.

Power is limited to look at effects by quantile, but quantile regression results suggest that the effects of the voucher on total formal sector earnings at age 33 are strongest at the top of the distribution for vocational school applicants. We see no gains at the top for applicants to academic schools, possibly because they are more likely to currently be enrolled in university (Figure 1). Additionally, we find little evidence of effects at the bottom of the distribution. Moreover, in the full sample of applicants, by type of school, or by gender, winning the voucher does not affect government welfare receipt of *Familias en Acción*, subsidized health care programs or eligibility for early childhood care (Table A7).

Since formal-sector days are fairly similar between lottery winners and losers, the higher earnings seem to reflect greater earnings per formal-sector day, rather than more hours. This result is contrary to a model in which education is used as a signaling device to ration formal sector jobs, but consistent with a human capital model of increased productivity.

One hypothesis for the concentration of labor market effects among vocational applicants is that private vocational education was more responsive to the labor market and advanced training opportunities than public vocational education. Private schools, which enter and exit more quickly than public schools may adapt more rapidly to changing labor market

needs. Within vocational schools, 92 percent of private schools offer a commercial curriculum, whereas only 62% of public schools do so (Bettinger, Kremer, Saavedra 2010). Among vocational school applicants, formal earnings effects are particularly strong among applicants to schools with a commercial focus, and for males in particular, we reject equality of voucher effects across different vocational curricula (p-value 0.06, Panel C, Table A8).

5.2 Self-reported earnings in SISBEN data

Although we do not have data on informal earnings for the full sample, we can draw some inferences by looking at the SISBEN survey to create bounds for the impact on earnings within a subpopulation. The SISBEN survey covers low-SES neighborhoods and includes about 52 percent of the voucher applicant population fifteen years after initial voucher award (Table 5). SISBEN 2010 earnings are a cross-section of self-reported earnings for 2010.

Lottery winners are 5.4 percent (2.8 percentage points) less likely to ever appear in SISBEN data, indicating that they are less likely to reside in poor neighborhoods fifteen years after winning the voucher. This difference is statistically significant at the 10% level (column 1, Table 5). To the extent that the approximately 5 percent of winners who moved out of the low-income SISBEN neighborhoods due to winning a voucher had better outcomes than those who remained in neighborhoods covered by SISBEN the win-loss contrast will be a lower bound. As explained in the methods section, we can estimate an upper bound by trimming the top 5 percent of earners among losers.

Table 6 reports bounds on the voucher effect on self-reported total annual earnings from the SISBEN census of the poor. Over two thirds of SISBEN respondents report not paying payroll taxes, which implies that for them these total earnings are likely informal earnings. The upper bound is $366 on a base of $2,000, and statistically significant. The lower bound impact on annual self-reported total earnings is statistically insignificant. Together with the fact that we see no formal labor supply response as a result of winning a voucher suggests that increased formal earnings are not merely the result of substitution from informal into formal employment among voucher winners.

5.3 Middle Class Consumption

Having shown the impact on earnings, we now turn our attention to consumption. We show impacts on three different types of middle class consumption – housing, car purchasing and credit card debt. We have already reported some evidence on housing consumption. The SISBEN census focuses on the poorest 70 percent of neighborhoods in Colombia. We find that voucher winners were five percentage points less likely to be living in these neighborhoods at the times of these surveys, suggesting housing upgrades among voucher winners.

We also find that voucher winners are more likely to own cars. Since the majority of people in Colombia use loans to buy a car (Fasecolda 2014), greater access to car loans suggests greater car ownership. Among vocational applicants, winning a voucher increases car loan access by 2.1 percentage points, a 55-percent difference from a base of 3.8 percent that is

significant at the 10 percent level (Panel A, Column 6, Table 7). Within vocational applicants, male lottery winners are 5.1 percentage points more likely to have access to a car loan, a 142-percent increase from a base of 3.6 percent (Panel C, Column 6, Table 7).

Finally, voucher applicants have greater access to consumer credit. Lottery winners are 3.8 percentage points more likely to have ever owned a credit card, a seven percent increase (Panel A, Column 2, Table 7). This effect is driven by vocational applicants, among whom winning a voucher increases credit card access by 5.4 percent, or close to 10 percent from a base of 56 percent (Panel A, Columns 5 and 6, Table 7).[17]

6. Voucher Impacts on Teen Fertility

Fertility is only observed for applicants in the SISBEN 2010 data. Since voucher winners have a lower likelihood of appearing in SISBEN 2010 data, estimated effects conditional on SISBEN appearance will be a lower bound on the true effect on teen fertility as long as winners who moved out of low-SES neighborhoods covered by SISBEN as a consequence of winning the voucher have a lower chance of being teenage parents than lottery winners who remained in neighborhoods covered by SISBEN. We can compute upper bound estimates on fertility by trimming the 5 percent of lottery losers with the lowest fertility. As discussed below, bounds on fertility effects of winning a voucher are tight.

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[17] Voucher winners actually seem to have lower credit risk, according to bounding estimates on interest rates paid on loans. Estimates of these bounds are negative in the full sample and in the sample of vocational applicants, particularly male applicants, suggesting that in these subpopulations, voucher winners unambiguously have lower credit risk (Table A9).

Voucher winners are between 18 and 19 percent (4.3 to 4.7 percentage points) less likely to have a child during their teenage years relative to the lottery losers' (untrimmed) mean of 23.4 percent (Table 8). Among females, winning a voucher reduces teen motherhood by between 17 and 19 percent (between 6.5 and 7.4 percentage points) relative to a base of 37.7 percent. Male lottery winners are between 32 and 34 percent (between 5.1 and 5.6 percentage points) less likely to have a spouse or partner who had a child as a teenager relative to a base rate of 16.1 percent (Panel C, Table 8.)[18] These effects are concentrated among applicants to academic schools (Columns 4 and 6, Table 8), suggesting that mechanisms may be quite different than those driving the effects on tertiary education and on the upper end of formal earnings and consumption.

The reduction in teen fertility could be the result of an "incarceration" effect by which winners stay in school longer and, or it could be an opportunity cost effect by which additional human capital increases wages, making time more valuable and reducing desired fertility. If the former is the driving mechanism, we might not observe voucher impacts on total fertility because there may be catch up fertility once schooling is completed. In contrast, if the driving mechanism is opportunity cost, we should observe an effect on total fertility.

In fact, we find no evidence that winning a voucher changed total fertility since both lower and upper bound estimates include zero. At the time of SISBEN 2010, in which applicants

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[18] The incidence of teen fatherhood of male's partners is low in our data because males are older than their partners.

are about twenty-eight years old, the average voucher lottery loser has one child. Lower and upper bound estimates of the effect of winning a voucher on total fertility are fairly precisely estimated and both close to zero. This pattern of results is consistent with the hypothesis that winning a voucher reduces teen fertility by keeping students in secondary school longer rather than permanently increasing the opportunity cost of time. One caveat is that impacts on total fertility may show up later in the potential childbearing years, so fertility gaps may appear later.

7.   Welfare Impacts

Subsection 7.1 discusses short-term fiscal costs and long-term fiscal benefits. Subsection 7.2 discusses short-term participant costs and long-term participant benefits. In subsection 7.3, we estimate how large net negative externalities on others would need to be to imply that the program is not welfare improving to society.[19]

7.1 Fiscal costs and benefits

In the short run, fiscal costs stem from: i) costs net of savings from reduced expenditure on public education, ii) costs net of savings from reduced secondary school grade repetition,

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[19] We quantify welfare impacts in the full sample of applicants and separately by applicants to academic and vocational schools and compute bootstrap confidence intervals for costs and benefits. Throughout the section, we make the following assumptions. The discount rate we use is 3.6 percent, the average real interest rate on new external government debt commitments for Colombia between 2002 and 2012 (World Development Indicators database). In all calculations that follow we estimate amounts per voucher winner, separately for males and females, which assumes that the counterfactual situation is no voucher program. Throughout the analysis, for each source of cost and revenue, we compute the NPVs converting into United States dollars (if not already) using the year-specific exchange rate (Dec. 31 of that year) between US dollars and Colombian pesos from the Colombian Central Bank, deflating nominal costs back to real value in base year (1995) using the US-CPI change between base year and incurrence of costs (or revenue), taking the present value of the cost and revenue stream. We express the NPV in US dollars for the year of analysis (2013) using US-CPI change between the analysis and the base year.

iii) increased tertiary education costs, iv) costs of government-provided welfare benefits, and

v) foregone tax revenues due to reduced work time among voucher winners to the extent that

they spend more time in school. Below we present estimates for, (i) and (ii), which are by far

the largest source of government costs. Appendix C contains detailed costs calculations for (iii)-

(v).

7.1.a. Short-term costs net of savings associated with private secondary school of

attendance

To estimate the increased secondary school fiscal cost per winner, we first consider the

impact on students who would have attended private school in the absence of the program, for

whom the voucher increases public expenditure.[20] We compute the six-year increase in

expenditure by taking the annual value of the PACES vouchers ($244) and multiplying it by

the proportion of students who would have used the voucher in grades 6 to 11 in the absence of

the program.[21] When we integrate over the usage patterns, we estimate that public expenditure

increased by $473 among all applicants ($472 for academic school applicants and $474 for

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[20] For example, a substantial proportion (87.7 percent) of lottery losers attended private school in sixth grade.
While the government did not have to pay for the fees of the lottery losers, it did have to pay for the voucher value
for students who won the lottery. This cost decreases over time because the proportion of applicants who attended
private school among lottery losers quickly deteriorated (53.9 percent by 8th grade).

[21] Among lottery winners, not all private school attendees continued to use the voucher through secondary
graduation. By 8th grade, 33 percent of lottery winners who were attending private school were not using the
voucher. These students may have repeated grades, transferred schools, or voluntary given up the voucher. After
8th grade, we have no data on voucher usage. From prior data, we know that 54 percent of lottery losers were
attending private school in 8th grade (Angrist et al. 2002 Table 3) and that 32 percent of them finished 11th grade
in private school (Is this from Angrist et al. 2006 Table 2, other source?). We assume a constant (linear)
deterioration from 8th grade to 11th grade in the fraction of losers attending private school. This implies a 40
percent relative reduction in the fraction attending private school, and we assume that deterioration in voucher
usage among winners follows a similar 40 percent decline from the 8th grade level until graduation.

vocational school applicants) as a result of the awarding of private school vouchers to students who would have attended private schools regardless of the voucher program (Row 3 of Table 9).

The voucher, however, also induced some who would have attended public school to instead attend private school. The voucher's value ($244) was considerably lower than the annual cost of public school ($449). Assuming that the marginal cost of public education equals the average cost for each student who moved from public to private school, the government saved $205 per year.[22] To figure out the net impact on overall costs, we multiply this cost savings by the proportion of students who attended private schools as a result of the voucher.[23] When aggregated across the six years after the voucher, we estimate that the vouchers reduced public expenditure by $175 among all applicants as a result of the shift of students from public to private schools (Row 4).

