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How Universal School Vouchers Affect Educational and Labor Market Outcomes: Evidence from Chile

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Keywords
School vouchers, Educational attainment, Labor market, EPS survey, Wage returns, Subsidized schools

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How Universal School Vouchers Affect Educational and Labor Market Outcomes: Evidence from Chile

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Abstract

This paper studies the effects of school vouchers in Chile, which adopted a nationwide school voucher program 28 years ago. Chile has a relatively unregulated, decentralized, competitive market in primary and secondary education and therefore provides a unique setting in which to study how voucher programs affect school choice as well as educational attainment and labor market outcomes. This paper develops and estimates a dynamic model of schooling and work decisions using data from the 2002 *Historia Laboral y Seguridad Social* and the 2004 *Enquesta Proteccion Social* (EPS) surveys. The dataset includes rich demographic information as well as contemporaneous and retrospective schooling and work information covering a thirty-five year time frame. Some individuals in the sample completed their schooling before the voucher program was introduced, while others had the option of using the vouchers over part or all of their schooling careers. The impacts of the voucher program are identified from the differences in the schooling and work choices made and wage returns received by individuals differentially exposed to the program. Simulations based on the estimated dynamic model indicate that the school voucher program induced individuals affected by the program to attend private subsidized schools at a higher rate, achieve higher educational attainment, receive higher wages and participate more in the labor force. Returns to both public and private education increased after the introduction of vouchers. An examination of distributional effects shows that the voucher program benefitted individuals from both poor and non-poor backgrounds, but that the non-poor experienced greater benefits.

1 Introduction

School vouchers were first proposed by Milton Friedman (1962) as a way of improving quality of schooling. Friedman supported a role for government in the funding of schooling, but he argued that schooling might be more efficiently provided in the private sector. At first, his voucher proposal was considered a radical idea and was not seriously considered as a policy alternative, but school vouchers have since garnered support among policy-makers looking for ways to improve school quality. Recent advocates of voucher programs point to their value in fostering competition among schools, which is thought to generate quality improvements in both public and private school systems, and to their potential value in promoting equality of educational opportunity (Brighouse, 2000, Rouse, 1998, Hoxby, 2001, 2003). However, critics caution that voucher programs deplete already poorly funded public school systems of revenue, of their best students and possibly also of their best teachers and therefore may increase inequality (e.g., Ladd, 2002).

School voucher programs have been implemented in some U.S. cities, including Milwaukee, Dayton, New York City, the District of Columbia, Cleveland, and Denver and also in the state of Florida. Most of the existing programs are available only to children from low income families and/or from poor performing schools.[1] The evidence on the effectiveness of these programs in improving child test scores is mixed. (See, e.g., Krueger and Zhu, 2004, Yau, 2004, Peterson, Howell and Greene, 1999 and section two of this paper). The small-scale of most programs and their selective targeting makes it difficult to draw inference about the likely effects of vouchers were they to be adopted on a broader scale. Notably, the scale of existing programs has been too small to induce a supply response in the private schooling sector, which one would expect to occur with wider adoption. There are also no empirical studies for the U.S. or other countries of the potential long-term effects of voucher programs on educational attainment, earnings and employment outcomes.

This paper studies the effects of school vouchers in Chile, which adopted a nationwide

[1] The Cleveland program is an exception.

school voucher program in 1980. The voucher program was one of several market-oriented reforms initiated under Augusto Pinochet's military regime. At the time of the voucher program's adoption, Chilean economic and social policy was strongly influenced by the Chicago school of economics. (Valdez, 1995) The design of Chile's voucher program is in many ways similar to Friedman's original proposal, with public financing of vouchers, voucher funds following the child to selected schools, coexistence of a government and private schooling sector with free entry in the private schooling sector, and some government monitoring of the quality of all schools. Since 1980, Chile has been a virtual laboratory for a relatively unregulated, decentralized, competitive market in primary and secondary education. It provides a unique setting in which to study how voucher programs affect school choice and to examine their longer-term effects on educational attainment and labor market outcomes. This paper also explores how school vouchers affect inequality by increasing the opportunities for children from poorer families to attend private schools and/or by changing the types of private schools attended by children from wealthier families.