Total fiscal costs are the sum of secondary education costs (6) plus other costs (Row 9 for additional tertiary costs, Row 10 for welfare costs, and Row 13 for foregone revenue, see Appendix C for details), or $360 ($333 for academic school applicants and $401 for vocational school applicants, Row 14).

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[22] Angrist et al. (2002, p. 1537) reports the annual cost of public school to be $350 and the average voucher value to be $190, both in 1998 dollars. We calculate that in 2013 prices, these figures correspond to $449 and 244, respectively. While marginal costs may be less than average costs if policy makers are loathe to close schools and enrollment is declining. This was a period of expanding school enrollment.

[23] We obtain these impacts on private school attendance for grades 6th through 8th from Table 4, column 2 (for males) and column 4 (for females). After 8th grade, we assume a constant change from the observed 8th grade effect to the eventual effect at graduation.

7.1.b Long-term taxpayer benefits associated with increased formal earnings

By increasing winners' earnings, the voucher increased tax revenue from VAT taxes and from payroll taxes. We assume that all formal sector earnings are spent on goods with VAT levied and that informal sector earnings are either unchanged by the program or are untaxed. We project annual formal sector earnings (from Table 4) for losers and winners over a 35-year work horizon allowing for a 3.02 percent annual growth rate.[24] Multiplying the NPV of additional earnings by the 13.3 percent VAT tax rate yields $1,098 in additional NPV of VAT tax revenue, ($151 for academic school applicants and $2,417 for vocational school applicants, Row 16). Expected additional government revenue from payroll taxes is this difference multiplied by 40 percent, since, we assume that the margin forty percent of payroll taxes represents a net transfer to the government. This comes to $929 ($45 for academic school applicants and $2,135 for vocational school applicants, Row 17). The estimated increase in additional taxpayer revenue is statistically significant at $2,027 ($196 for academic school applicants and $4,551 for vocational school applicants, Row 18).

The point estimate of the net fiscal cost to taxpayers is -$1,667 ($136 for academic school applicants and -$4,151 for vocational school applicants, Row 20). The upper bound of the 95 percent confidence interval on the net fiscal cost per voucher recipient is $304 ($2,913 for academic school applicants and -$372 for vocational school applicants) indicating that

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[24] The rate of 3.02 percent is the average annual growth in GDP per capita in Colombia between 2002 and 2012 (World Development Indicators database).

expected net fiscal costs to taxpayers are likely to be negative in the full sample, with a small probability that they are small and positive. Among vocational school applicants, the cost to taxpayers is strongly negative.

The result that net fiscal costs are negative is robust to a variety of alternative assumptions. Even under the extremely conservative assumption that any increase in formal sector earnings are offset by reduced informal earnings, so there are no gains in VAT revenue, expected net costs for taxpayers are -$569 due solely to increased payroll tax receipt (Row 14 minus Row 19). This is an extreme assumption, since our formal labor market results imply in an unlikely scenario no more than 50 percent offset.[25] Net fiscal costs are also negative if we assume a discount rate of 6 percent instead of 3.66 percent.

7.2 Costs and benefits to participants

Welfare impacts on voucher recipients can be measured in two different ways. First, we can conduct a straightforward financial calculation of the net present value of increased long-term earnings minus the short-term additional costs to families of private schooling and lost earnings during additional years of education. This financial calculation yields that the net benefits per voucher recipient are $8,167.3 ($1,091.6 for academic applicants, $18,034.8 for vocational applicants, Row 22).

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[25] Table 4 results suggest that formal earnings for voucher winners increase by 8 percent (all applicants). Formal tenure sector tenure increases by 0.23 statistically insignificant months/year, or 4 percent from a base of 5.52 months/year. Therefore the maximum offset of VAT tax revenue from a transition from informal into formal work is 4 percent divided by 8 percent, which equals 50 percent.

In the even more conservative revealed-preference approach, welfare gains stem only from infra-marginal transfers to those who would have gone to private school anyway. Angrist et. al (2002) shows that over 85 percent of recipients would have attended private school anyway. This implies that gains to infra-marginal recipients were at least $249 per voucher winner.[26]

7.3 Externality impacts on others

While we can measure impacts on taxpayers and voucher recipients, we are not able to identify potential externality impacts on others, and to the extent that such effects exist, they should be part of any welfare calculation. The program could potentially have created positive externalities from human capital and reduced teen fertility, or negative externalities if gains for program winners reflect assignment to more favorable peers or signaling benefits in the labor market. In earlier work, a subset of the authors of this paper argues against the view that effects are entirely due to changes in peer assignment (Bettinger, Kremer and Saavedra 2010).

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[26] The gain for infra-marginal recipients = (fraction of infra-marginal recipients)*(impact on voucher amount)*(sum of year-by-year utilization rate). The fraction of lottery losers who attend private school in 6th grade is 0.897 among females and 0.857 among males. The impact on voucher amount is $93.2 (from Angrist et al. 2002 Table 8, column 3 updated to 2013 dollars). We observe the fraction of winners in private school using the voucher for grades 6th and 8th only. The 7th grade fraction is the linear combination of the 6th and 8th grade rates. For females the fraction of winners in private school using the voucher is 0.953 (6th), 0.736 (7th) and 0.519 (8th). For males it is 0.933 (6th), 0.698 (7th) and 0.463 (8th). After 8th grade, we have no data on voucher usage. We know that 32 percent of the overall lottery loser sample finished 11th grade in private school. We assume a constant deterioration from 8th grade to 11th grade in the fraction of losers attending private school. This implies a 40 percent reduction in the fraction attending private school, and we assume that deterioration in voucher usage among winners follows a similar 40 percent decline from the 8th grade level. Under these assumptions, voucher usage rates for females are 0.415 (9th), 0.310 (10th) and 0.206 (11th). For males the voucher usage rates are 0.374 (9th), 0.284 (10th) and 0.195 (11th).

The calculations above imply that the program is welfare improving as long as any externalities are either positive, or negative and less than $1,916 per voucher recipient in the case in which we compute benefits to recipients using the lower bound revealed preference approach (Row 23) or as long as they are positive, or negative and less than $9,834 per voucher recipient when we estimate benefits to recipients based on financial impact (Row 24). The estimated lower bound seems plausible since participants' likely value the increased years of schooling and any gains on standardized tests. While they conceivably could have experienced either positive or negative changes in non-financial utility from school and potentially switching to winning the lottery, it seems unlikely that this was both negative and large enough to outweigh the later non-financial benefits.

8. Conclusion

In many low-income countries access to primary education is nearly universal. To cope with increased demand, policymakers have turned to financing private secondary schools—in an effort to expand capacity at potentially a reduced fiscal cost—with renewed interest in vocational education. There is a question, however, of how well prepared new cohorts of primary school graduates from disadvantaged backgrounds are for secondary schooling. Colombia's experience suggests that there is a way of increasing access to secondary education for the poor through school vouchers that does not create undue fiscal costs, and that an appropriately structured program that includes a vocational option can yield long-term human

capital benefits for participants. Moreover, it can do so in a way in which opens up a vehicle for social mobility, as PACES voucher beneficiaries greatly increased their chance of transitioning to the middle class in the long run.

Our evidence indicates that private vocational schools may have played a key role, and the concentration of effects among vocational students enables us to shed light on mechanisms why may or may not have been at play. For example, our results suggest that effects are unlikely to be primarily the result of lottery winners obtaining more desirable peers, since among vocational applicants, lottery winners did not attend schools with better observable peers. Similarly, gains at the tertiary education level and in the labor market, particularly among vocational school applicants, suggest that the impact of the program on secondary completion was not simply due to private schools gaming of the system by lowering the standards for grade progression. Insofar as renewal of the voucher was conditional on grade progression, the voucher program combined elements of a private school voucher program with elements of a merit voucher program. However, it seems unlikely that this incentive effect explains the results. If the effects of the program were solely due to its merit voucher component, then one would expect the strongest impacts to occur among those who are near the boundary of failing grades. In fact, it seems that many of the strongest impacts are at the top of the distribution, such as on tertiary enrolment—which only 19 percent of lottery losers ever accomplish—and on tertiary graduation—which only 5 percent of losers accomplish. Effects on formal sector

earnings are also relevant for applicants to vocational schools at the top of the distribution. Moreover, we do not observe any effects on the fraction of applicants who are eligible to receive government subsidies. The main place we see an effect that might be at the bottom of the distribution is on teen fertility. The evidence suggests that the voucher improves outcomes through other mechanisms, such as private vocational education improving long-term outcomes by providing more pertinent education that helps students to more effectively transition from secondary school into advanced training and the labor force.

One parsimonious explanation that can reconcile our results with the broader school voucher literature, which typically has not found very positive results, is that private school vouchers were particularly important for the subset of the population that wishes to pursue options other than traditional academic secondary schools. The government may not offer these students an option that is located appropriately in the physical or product market space. However, a voucher program focused only on vocational education would likely have a different impact because it would affect families' application incentives.

Some features of the program design helped to minimize its cost to taxpayers. First, vouchers covered only part of the cost of private school and applicants had to cover the rest of the costs. Indeed, the vouchers crowded-in educational expenses as households invested more total resources in education (Angrist et al 2002). The conditioning of voucher renewal created incentives that reduced grade repetition (Angrist et al 2002). PACES allowed households to top

up additional financial investments by households in education generate positive fiscal externalities if the additional human capital of voucher lottery winners increases long-run earnings. Moreover, there is no offsetting reduction on short-run labor supply (and hence short-run tax collection).[27] On the whole, the evidence suggests that it likely costs substantially less than a dollar to transfer one dollar in net present value to children born in strata one and two households through private school vouchers.

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[27] By contrast, other educational subsidy programs such as state merit aid programs in the US that pay for additional years of school and keep students in school longer (see for example Dynarski 2000; Kane 2003) will have offsetting effects. They reduce short-run tax revenue by delaying labor market entry and increase long-run revenue by boosting later earnings, with the overall impact on the NPV of tax revenue unclear.

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Table 1. Voucher impact on enrollment by school type after three years

3 years after the lottery	Academic Applicants		Vocational Applicants	
	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher
	(1)	(2)	(3)	(4)
Attending a vocational school	0.063	-0.029	0.426	0.176
		(0.015)*		(0.059)**
Attending an academic school	0.757	0.035	0.426	-0.186
		(0.027)		(0.057)**
Attending a private school	0.531	0.171	0.539	0.151
		(0.059)**		(0.032)***
In school	0.86	0.007	0.82	0.02
		(0.020)		(0.020)

Notes: This table replicates Table 1 in Bettinger, Kremer and Saavedra (2010) based on survey data from Angrist et al. (2002) for 1,176 voucher applicants from Bogota in 1995.

Table 2. Descriptive statistics of the Bogotá 1995 PACES voucher applicant cohort

	All			Academic Applicants		Vocational Applicants	
	Loser's Mean	Won Voucher	Won Voucher, Valid School Type Info	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher
	(1)	(2)	(3)	(4)	(5)	(7)	(8)
A. Data from PACES Application							
Has Phone	0.882	0.009	0.009	0.869	0.013	0.899	0.003
		(0.011)	(0.011)		(0.015)		(0.016)
Age at time of application	12.74	-0.086	-0.086	12.78	-0.033	12.63	-0.144
	(1.327)	(0.045)*	(0.046)*	(1.333)	(0.062)	(1.287)	(0.068)**
Male	0.49	0.011	0.018	0.504	0.008	0.457	0.033
		(0.017)	(0.017)		(0.023)		(0.026)
Applied to Vocational School	0.433	0.017	0.017				
		(0.017)	(0.017)				
B. National Identification Data							
Valid youth identification number	0.967	0.001	0.002	0.959	0.013	0.976	-0.011
		(0.006)	(0.006)		(0.009)		(0.009)
Valid adult identification number	0.978	-0.003	-0.004	0.979	-0.008	0.979	0.001
		(0.005)	(0.005)		(0.007)		(0.007)
N	1519	3661	3413	803	1901	613	1512

Notes: Table reports OLS voucher lottery loser's means and estimated effects of winning a voucher. Numbers in parentheses are standard deviations in columns of means and standard errors in columns of estimated voucher effects. Results in Panel A are the same as those in Angrist et al. (2006) for having a phone, age at the time of application and gender, and as those in Bettinger et al. (2010) for having applied to a vocational school.

Table 3. Voucher impacts on long run educational outcomes

	All		Academic Applicants		Vocational Applicants		
	Loser's Mean (1)	Won Voucher (2)	Loser's Mean (3)	Won Voucher (4)	Loser's Mean (5)	Won Voucher (6)	Difference (6) - (4) (7)
A. Secondary school completion (ICFES secondary graduation exam database)							
Graduated on schedule	0.452	0.076	0.455	0.071	0.473	0.083	0.012
	(0.498)	(0.016)***	(0.498)	(0.021)***	(0.5)	(0.025)***	(0.715)
Graduated with up to a six-year delay	0.565	0.054	0.552	0.055	0.605	0.060	0.006
	(0.496)	(0.015)***	(0.498)	(0.021)***	(0.489)	(0.024)**	(0.858)
B. Tertiary enrollment and persistence (Tertiary education database)							
Ever enrolled in tertiary education	0.189	0.024	0.194	0.000	0.188	0.070	0.069
	(0.392)	(0.013)*	(0.396)	(0.018)	(0.391)	(0.021)***	(0.012)**
Ever enrolled in a vocational college	0.066	0.014	0.071	0.006	0.064	0.028	0.021
	(0.248)	(0.009)*	(0.257)	(0.012)	(0.244)	(0.014)**	(0.238)
Ever enrolled in a university	0.131	0.014	0.130	-0.002	0.135	0.046	0.048
	(0.338)	(0.011)	(0.336)	(0.015)	(0.342)	(0.019)**	(0.044)**
Enrolled in tertiary as of 2012	0.036	0.023	0.030	0.031	0.039	0.021	-0.010
	(0.185)	(0.007)***	(0.17)	(0.009)***	(0.194)	(0.011)*	(0.502)
Enrolled in private institution as of 2012	0.030	0.018	0.025	0.027	0.038	0.012	-0.016
	(0.171)	(0.006)***	(0.156)	(0.009)***	(0.19)	(0.011)	(0.252)
Enrolled in a public institution as of 2012	0.005	0.006	0.005	0.006	0.002	0.010	0.004
	(0.072)	(0.003)**	(0.07)	(0.004)	(0.04)	(0.004)**	(0.458)
Graduated from tertiary as of 2012	0.050	0.006	0.054	-0.008	0.049	0.024	0.032
	(0.218)	(0.007)	(0.225)	(0.01)	(0.216)	(0.012)**	(0.042)**
Years of tertiary education	0.420	0.064	0.428	-0.019	0.423	0.191	0.210
	(1.19)	(0.04)	(1.202)	(0.054)	(1.2)	(0.067)***	(0.014)**

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher with application controls. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Estimates in columns 2,4 and 6 are from linear probability models. Numbers in parentheses are robust standard errors in columns of estimated voucher effects. Graduated on schedule is if the applicant took the college entry test in 2001 or before; graduated with up to a two-, four- or six-year delay is if the applicant took the college entry test on or before 2003, 2005 and 2007, respectively. * significant 10%, ** significant 5%, *** significant 1%.

Table 4. Voucher impacts on formal sector employment intensity, earnings and payroll taxes 2008-2014

	All		Academic Applicants		Vocational Applicants		
	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Difference (6) - (4) (p-value)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. All applicants							
Matched to formal sector earnings data	0.801	0.008	0.797	0.009	0.811	0.012	-0.169
		(0.013)		(0.018)		(0.020)	(0.55)
Average annual formal sector employment (months)	5.52	0.23	5.57	0.22	5.59	0.28	0.07
	(4.40)	(0.15)	(4.40)	(0.20)	(4.42)	(0.23)	(0.83)
Average Annual Formal Sector Earnings	2,470.5	196.0	2,462.5	31.4	2,568.3	427.0	395.6
	(3,019.9)	(104.7)*	(2,986.2)	(132.7)	(3,147.3)	(184)**	(0.08)*
Middle Class Earnings	0.44	0.037	0.46	0.03	0.46	0.04	0.01
	(0.50)	(0.02)**	(0.50)	(0.02)	(0.50)	(0.03)	(0.83)
Middle Class through Formal Earnings or Tertiary Education	0.51	0.03	0.52	0.02	0.50	0.06	0.04
	(0.50)	(0.02)*	(0.50)	(0.02)	(0.50)	(0.03)**	(0.25)
B. Females							
Average annual formal sector tenure (months)	5.17	0.26	5.22	0.29	5.32	0.12	-0.17
	(4.41)	(0.20)	(4.38)	(0.28)	(4.49)	(0.32)	(0.69)
Average Annual Formal Sector Earnings	2,264.1	240.6	2,238.0	121.6	2,422.4	328.8	207.2
	(2,826.9)	(143.4)*	(2,810.2)	(182.3)	(2,941.1)	(248.4)	(0.5)
Middle-Class Earnings	0.40	0.042	0.41	0.04	0.41	0.04	0.00
	(0.49)	(0.02)*	(0.50)	(0.03)	(0.49)	(0.04)	(1.00)
Middle Class through Formal Earnings or Tertiary Education	0.46	0.05	0.47	0.04	0.47	0.05	0.01
	(0.50)	(0.02)**	(0.50)	(0.04)	(0.50)	(0.04)	(0.86)
C. Males							
Average annual formal sector tenure (months)	5.9	0.19	5.91	0.11	5.91	0.46	0.35
	(4.35)	(0.21)	(4.39)	(0.29)	(4.32)	(0.33)	(0.43)
Average Annual Formal Sector Earnings	2,687.7	146.9	2,685.8	-64.7	2,743.0	535.3	600.0
	(3,198.1)	(152.7)	(3,139.2)	(191.9)	(3,375.0)	(272.7)**	(0.07)*
Middle-Class Earnings	0.49	0.031	0.50	0.03	0.49	0.05	0.02
	(0.50)	(0.02)	(0.50)	(0.03)	(0.50)	(0.04)	(0.72)
Middle Class through Formal Earnings or Tertiary Education	0.56	0.02	0.57	0.01	0.54	0.07	0.07
	(0.50)	(0.02)	(0.50)	(0.03)	(0.50)	(0.04)*	(0.17)

Table 5. Voucher impact on SISBEN coverage

	All Applicants		Academic Applicants		Vocational Applicants	
	(1)	(2)	(3)	(4)	(5)	(6)
Won voucher	-0.028	0.051	-0.029	-0.008	-0.032	0.300
	(0.017)*	(0.169)	(0.023)	(0.235)	(0.026)	(0.264)
Age * won voucher		-0.001		0.007		-0.029
		(0.013)		(0.017)		(0.020)
Phone * won voucher		-0.078		-0.127		0.026
		(0.053)		(0.07)*		(0.087)
Male * won voucher		0.009		0.000		0.020
		(0.034)		(0.046)		(0.053)
Loser's mean	0.515		0.504		0.524	
p-value on F-stat of joint test of		0.525		0.327		0.508
N	3661	3661	1901	1901	1512	1512

Table 6. Bounds on voucher impact on self-reported annual earnings (SISBEN subsample)

	All		Academic Applicants		Vocational Applicants	
	Loser's Mean (1)	Won Voucher (2)	Loser's Mean (3)	Won Voucher (4)	Loser's Mean (5)	Won Voucher (6)
A. All applicants						
Lower bound	2,517.9	-139.6	2,699.6	-311.6	2,359.6	14.2
		(218.4)		(399.1)		(165.5)
Upper bound	2,000.2	365.8	2,041.0	331.8	2,064.9	315.8
		(80.1)***		(113.5)***		(125.4)**
B. Females						
Lower bound	1,944.1	0.5	1,894.0	31.6	2,082.1	-71.9
		(138.6)		(166.6)		(251.6)
Upper bound	1,696.3	247.7	1,702.9	223.5	1,736.6	283.6
		(112.7)**		(158.9)		(175.2)
C. Males						
Lower bound	3,198.5	-311.7	3,567.6	-765.8	2,749.0	154.4
		(446.3)		(845.0)		(183.1)
Upper bound	2,439.6	440.5	2,461.0	366.7	2,581.7	324.5
		(111.8)***		(158.1)**		(175.8)*

Notes: Table reports voucher lottery loser's means and bounds of the effects of winning a voucher on total self-reported annual earnings expressed in 2013 USD. Lower bound earnings are obtained from an OLS regression of SISBEN self-reported earnings, with missing values for those not in the SISBEN 2010 census. Upper bound earnings from an OLS regression in which SISBEN earnings from the top 5 percent of voucher winners are trimmed from the sample. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Robust standard errors in parentheses. * significant 10%, ** significant 5%.