Education in Chile is provided by three types of schools: municipal schools, private subsidized schools, and private non-subsidized (fee-paying) schools. Until 1994 (and over the time period covered by our data), private subsidized schools and municipal schools were financed primarily through the per capita government voucher given to every child.[2] Private non-subsidized schools, which include both religious (mainly Catholic) and lay schools, are financed from private tuition. Private subsidized schools can be for profit or not for profit, while private nonsubsidized schools are usually for profit. Parents are free to choose among both municipal and both types of private schools. Private schools can be selective in their admissions, while public schools are only allowed to be selective if there is excess demand. At all types of schools, students are required to take standardized tests in the 4th, 8th and 10th grades, called the SIMCE tests. The school's average test results are published annually and are used by parents as an indicator of educational performance.

[2]Municipal schools may also receive some additional funding in the form of government transfers when the voucher amounts are not sufficient to cover operating expenses. In 1993, there was a change in rules to allow public and private schools to impose a small tuition charge on top of the voucher.

Figure 1 shows the percentage of students attending different kinds of schools from 1981-2004.[3] In the first five years after the voucher program was introduced, the percentage of students enrolled in private subsidized schools increased rapidly, from 15% to over 30%, with a corresponding decline in enrollment in public schools. Subsequently, the share of private subsidized schools continued to increase at a more gradual pace and the corresponding market share of public schools to decrease. The market share of private nonsubsidized schools varied only a little over time, ranging from 5.5 to 9.5%.

There are a number of previous studies of the effects of voucher programs in Chile. All of the studies (e.g. Sapelli and Vial, 2002, Contreras, 2001, Hsieh and Urquiola, 2005, McEwan and Carnoy, 2001), analyze the relationship between standardized test scores (usually SIMCE test scores) and attendance at voucher schools using data collected at the schools. With data collected in school, one encounters multiple selection problems, namely, that the children/youth attending each type of school are self-selected and that test scores are only observed for those who attend school and not for drop-outs. Section two discusses some of the ways that literature has addressed selectivity problems in analyzing the effects of vouchers on tests scores. Some studies in the literature find little difference in test score performance between municipal and private subsized schools after controlling for family background (e.g., Mizala and Romaguera, 1997). As they note, however, the available test score data were collected many years after the introduction of the voucher reform, and the finding of no significant difference in test scores between municipal and private subsidized schools is consistent with the voucher program having improved performance in both the private and public sectors. Other studies in the literature, such as McEwan and Carnoy (1999), Bravo, Contreras and Sanhueza (1999), and Sapelli and Vial (2002) do find evidence of better performance in private schools.

Rather than study the determinants of test scores, this paper uses household survey data to analyze the longer term effects of school vouchers on educational attainment, employment, and earnings outcomes. In particular, we use the newly available, longitudinal survey in Chile

[3]The figure is based on data from the Ministry of Education.

called the *Enquesta Proteccion Social* (EPS) which elicited information from respondents on the types of primary and secondary schools they attended.[4] These data, collected in 2002 and 2004, contain rich labor market, demographic and pension-related information. Most relevant for our analysis is the information that was collected on the types of primary and secondary schools attended, the geographic location of the schools attended, family background, work history and earnings. The data cover a random sample of Chileans age 15 and older. The sample includes individuals who attended school prior to the introduction of vouchers, who were in the midst of their schooling careers at the time vouchers were introduced and who attended solely in the post-voucher regime. The thirty five year time frame covered by our data permits evaluation of the effects of the school voucher program on longer term educational and labor market outcomes, a question that has never been previously examined.

This paper develops and implements a behavioral model of decision-making about schooling and labor force participation over the life-cycle. The model builds on a very rich labor literature that analyzes labor market outcomes in the presence of self-selection into educational and/or occupational sectors. The seminal paper is that of Roy (1951), which explores the implications of occupational self-selection for earnings distributions within a static earnings optimization model.[5] Rosen and Willis (1979) extend the Roy model to an educational choice setting where individuals choose whether to attend college, basing their decisions on expected lifetime earnings, on financing capacities that differ by family background and on nonpecuniary benefits of education. The model also builds on the Heckman and Sedlacek (1985) study of earnings distributions when individuals self-select into different economic sectors with the option of remaining out of the labor force. In our context, individuals select among different schooling sectors, representing the three schooling types, and make decisions about how long to attend school and whether to participate in the labor force. Our model-

[4] The first round of data were collected under the survey name *Historia Laboral y Seguridad Social* (HLLS). These data were collected by the Microdata Center at the University of Chile, under the leadership of David Bravo, with cofunding from an NIH grant to Petra Todd at the University of Pennsylvania.