Table 7. Impacts on Middle Class Consumption

	All		Academic Applicants		Vocational Applicants		
	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Difference (6) - (4) (p-value)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	A. All applicants						
Has Credit Card	0.564	0.038	0.568	0.034	0.560	0.054	0.020
		(0.016)**		(0.023)		(0.025)**	(0.034)
Has Car Loan	0.041	0.006	0.042	-0.003	0.038	0.021	0.024
		(0.007)		(0.009)		(0.011)*	(0.014)*
	B. Females						
Has Credit Card	0.542	0.030	0.543	0.042	0.550	0.023	-0.018
		(0.023)		(0.032)		(0.035)	(0.048)
Has Car Loan	0.037	-0.001	0.035	0.005	0.039	-0.006	-0.011
		(0.009)		(0.013)		(0.014)	(0.019)
	C. Males						
Has Credit Card	0.586	0.045	0.593	0.026	0.571	0.087	0.062
		(0.023)*		(0.032)		(0.037)**	(0.048)
Has Car Loan	0.044	0.013	0.049	-0.010	0.036	0.051	0.061
		(0.010)		(0.013)		(0.018)***	(0.022)***

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher on access to formal consumer credit (credit cards and car loans). Numbers in parentheses are standard deviations in columns of means and standard errors in columns of estimated voucher effects. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Credit data is collected quarterly and it begins in the first quarter of 2004 and end in the last quarter of 2014 and is restricted to applicants with valid adult identification number that have complete application controls. In Panel A the sample of all applicant has 3661 observations, the sample of academic school applicants has 1901 observations and the sample of vocational school applicants has 1512 observations. In Panel B, the full female sample has 1845 observations; the sample of academic school female applicants has 933 observations and the sample of vocational school female applicants has 792 observations. In Panel C, the full male sample has 1816 observations; the sample of academic school male applicants has 968 observations and the sample of vocational school male applicants has 720 observations.* significant 10%, ** significant 5%, *** significant 1%.

Table 8. Bounds on voucher effects on fertility

		All		Academic Applicants		Vocational Applicants		
		Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Difference (6) - (4) (p-value)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. All applicants								
Had any child as a teen	LB	0.234 (0.424)	-0.043 (0.018)**	0.240 (0.427)	-0.064 (0.025)**	0.224 (0.418)	-0.023 (0.029)	0.041 (0.286)
	UB	0.242 (0.429)	-0.047 (0.019)**	0.249 (0.433)	-0.070 (0.026)***	0.228 (0.421)	-0.025 (0.030)	0.045 (0.252)
Spouse/partner had a child as a teen	LB	0.106 (0.308)	-0.030 (0.014)**	0.111 (0.315)	-0.034 (0.020)*	0.087 (0.283)	-0.019 (0.020)	0.015 (0.589)
	UB	0.108 (0.310)	-0.032 (0.014)**	0.113 (0.317)	-0.036 (0.020)*	0.093 (0.291)	-0.025 (0.021)	0.011 (0.697)
Total number of children	LB	1.061 (1.034)	-0.040 (0.045)	1.047 (1.022)	-0.016 (0.063)	1.006 (0.981)	0.013 (0.067)	0.029 (0.751)
	UB	1.082 (1.045)	-0.049 (0.046)	1.064 (1.026)	-0.022 (0.064)	1.033 (0.991)	-0.003 (0.069)	0.019 (0.842)
B. Females								
Had any child as a teen	LB	0.377 (0.485)	-0.065 (0.031)**	0.402 (0.492)	-0.105 (0.045)**	0.337 (0.474)	-0.035 (0.047)	0.071 (0.273)
	UB	0.387 (0.488)	-0.074 (0.032)**	0.418 (0.495)	-0.121 (0.046)***	0.337 (0.474)	-0.034 (0.047)	0.087 (0.183)
Spouse/partner had a child as a teen	LB	0.056 (0.231)	-0.011 (0.015)	0.055 (0.229)	-0.007 (0.021)	0.043 (0.204)	-0.010 (0.020)	-0.003 (0.923)
	UB	0.059 (0.236)	-0.014 (0.015)	0.058 (0.235)	-0.010 (0.022)	0.046 (0.209)	-0.012 (0.020)	-0.002 (0.940)
Total number of children	LB	1.355 (1.031)	-0.023 (0.065)	1.367 (1.021)	0.019 (0.092)	1.250 (0.993)	0.021 (0.095)	0.002 (0.990)
	UB	1.399 (1.026)	-0.061 (0.065)	1.413 (1.015)	-0.024 (0.093)	1.280 (0.992)	0.001 (0.097)	0.025 (0.851)
C. Males								
Had any child as a teen	LB	0.078 (0.268)	-0.020 (0.018)	0.083 (0.276)	-0.022 (0.024)	0.073 (0.261)	-0.007 (0.028)	0.015 (0.682)

	UB	0.081	-0.024	0.087	-0.026	0.075	-0.008	0.017
		(0.274)	(0.018)	(0.282)	(0.025)	(0.264)	(0.028)	(0.643)
	LB	0.161	-0.051	0.165	-0.058	0.146	-0.031	0.028
Spouse/partner had a child as a teen		(0.368)	(0.024)**	(0.372)	(0.033)*	(0.354)	(0.038)	(0.581)
	UB	0.166	-0.056	0.173	-0.066	0.149	-0.034	0.032
		(0.372)	(0.024)**	(0.380)	(0.034)**	(0.358)	(0.039)	(0.531)
	LB	0.740	-0.061	0.738	-0.033	0.679	0.003	0.037
Total number of children		(0.939)	(0.062)	(0.926)	(0.086)	(0.865)	(0.092)	(0.770)
	UB	0.742	-0.060	0.750	-0.041	0.687	-0.002	0.040
		(0.947)	(0.063)	(0.941)	(0.088)	(0.871)	(0.093)	(0.756)

Notes: Table reports voucher lottery loser's means and estimated bounds on the effects of winning a voucher fertility outcomes based on SISBEN 2010 data. Lower bound (LB) earnings are obtained from an OLS regression of SISBEN self-reported earnings, with missing values for those not in the SISBEN census. Upper bound (UB) earnings from an OLS regression in which SISBEN earnings from the top 5 percent of voucher losers are trimmed from the sample. Numbers in parentheses are robust standard errors with the exception of total number of children in columns 1, 3 and 5, which are standard deviations of the loser's mean. Controls include age, male and whether the applicant had a phone number at the time of voucher application. * significant 10%, ** significant 5%.

Table 9. Fiscal and welfare impacts of vouchers

Row #		All Applicants		Academic Applicants		Vocational Applicants		Notes
		Estimate	95% C.I.	Estimate	95% C.I.	Estimate	95% C.I.	
A. Government Costs								
	Secondary Education Costs							
1	Annual per-pupil cost of public school	$ 449.1		$ 449.1		$ 449.1		From Angrist et al. (2002), converted to 2013 dollars
2	Annual value of PACES voucher	$ 243.8		$ 243.8		$ 243.8		From Angrist et al. (2002), converted to 2013 dollars
3	Expenditure from voucher costs for students who would have enrolled in private school, aggregated over 6 years	$ 473.0		$ 472.4		$ 473.9		Row (2)*Proportion of lottery winners attending private school*proportion of winners continuing to use vouchers; computed annually and summed over the six years
4	Expenditure resulting from transfers from public to private schools, aggregated over 6 years	-$ 175.3		-$ 175.2		-$ 175.4		(Row (2) – Row (1))*Voucher Effect on Private School Attendance; computed annually and summed over the six years
5	Cost savings from reduced grade repetition	-$ 4.3	($-4.9 - $-3.5)	-$ 4.2	($-4.9 - $-3.1)	-$ 4.0	($-5.2 - $-2.5)	See Appendix B
6	Total secondary education costs to the government	$ 293.5	($292.9 - $294.3)	$ 293.1	($292.3 - $294.1)	$ 294.6	($293.3 - $296.0)	Row (3) + Row (4) + Row (5)
	Tertiary Education Costs							
7	Additional public tertiary education costs	$ 10.9	($-4.1 - $26.1)	-$ 5.9	($-26.6 - $14.2)	$ 36.8	($8.0 - $75.1)	See Appendix C
8	Additional tertiary education loan subsidies	$ 4.3	($-7.1 - $15.4)	-$ 5.8	($-19.7 - $7.6)	$ 17.9	($-2.9 - $37.7)	See Appendix C
9	Additional tertiary education costs (public education + loan subsidies)	$ 15.2	($-6.7 - $36.6)	-$ 11.7	($-38.1 - $15.3)	$ 54.7	($14.4 - $98.3)	Row (7) + Row (8)
	Welfare Receipt Costs							
10	Additional CCT receipt costs	-$ 0.4	($-4.4 - $3.5)	$ 0.1	($-4.8 - $5.0)	-$ 2.3	($-8.1 - $3.3)	See Appendix C
	Foregone Revenue							

11	Foregone tax revenue from VAT tax	$ 27.9	($26.2 - $29.6)	$ 27.8	($25.6 - $30.2)	$ 29.1	($26.3 - $31.9)	Formal annual earnings of losers* Voucher impact on years of education *VAT tax of 13.3%
12	Foregone net government transfers through payroll taxes	$ 23.7	($22.1 - $25.1)	$ 23.6	($21.6 - $25.8)	$ 24.6	($22.3 - $27.1)	Annual payroll taxes of losers* Voucher impact on years of education *0.4
13	Total foregone revenue	$ 51.6	($48.3 - $54.7)	$ 51.4	($47.2 - $56.0)	$ 53.7	($48.6 - $58.9)	Row (11) + Row (12)
14	**Expected voucher costs to government**	**$ 359.8**	**($338.3 - $381.8)**	**$ 332.9**	**($308.1 - $359.1)**	**$ 400.6**	**($361.4 - $445.2)**	Row (6) + Row (9) + Row (10) + Row (13)
15	Expected voucher costs to government, 6% discount rate	$ 319.4	($304.4 - $334.6)	$ 300.5	($282.9 - $318.7)	$ 348.1	($320.9 - $379.9)	Same calculations as above using 6% discount rate

B. Government Revenue

16	Additional VAT tax revenue	$ 1,098.0	($41.2 - $2,254.2)	$ 151.5	($-1,310.5 - $1,576.8)	$ 2,416.8	($432.0 - $4,498.2)	Additional earnings of voucher winners (see notes below) * VAT tax of 13.3%
17	Additional government transfers through payroll taxes	$ 928.7	($-11.2 - $1,962.7)	$ 45.0	($-1,275.0 - $1,305.1)	$ 2,134.5	($324.3 - $3,931.7)	Additional payroll taxes of voucher winners (see notes below) * 0.4
18	**Additional government revenue**	**$ 2,026.8**	**($62.5 - $4,213.6)**	**$ 196.5**	**($-2,588.0 - $2,898.8)**	**$ 4,551.3**	**($764.4 - $8,415.3)**	Row (16) + Row (17)
19	Additional government revenue, no VAT revenue	$ 928.7	($-11.2 - $1,962.7)	$ 45.0	($-1,275.0 - $1,305.1)	$ 2,134.5	($324.3 - $3,931.7)	Assume VAT revenue is zero
20	**Net cost to taxpayers**	-$ 1,666.9	($-3,857.5 - $303.9)	$ 136.5	($-2,559.2 - $2,913.0)	-$ 4,150.7	($-7,997.0 - $-372.2)	Row (14) - Row (18)

C. Benefits to Participants

21	**Lower bound on net benefits to voucher recipients: revealed preference approach**	**$ 249.0**		**$ 248.7**		**$ 249.6**		Fraction of infra-marginal recipients*impact on voucher amount*sum of year-by-year utilization rate. See notes below
22	**Upper bound net benefits to voucher recipients: pure financial calculation**	$8,167.3	($317.3 - $16,763.9)	$1,091.6	($-9,767.1 - $11,679.1)	$18,034.8	($3,255.5 - $33,540.4)	Additional earnings of voucher winners-foregone earnings of voucher winners-additional schooling costs to winners. See notes below
23	**Lower bound net benefit to society: revealed preference approach**	$ 1,916.0	($-54.9 - $4,106.5)	$ 112.2	($-2,664.4 - $2,807.9)	$ 4,400.3	($621.8 - $8,246.6)	Benefit to taxpayers (-Row 20) + Lower bound benefit to recipients (Row 21)

24	Upper bound net benefit to society: financial calculation approach	$9,834.2	($13.4 - $20,621.4)	$955.1	($-12,680.1 - $14,238.1)	$22,185.5	($3,627.7 - $41,573.4)	Benefits to taxpayers (-Row 20) + Upper bound benefit to recipients (Row 22)

Notes: We express all figures in 2013 dollars per voucher winner. For annual per-pupil costs of public school and voucher impact on voucher value three years after the lottery: Angrist et al. (2002) report the cost of public schooling in 1998 to be $350 and the voucher cost to be $190. We follow order of operations described in text to obtain values in analysis year. For Expenditure from voucher costs for students who would have enrolled in private school, aggregated over 6 years: In the full sample, the fraction of lottery losers that attend private school is 0.895 (6th), 0.693 (7th) and 0.548 (8th). For academic lottery losers it is 0.909 (6th), 0.703 (7th) and 0.572 (8th). For vocational lottery losers it is 0.877 (6th), 0.695 (7th) and 0.529 (8th). See Table A1 for additional details. We do not observe private school attendance for grades 9th or 10th. We observe private school graduation, which is 0.273 for all applicants, 0.284 for academic applicants and 0.281 for vocational applicants. We interpolate linearly between the 8th grade rate and the graduation rate to obtain the private school attendance rates for grades 9th and 10th, which we estimate to be for all applicants 0.456 (9th) and 0.365 (10th); for academic applicants 0.476 (9th) and 0.381 (10th); for vocational applicants 0.446 (9th) and 0.364 (10th) . We observe the fraction of winners in private school using the voucher for grades 6th and 8th only, which is 0.903 (6th) and 0.509 (8th) for all applicants; 0.924 (6th) and 0.543 (8th) for academic applicants and 0.897 (6th) and 0.481 (8th) for vocational applicants. See Table A1 for details. The 7th grade fraction is the linear combination of the 6th and 8th grade rates, which is 0.706 for all applicants; 0.734 for academic applicants and 0.689 for vocational applicants. After 8th grade, we have no data on voucher usage. We know that 27.3 percent of the overall lottery loser sample finished 11th grade in private school. We assume a constant deterioration from 8th grade to 11th grade in the fraction of losers attending private school. This implies a 40 percent reduction in the fraction attending private school, and we assume that deterioration in voucher usage among winners follows a similar 40 percent decline from the 8th grade level. Under these assumptions, voucher usage rates among all applicants are 0.410 (9th), 0.310 (10th) and 0.211 (11th). For academic applicants the voucher usage rates are 0.439 (9th), 0.335 (10th) and 0.231 (11th). For vocational applicants the voucher usage rates are 0.380 (9th), 0.279 (10th) and 0.178 (11th). For cost-savings from reduced grade repetition: See Appendix B. For tertiary costs: See Appendix C. For Welfare Receipt: See Appendix C. Foregone earnings: We estimate annual foregone revenue from average annual formal sector earnings of voucher losers in Panel A of Table 4, columns 3 and 5. We follow order of operations above to obtain NPV in USD of analysis year. Earnings: Annual earnings are projected annual earnings from Panel A, Table 4. We project earnings for losers and winners over a 35-year horizon allowing for a 3.02% annual growth in earnings per annum, which is the average annual growth in GDP per capita in Colombia between 2002 and 2012, obtained from the World Development Indicators database). US-CPI for years after 2013 is that for 2013. We then follow remaining order of operation to obtain NPV of earnings for winners and losers. Payroll taxes: Annual payroll taxes are proportional to formal earnings, from Panel A, Table 4. We follow the same procedure as for earnings to obtain the NPV of payroll taxes in analysis year. Lower bound benefits to recipients (revealed preference approach): The fraction of infra-marginal recipients is the fraction of lottery losers who attend private school in 6th grade. The impact on voucher amount is $93.2 (from Angrist et al. 2002 Table 8, column 3 updated to 2013 dollars). For utilization rates see notes above for expenditure from voucher costs for students who would have enrolled in private school, aggregated over 6 years. Upper bound benefit to recipients (purely financial calculation): Additional earnings and foregone earnings of voucher winners are estimated as explained above in this note. Schooling costs are additional schooling costs to winners (net fees, see Table A1) times the fraction of winners using the voucher in each year of secondary school, aggregated over six years. Voucher usage rates among lottery winners are calculated following the procedure explained above in this note. We obtain 95% confidence intervals for each calculation using the bootstrap.

Figure 1. Quantile regression estimates of voucher impacts on formal sector earnings
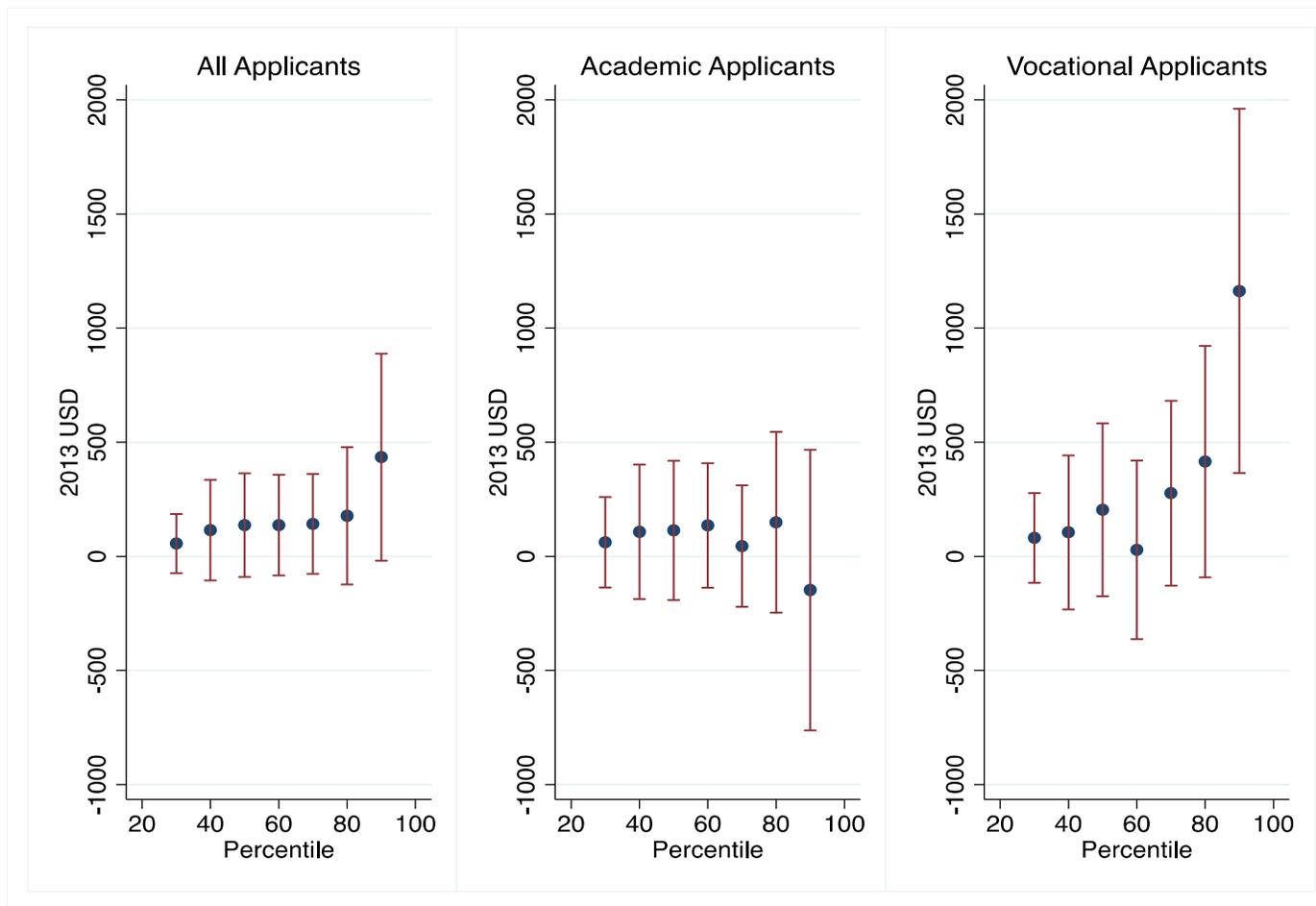
Notes: Figure reports estimated voucher effects for various percentiles of the annual total formal sector earnings distribution. Monetary values are expressed in 2013 USD. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Formal sector earnings estimates use the health payroll account. Formal sector earnings data begins in July 2008 and end in December 2014 and is restricted to applicants with valid adult identification number that have complete application controls. The sample of all applicants has 3574 observations, the sample of academic school applicants has 1852 observations and the sample of vocational school applicants has 1481 observations.

Appendix A. Additional results

Figure A.1. P-values from Simulations on Ability of Covariates to Predict Treatment Assignment
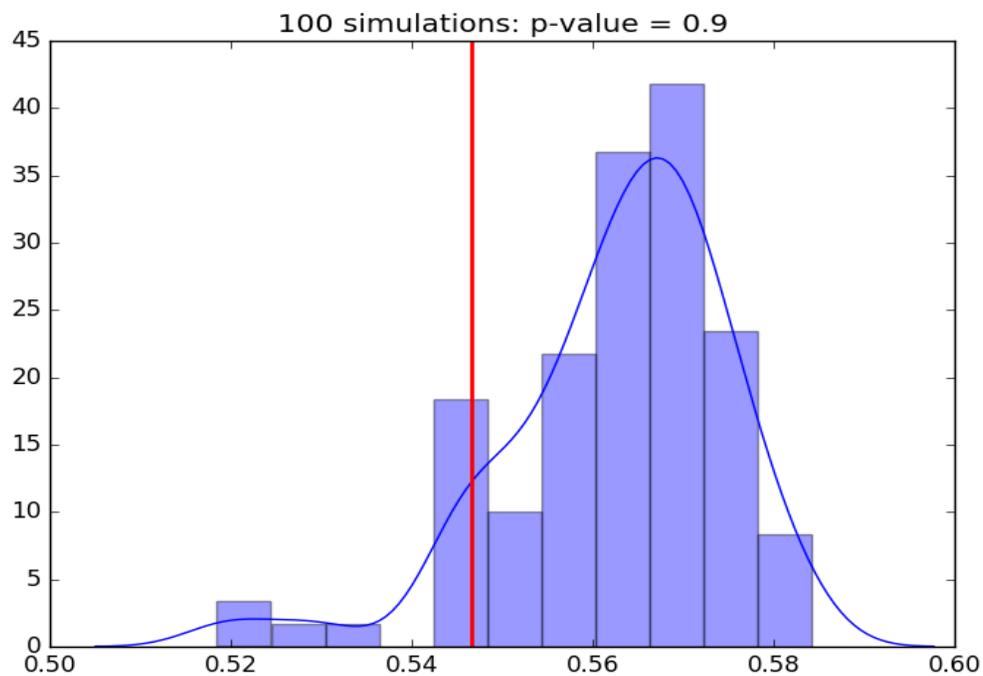
Notes: Figure plots p-values from joint test of whether covariates predict voucher status with different draws. Red line shows the p-value for the actual sample. Covariates included in the test are age, dummies for school, area, sex, vocational.

Figure A.2. P-values from Simulations on Ability of Covariates to Predict Treatment Assignment, Vocational Applicant Sample
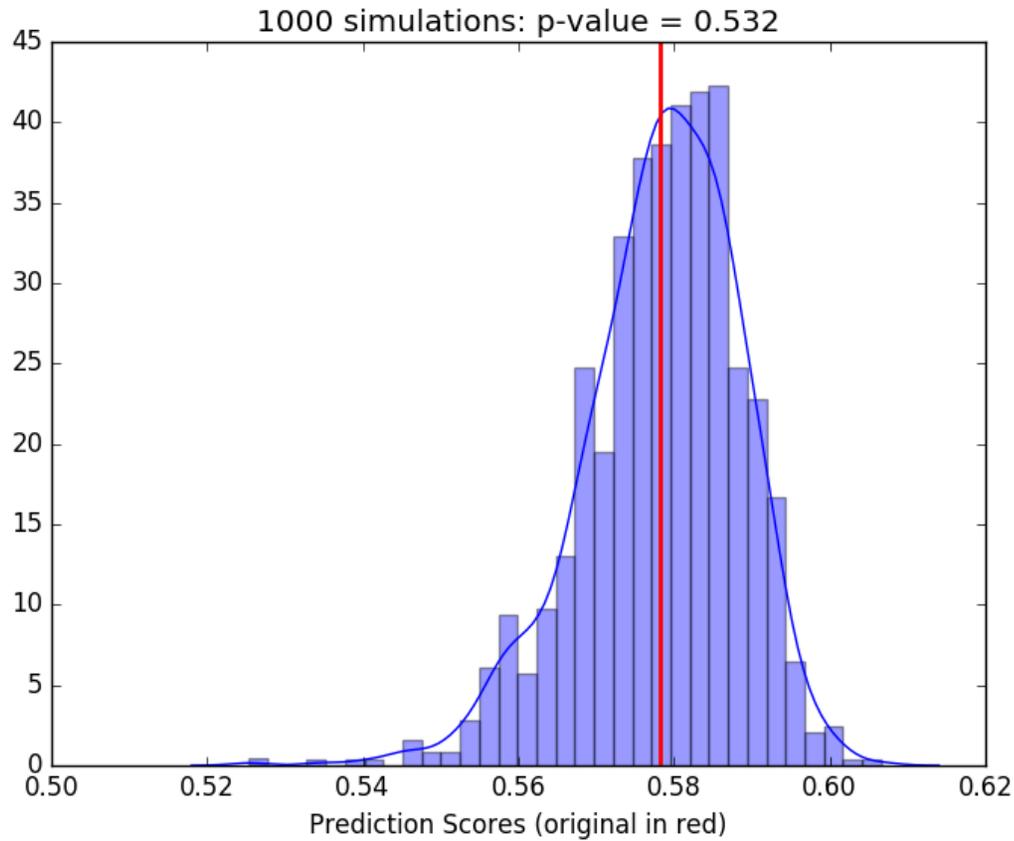
Figure plots p-values from joint test of whether covariates predict voucher status with different draws. Red line shows the p-value for the actual sample. Covariates included in the test are age, dummies for school, area, sex, vocational.

Table A1. Voucher impacts on school fees, private school attendance and voucher usage

|	All		Academic Applicants		Vocational Applicants		Vocational - Academic Difference (p-value)
	Loser's Mean	Won a Voucher	Loser's Mean	Won a Voucher	Loser's Mean	Won a Voucher	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Gross Fees	278.0	71.9	288.5	64.1	270.7	82.4	18.35
	(268.5)	(15.9)***	(270.8)	(21.2)***	(265.8)	(24.3)***	(0.568)
Net Fees	255.1	-39.9	254.7	-51.5	260.7	-28.3	23.21
	(264.3)	(13.9)***	(265.6)	(18.1)***	(263.7)	(21.6)	(0.407)
Started 6th grade in private school	0.895	0.049	0.909	0.039	0.877	0.062	0.02
	(0.307)	(0.016)***	(0.288)	(0.021)*	(0.33)	(0.025)**	(0.482)
Started 7th grade in private school	0.693	0.160	0.703	0.167	0.695	0.144	-0.02
	(0.462)	(0.024)***	(0.458)	(0.032)***	(0.461)	(0.037)***	(0.631)
Started 8th grade in private school	0.548	0.149	0.572	0.123	0.529	0.178	0.06
	(0.498)	(0.028)***	(0.496)	(0.038)***	(0.5)	(0.041)***	(0.319)
Used scholarship in 8th grade	0.038	0.471	0.057	0.486	0.016	0.465	-0.02
	(0.192)	(0.023)***	(0.233)	(0.032)***	(0.127)	(0.032)***	(0.631)
Ever used voucher	0.000	0.903	0.000	0.924	0.000	0.897	-0.03
	(0)	(0.012)***	(0)	(0.015)***	(0)	(0.018)***	(0.246)
Graduated from private school	0.605	0.169	0.626	0.133	0.594	0.206	0.07
(if graduated)	(0.489)	(0.021)***	(0.484)	(0.029)***	(0.492)	(0.031)***	(0.089)*

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher with application controls for outcomes measured three years after the lottery (with the exception of graduation from private school) from a student survey conducted by Angrist et al. (2002). See Angrist et al. (2002) for additional details. We have updated monetary values for estimates on schools fees to reflect 2013 USD using the US CPI. Graduation from private secondary school is obtained from the secondary graduation database (see Data section for additional details). Controls in all regressions include age, male and whether the applicant had a phone number at the time of voucher application. Numbers in parentheses are robust standard errors in columns of estimated voucher effects. * significant 10%, ** significant 5%, *** significant 1%.

Table A2. Voucher impacts on long run tertiary education outcomes by gender

	All Applicants		Academic Applicants		Vocational Applicants	
	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher
	(1)	(2)	(3)	(4)	(5)	(6)
A. Females						
Ever enrolled in tertiary education	0.203	0.023	0.204	0.007	0.213	0.043
		(0.019)		(0.026)		(0.029)
Ever enrolled in a vocational college	0.074	-0.002	0.083	-0.004	0.069	-0.002
		(0.012)		(0.018)		(0.018)
Ever enrolled in a university	0.139	0.025	0.128	0.015	0.159	0.038
		(0.016)		(0.022)		(0.027)
Enrolled in tertiary as of 2012	0.039	0.027	0.033	0.033	0.048	0.022
		(0.01)***		(0.014)**		(0.017)
Graduated from tertiary as of 2012	0.057	0.012	0.053	0.004	0.066	0.017
		(0.011)		(0.015)		(0.019)
Years of tertiary education	0.463	0.093	0.455	0.035	0.489	0.165
	(1.25)	(0.06)	(1.228)	(0.08)	(1.293)	(0.098)*
N	775	1845	398	933	333	792
B. Males						
Ever enrolled in tertiary education	0.175	0.025	0.185	-0.007	0.157	0.098
		(0.018)		(0.024)		(0.03)***
Ever enrolled in a vocational college	0.058	0.031	0.059	0.016	0.057	0.061
		(0.012)**		(0.016)		(0.021)***
Ever enrolled in a university	0.122	0.003	0.131	-0.019	0.107	0.054
		(0.016)		(0.021)		(0.026)**
Enrolled in tertiary education as of 2012	0.032	0.019	0.027	0.029	0.029	0.02
		(0.009)**		(0.012)**		(0.014)
Graduated from tertiary education as of 2012	0.043	0.000	0.054	-0.02	0.029	0.032
		(0.01)		(0.014)		(0.015)**
Years of tertiary education	0.375	0.033	0.402	-0.074	0.343	0.217
	(1.124)	(0.054)	(1.177)	(0.071)	(1.076)	(0.091)**
N	744	1816	405	968	280	720

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher with application controls. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Estimates in columns 2,4 and 6 are from linear probability models. Numbers in parentheses are robust standard errors in columns of estimated voucher effects. * significant 10%, ** significant 5%, *** significant 1%.

Table A3. Match rates to SISPRO formal earnings data

	All applicants		Academic Applicants		Vocational Applicants		Vocational - Academic Difference (p-value)
	(1)	(2)	(3)	(4)	(5)	(6)	(8)
Won a voucher	0.008	-0.086	0.009	-0.052	0.012	-0.221	-0.169
	(0.013)	(0.137)	(0.018)	(0.197)	(0.020)	(0.206)	(0.552)
Age * won a voucher		0.005		0.003		0.017	0.015
		(0.010)		(0.015)		(0.016)	(0.505)
Phone * won a voucher		0.041		0.053		0.015	-0.038
		(0.041)		(0.054)		(0.065)	(0.656)
Male * won a voucher		-0.022		-0.041		0.002	0.043
		(0.026)		(0.037)		(0.040)	(0.425)
Loser's mean	0.801		0.797		0.811		
p-value on F-stat of joint test of interactions		0.609		0.545		0.733	
N	3661	3661	1901	1901	1512	1512	

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher on the probability of being matched to SISPRO data using linear probability models. Additional controls, not shown in the table include, age, male and whether the applicant had a phone number at the time of voucher application. SISPRO sample is from July 2008 to 2014.

Table A4. Voucher impacts on formal sector earnings and payroll taxes 2008-2014, various age specifications

		Coefficient on winning a voucher, various specifications			
Outcome	Loser's Mean	No controls	Application controls, linear age	Application controls, age indicators	Entropy weights
	(1)	(2)	(3)	(4)	(5)
A. All applicants					
Average Annual Formal Sector Earnings	2,470.5	250.4	196.0	200.2	197.8
		(107.163)**	(104.719)*	(104.403)*	(106.572)*
Average Annual Payroll Taxes	695.9	71.0	55.1	56.3	55.6
		(31.168)**	(30.445)*	(30.367)*	(31.023)*
B. Vocational Applicants					
Average Annual Formal Sector Earnings	2,568.3	516.0	427.0	425.2	419.4
		(185.022)***	(183.980)**	(183.060)**	(189.095)**
Average Annual Payroll Taxes	723.5	152.3	125.3	124.3	123.9
		(53.816)***	(53.313)**	(53.025)**	(54.984)**
C. Academic Applicants					
Average Annual Formal Sector Earnings	2,462.5	58.8	31.4	39.0	37.9
		(137.2)	(132.7)	(132.7)	(133.5)
Average Annual Payroll Taxes	694.2	11.9	3.9	6.1	5.5
		(39.9)	(38.7)	(38.7)	(39.0)

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher on total formal sector earnings and annual payroll taxes under various age specifications. Annual averages are for the period July 2008 to December 2014. Monetary values are expressed in 2013 USD. Total payroll taxes include employer and employee contributions. Numbers in parentheses are standard deviations in columns of means and standard errors in columns of estimated voucher effects. Application controls include age, male and whether the applicant had a phone number at the time of voucher application. Formal sector earnings estimates use the health payroll account. Formal sector earnings data begins in July 2008 and end in December 2014 and is restricted to applicants with valid adult identification number that have complete application controls. The sample of all applicants with application controls has 3574 observations, for academic school applicants it has 1852 observations and for vocational school applicants it has 1481 observations. Entropy weights uses the Hainmueller (2012) re-weighting approach to impose equal first and second moments of the covariate distribution across voucher winners and losers. * significant 10%, ** significant 5% *** significant 1%.

Table A5. Upper Bound Estimated Effect on Formal Earnings For Those Not Induced to Attend Tertiary Education by Voucher

	All		Academic Applicants		Vocational Applicants		
	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Difference (6) - (4) (p-value)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. All applicants							
Percent of top-earning voucher losers trimmed from	*2.4 %*		*3.3%*		*2.2%*		
Average Annual Formal Sector Earnings	2,172.7	490.2	2,086.6	395.9	2,297.5	701.5	305.7
	(2239)	(91.2)***	(2082.4)	(110.9)***	(2423.7)	(164.4)***	(0.12)
B. Females							
Percent of top-earning voucher losers trimmed from	*2.8%*		*3.3%*		*2.2%*		
Average Annual Formal Sector Earnings	2,009.6	490.1	1,877.1	475.4	2,198.2	552.1	76.6
	(2191.3)	(128.8)***	(1921.6)	(151.6)***	(2428.6)	(231.7)**	(0.78)
C. Males							
Percent of top-earning voucher losers trimmed from	*2.0%*		*3.3%*		*2.1%*		
Average Annual Formal Sector Earnings	2,383.4	449.7	2,314.3	291.4	2,418.4	864.2	572.8
	(2346.1)	(130.2)***	(2241.5)	(161.7)*	(2422.7)	(231.7)***	(0.04)**

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher on average annual, annual total formal sector earnings and annual payroll taxes after trimming the stated percent of top-earnings voucher losers from each sample. Annual averages are for the period July 2008 to December 2014. Monetary values are expressed in 2013 USD. Total payroll taxes include employer and employee contributions. Numbers in parentheses are standard deviations in columns of means and standard errors in columns of estimated voucher effects. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Formal sector earnings estimates use the health payroll account. Formal sector earnings data begins in July 2008 and end in December 2014 and is restricted to applicants with valid adult identification number that have complete application controls.* significant 10%, ** significant 5% *** significant 1%.

Table A6. Upper bound estimates (imputation) of the voucher impact on future formal earnings

	All		Academic Applicants		Vocational Applicants		
	Loser's Mean	Won a Voucher	Loser's Mean	Won a Voucher	Loser's Mean	Won a Voucher	Difference (6) - (4) (p-value)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. All applicants							
Average Annual Formal Sector Earnings	2,470.5	206.4	2,462.5	38.4	2,568.3	443.4	404.959
	(3019.9)	(104.7)**	(2986.2)	(132.6)	(3147.3)	(183.8)**	(0.07)*
B. Females							
Average Annual Formal Sector Earnings	2,264.1	244.4	2,238.0	121.6	2,422.4	337.5	215.900
	(2826.9)	(143.4)*	(2810.2)	(182.3)	(2941.1)	(248.3)	(0.48)
C. Males							
Average Annual Formal Sector Earnings	2,687.7	161.7	2,685.8	-53.3	2,743.0	558.2	611.519
	(3198.1)	(152.5)	(3139.2)	(191.8)	(3375)	(272.3)**	(0.07)*

Notes. Table reports voucher lottery loser's means and estimated effects of winning a voucher on annual formal sector earnings in USD of 2013 imputing the average of losers' earnings with incomplete tertiary education to winners who are enrolled in higher education as of 2012 and have no earnings in the formal sector. Total payroll taxes include employer and employee contributions. Numbers in parentheses are standard deviations in columns of means and standard errors in columns of estimated voucher effects. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Formal sector earnings estimates use the health payroll account. Formal sector earnings sample is restricted to begin in July 2008 and is restricted to applicants with valid adult identification number (3926) that have complete application controls (3903).* significant 10%, ** significant 5%.

Table A7. Voucher impacts on government subsidy receipt

	All		Academic Applicants		Vocational Applicants	
	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher
	(1)	(2)	(3)	(4)	(5)	(6)
Familias En Acción CCT program	0.074	-0.003	0.072	0.001	0.073	-0.008
		(0.009)		(0.012)		(0.013)
Subsidized Health Care Level 1	0.196	-0.012	0.196	-0.024	0.188	-0.003
		(0.013)		(0.018)		(0.02)
Subsidized Health Care Level 2	0.243	0.000	0.24	-0.008	0.228	0.014
		(0.014)		(0.02)		(0.022)
Early childhood care (ICBF)	0.27	-0.004	0.265	-0.006	0.258	0.004
		(0.015)		(0.02)		(0.023)

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher with application controls. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Estimates in columns 2,4 and 6 are from linear probability models. Numbers in parentheses are robust standard errors in columns of estimated voucher effects. Receipt of Familias en Acción CCT program is based on having SISBEN 2010 scores below the eligibility cutoff and children under the age of 18. Receipt of subsidized health care levels 1 and 2, and early childhood care is based on having SISBEN 2010 scores below the eligibility cutoff. Applicants who are not in SISBEN 2010 cannot receive these subsidies so for them receipt is zero.

Table A8. Voucher impacts on formal annual earnings for applicants to vocational schools of various curricula

	Vocational Applicants		Applicants to Commercial Curriculum		Applicants to Other Curricula		
	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Difference (4) - (6) (p-value)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	A. All applicants						
Average Annual Formal Sector Earnings	2,568.3	427.0	2,252.5	554.2	2,789.2	341.7	212.5
	(3,147.3)	(184.0)**	(2,686.7)	(254.2)**	(3,419.4)	(260.2)	(0.56)
Average Annual Payroll Taxes	723.5	125.2	640.1	158.2	781.8	103.0	55.2
	(908.4)	(53.3)**	(775.3)	(73.8)**	(987.9)	(75.5)	(0.60)
N	600	1481	247	637	353	844	
	B. Females						
Average Annual Formal Sector Earnings	2,422.4	328.8	2,501.7	136.0	2,365.3	491.2	-355.1
	(2,941.1)	(248.4)	(3,034.7)	(360.6)	(2,878.3)	(346.9)	(0.48)
Average Annual Payroll Taxes	665.1	93.3	701.2	26.3	639.1	148.3	-121.9
	(833.4)	(70.7)	(874.3)	(102.5)	(803.9)	(99.1)	(0.39)
N	327	779	137	354	190	425	
	C. Males						
Average Annual Formal Sector Earnings	2,743.0	535.3	1,942.2	1,119.1	3,283.5	151.0	968.1
	(3,375.0)	(272.7)**	(2,150.6)	(348.0)***	(3,909.4)	(384.4)	(0.06)
Average Annual Payroll Taxes	793.3	160.8	563.9	333.9	948.2	47.1	286.8
	(987.9)	(80.5)**	(626.3)	(103.8)***	(1,146.6)	(113.3)	(0.06)
N	273	702	110	283	163	419	

Notes: Table reports voucher lottery loser's means and estimated effects of winning a voucher on formal sector earnings and payroll taxes in USD of 2013 among applicants to vocational schools of various curricula. Columns 1 and 2 replicate results for vocational applicants from Table 4 in the main text. Columns 3 and 4 show results for applicants to vocational schools with a commercial curriculum. Columns 5 and 6 show results for applicants to schools with other curricula, which includes industrial, agricultural, pedagogical and those without curriculum information. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Formal sector earnings estimates use the health payroll account. Formal sector earnings sample is restricted to begin in July 2008 and is restricted to applicants with valid adult identification number (3926) that have complete application controls (3903).* significant 10%, ** significant 5%.

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Table A9. Bounds on interest rates paid on loans

		All		Academic Applicants		Vocational Applicants	
		Loser's Mean	Won Voucher	Loser's Mean	Won Voucher	Loser's Mean	Won Voucher
		(1)	(2)	(3)	(4)	(5)	(6)
		A. All applicants					
Percent of top-interest rate voucher winners trimmed		*4.9%*		*3.3%*		*8.8%*	
	UB	24.62	-0.52	24.30	0.13	24.86	-1.45
Interest Rate (Weighted Quarterly Average)		(4.87)	(0.22)**	(5.35)	(0.31)	(4.31)	(0.32)***
	LB	24.62	-0.20	24.30	0.35	24.86	-0.85
		(4.87)	(0.22)	(5.35)	(0.31)	(4.31)	(0.32)***
		B. Females					
Percent of top-interest rate voucher winners trimmed		*4.6%*		*7.2%*		*3.5%*	
	UB	24.53	-0.65	24.42	-0.38	24.57	-1.07
Interest Rate (Weighted Quarterly Average)		(4.93)	(0.33)**	(5.18)	(0.47)	(4.65)	(0.48)**
	LB	24.53	-0.35	24.42	0.07	24.57	-0.83
		(4.93)	(0.32)	(5.18)	(0.47)	(4.65)	(0.48)*
		C. Males					
Percent of top-interest rate voucher winners trimmed		*4.9%*		*0.0%*		*13.1%*	
	UB	24.70	-0.38	24.20	0.58	25.19	-1.75
Interest Rate (Weighted Quarterly Average)		(4.82)	(0.29)	(5.50)	(0.42)	(3.88)	(0.41)***
	LB	24.70	-0.06	24.20	0.58	25.19	-0.86
		(4.82)	(0.29)	(5.50)	(0.42)	(3.88)	(0.41)**

Notes: Table reports bounds on interest rates paid on formal consumer loans. Controls include age, male and whether the applicant had a phone number at the time of voucher application. Credit data is collected quarterly and it begins in the first quarter of 2004 and end in the last quarter of 2014 and is restricted to applicants with valid adult identification number that have complete application controls.* significant 10%, ** significant 5%, *** significant 1%.

Appendix B. Calculation of cost-savings to the government from reduced grade repetition

This appendix explains how we calculate cost savings to the government from reduced grade repetition. We observe public school attendance and repetitions through grade 8 from Table 4 in Angrist et al. (2002) and whether the applicant finished secondary school on time, with delays or did not finish (Table 2 in main text).

To calculate the cost-savings from reduced grade repetition, we assume that: i) only public school repetitions cost the government money, ii) among applicants who finish on-schedule, there is no repetition; ii) among applicants who finish with delays, the delays are all a consequence of grade repetition and iii) among those who never finish secondary school, all dropouts occurred in 9th grade, so that total repetitions for this group are the ones reported in Table 4 columns 2 and 4 of Angrist et al. 2002. This last assumption understates the cost savings given that we ignore additional costs the government would have incurred if dropout had occurred later.

There are three types of students: those who finish on time; those who finish with delays; and those who never finish. For those who finish on time, the government receives no cost savings. For those who pass with delays, the government saves from reduced grade repetition in the public sector. We multiply public school costs by the fraction in public schools and by the overall reduction in grade repetitions to estimate these cost benefits. For those who never graduate, we only record the savings from grade repetition after three years. As before, we multiply public school costs by the fraction in public by the effect of the voucher on repetitions after three years. We use data from Angrist et al (2002) to compute these effects and the fractions in public. Again, we underestimate the likely savings given that we know that more

attrition from private schools happened after 8th grade and hence might have increased the probability that post-8th grade retention occurred in public rather than private schools.

Based on estimates from Table 2, Table B1 shows the distribution of secondary school completion outcomes for voucher winners and losers, separately by gender:

For those who complete secondary school with delays, since we assume that the delay is all a consequence of grade repetition, the reduction in grade repetition as a consequence of winning the voucher is 0.095 – 0.105 = -0.01 for females and 0.090 – 0.123 = -0.033 for males. Annual cost-savings from reduced grade repetition in this group is annual per-pupil public school costs (from Table 10), times the fraction of lottery losers who attend public school, times reduction in the probability of grade repetition. For females this is: $449.08 * 0.284 * (-0.01) = - $1.28 and for males it is $449.08 * 0.300 * (-0.03) = - $4.44. Note that the figures are reported as negative numbers indicating negative costs (i.e. cost savings).

Table B1. Distribution of secondary school completion outcomes

| | Losers | | Winners | |
	Female	Male	Female	Male
Completed secondary school on time	0.486	0.415	0.558	0.495
Completed secondary school with delays	0.105	0.123	0.095	0.090
Never completed	0.409	0.462	0.347	0.415

Notes: Completed with delays is completed with up to a six-year delay. We assume that the fraction of applicants who never complete secondary school is 1 – (fraction who complete on time + fraction who complete with delays).

We need to multiply these annual amounts by the number of extra years that it takes for winners to graduate from secondary school among those that graduate with delays.

We estimate the distribution of delayed graduation in Table B2 to estimate the annual cost-savings from reduced grade repetition. Cost savings from grade repetition among voucher winners who complete secondary school with delays are as follows. For females it is: - [$1.28*2 years*0.67 (conditional on delay, the fraction who completes with a two-year delay) + $1.28*4 years*0.16 (fraction who completes with 4-year delay) + $1.28*6 years*0.17 (fraction who completes with a 6-year delay)] = - $3.84. For males it is: - [$4.44*2 years*0.69 + $4.44*4 years*0.21 + $4.44*6 years*0.10] = - $12.52.

For voucher winners who never complete secondary school, we assume that they dropped out in 9th grade so the reduction in the total number of repetitions is the one reported by Angrist et al (2002) in Table 4 for the Bogotá sample with controls, which is -0.031 for females and -0.101 for males.   Therefore, cost-savings for those who never complete is $449.08*0.284*(-0.031) = -$3.95 for females and $449.08*0.300*(-0.101) = -$13.61 for males.

Total cost-savings from reduced grade repetition among voucher winners is the weighted sum of the cost-savings among those who complete secondary school with delays and those who never complete. Impacts estimates on delayed secondary school completion are in Table B2. The weights are given by the fraction of voucher winners who complete secondary school with delays and who never complete, from Table B1. For females, we have that total cost-savings are [-$3.84* 0.095 - $3.95*0.347] = -$1.76. For males, total cost-savings from reduced grade repetition are [-$12.52*0.090 -$13.61*0.415] = -$6.78.

Table B2. Distribution of delayed secondary school completion for voucher winners

	Females		Males	
	Percentage	Percent	Percentage	Percent
Fraction of winners who complete secondary school with delays	0.095	100%	0.090	100%
Fraction who complete with up to a two-year delay	(0.555+0.067)-0.558 = 0.064	67%	(0.499+0.058)-0.495 = 0.062	69%
Fraction who complete with a 2- to 4-year delay	(0.574+0.063)-0.622 = 0.015	16%	(0.530+0.046)-0.557 = 0.010	21%
Fraction who complete with a 4- to 6-year delay	(0.095-0.064-0.015) = 0.016	17%	(0.093-0.066-0.017) = 0.009	10%

Appendix C. Computation of other fiscal costs

In this appendix we explain how we compute other costs associated with the program including increased tertiary education costs as a result of increased attendance; foregone tax revenue from foregone earnings and changes in welfare program expenditures.

Additional Tertiary Education Costs to Taxpayers

There are two sources of additional tertiary education costs to taxpayers: costs from public tertiary education attendance and tertiary education loan subsidies. Additional tertiary education costs to taxpayers from tertiary education attendance are annual per-pupil expenditure in public tertiary education * voucher impact on years of tertiary education (Panel B, Table 3, cols. 4 & 6)* Fraction of lottery winners attending a public institution (Panel B, Table 3, col. 1 + col. 3).

Average per-pupil government expenditure in tertiary education is COP 3,280,000 in 2010 (Ministry of Education 2010). We use the exchange rate of COP 1913.98/USD (Dec 31, 2010) to convert to nominal USD and follow order of operations described in text to obtain NPV in USD of analysis year.

Tertiary education subsidies are COP 682.432 per semester in COP of 2013 (ICETEX 2014). We use the exchange rate of COP 1926.83/USD (Dec 31, 2013) to convert to nominal USD and follow order of operations described in text to obtain NPV in USD of analysis year. To obtain the additional costs to taxpayers from loan subsidies we take the annual per-pupil tertiary education subsidy * Scholarship impact on number of years of subsidy receipt. From the Higher Education Database, in the full applicant sample, 1.4 percent of lottery losers had received government loans for tertiary education and the voucher effect in the full sample is 0.005 (0.004). Among academic applicants, 1.5 percent had received government loans, with

an associated voucher effect of 0.000 (0.006). Among vocational applicants, 1.3 percent had received government loans, with a voucher effect of 0.013 (0.007).

Foregone Tax Revenue

Based on results in Table 6, we assume that there is no difference in informal sector earnings between voucher winners and losers. We assume foregone VAT tax revenue, equals annual formal sector earnings of voucher lottery losers' times the voucher impact on years of education times the average VAT rate of 13.3 percent. Jaramillo and Tovar (2008) Table 3 reports average VAT rates for five consumption groups. We use data from Colombia's *Encuesta de Ingresos y Gastos* from 2006/2007 to estimate the distribution of consumption across these groups in the two lowest deciles of the consumption distribution. The assumed average VAT tax rate of 13.3% is a weighted average of the VAT rates across the different consumption groups, with the weights given by the share of consumption among the two lowest deciles in each category. Foregone VAT revenue is $28 (Row 11, Table 9). Note that the current difference in formal sector earnings and payroll taxes between voucher winners and losers already accounts for foregone earnings due to any additional time in school between 2008 and 2012, which is the period that our formal sector earnings data covers. Evidence from Table 2 indicates that voucher winners, however, already spent additional time in school prior to 2008, particularly finishing secondary school. Since we do not observe earnings that far back, the assumption that foregone earnings then are similar to those now is fairly conservative.

We assume foregone payroll taxes equal annual payroll taxes for voucher lottery losers times the voucher impact on years of education. We estimate that at the margin forty percent of payroll taxes represents a net transfer to the government. Ten percent of payroll taxes are earmarked to finance Colombia's national job training agency (SENA) and the national institute

for family welfare (ICBF) and therefore represent a net transfer to the government. Thirty percent of total payroll taxes are for health care services and also constitute a net government transfer because the mandatory health plan, known as POS, provides services that do not depend on the amount paid in the system so additional health payroll taxes among winners relax the government budget constraint. We conservatively assume that the pension scheme involves no redistribution. Foregone net government transfers from payroll taxes are $24 (Row 12, Table 9). Total foregone revenue is the sum of foregone VAT taxes and the net transfer from foregone payroll taxes, which totals $52 ($51 for academic school applicants and $54 for vocational school applicants, Row 13, Table 9).

Colombia's Law 100 of 1993, created two pension regimes: average premium (*Regimen de Prima Media)* and individual savings with solidarity (*Regimen de Ahorro Individual con Solidaridad).* In the average premium regime, employee and employer-side contributions go to a common pool of resources and pension benefits are a function of age, formal sector earnings, and time in formal sector employment. The individual savings regime is akin to individual retirement accounts in the US in which accounts belong to the individual and pension benefits do not depend on age or other parameters; they only depend on the principal and interest earned. In neither case, therefore, are there government subsidies to retirees.

Additional Costs from Welfare Receipt

To obtain annual costs we assume one child, which is the mean number of children of voucher applicants at age 28 (see Table 8). We assume the child is between zero and seven years of age in 2013, so can receive CCT health transfer but no education transfer. We assume applicant resides in Bogotá so monthly health subsidy amount is that for Group 1 municipalities,

COP 61,200/month (see: http://www.dps.gov.co/Ingreso_Social/FamiliasenAccion.aspx, retrieved October 28, 2014). We obtain annual CCT transfer amount by multiplying by 12. We follow order of operations above to obtain NPV in USD of analysis year. We only assume one year of costs since there is no difference by voucher status in total fertility, indicating simply a difference in the probability of having age-appropriate children. Therefore, CCT cost is annual cost * impact on receipt.Annual CCT subsidy amount (see notes below) * Voucher impact on CCT receipt (Appendix Table A7, cols. 4 & 6)

Estimates for Colombia do not break out fiscal costs of teen fertility (Arturo José Parada-Baños 2005). Therefore, we do not, account for fiscal cost-savings from reduced teen fertility, which U.S. evidence suggests are substantial (Saul Hoffman 2006).