[5] Heckman and Honore (1990) exposit the mathematical foundations for the Roy model and generalize it to nonnormal distributions.

ing framework explicitly controls for both observed and unobserved sources of heterogeneity that may affect selection into different types of schools as well as wage offers and preference parameters. Along the lines of Ben-Porath (1967), Keane and Wolpin (1997) and Heckman and Navarro (2005), our conceptualization of the schooling decision and of the wage offer equation assumes that individuals forgo earnings opportunities during periods of schooling investment, that they are motivated to undertake investments in part by anticipated future returns, and that wage offers represent a price paid to the human capital embodied in a person.[6] In the tradition of Behrman and Birdsall (1983) and Card and Krueger (1992a,b), we allow the returns to schooling depend on the quality of schooling provided. Specifically, the returns differ depending on the types of primary and secondary school attended and on whether attendance took place in the pre or post voucher regime. This allows the voucher system to have potentially altered the quality of schooling provided in both the private and public sectors.

The model we estimate allows components of future wage offers and of the payoffs to different types of schooling to be unknown at the time individuals make schooling and labor market decisions. It also incorporates permanent unobservable heterogeneity, in the form of discrete types, that is assumed to be known to the agent but unknown to the econometrician (Heckman and Singer, 1984). Labor market experience accumulates endogeneously as a function of past labor supply choices. Identification of voucher effects comes from differences in the choices made and wage returns received by individuals differentially exposed to the voucher program during their schooling careers. The model is estimated solely on males to avoid consideration of fertility choices.

The estimated behavioral model is used it to assess how the introduction of school vouchers affected school choice, educational attainment, earnings and labor market participation. By simulating schooling and labor supply choices over the life-cycle with and without vouchers, we directly evaluate the cumulative effects of the voucher program as it operates through

[6] Also see Heckman, Layne-Farrar and Todd (1996, 1997) for further discussion of the human capital pricing interpretation of the wage equation.

schooling and labor market channels. The empirical findings show that school vouchers increase the likelihood of attending private subsidized schools and lower the probability of attending other types of schools (municipal and private nonsubsidized) at the primary level. They also lower the likelihood of attending municipal schools at the secondary level. With vouchers, individuals achieve higher educational attainment levels and higher high school and college graduation rates. The wage parameter estimates indicate that returns to schooling are lowest in municipal schoolings and highest in the private nonsubsidized schools. Returns to both public and private primary schooling increase subsequent to the introduction of the voucher program, which is consistent with increased competition having improved the quality of both public and private education. The gap in returns to private and public schools narrows after the voucher program. Individual wage offers are higher with the voucher program, both because completed education levels are higher and returns to schooling are higher. When individuals are young, there is no observed effect of the voucher program on labor force participation, because the increased incentive to work stemming from higher wage offers is counterbalanced by delayed entry in the workforce due to longer terms of schooling. However, after age 25, we observe that the higher wage offers stimulate labor force participation. Overall, we find that the voucher program increased wages of workers on average by 7%.

The paper develops as follows. Second two discusses the existing literature and some of the results of previous studies of the Chilean voucher program. Section three describes the model and section four the estimation approach. Section five presents the empirical results and section six concludes.

2 Background and Related Literature

Although there has been much speculation and debate about the likely short-run and longer-term effects of large scale school voucher programs in the U.S. on students and teachers, (e.g. Neal, 2002, Hoxby, 2002, 2003, Ferreyra, 2002), the empirical evidence is still scarce. Much of what we know about school vouchers comes from small-scale studies examining the short-

term effects of privately funded voucher programs on student test scores (e.g., Rouse,1998, Krueger and Zhu 2003, Yau 2004). For example, Howell and Peterson (2002) and Peterson, Howell, Wolf and Campbell (2003) describe the results of evaluations of voucher programs in Dayton, OH, New York City, and Washington, D.C. Each of the programs was evaluated using a randomized design in which families who applied to participate in the program and met the eligibility criteria where randomized into treatment or control groups. The treatment group received a voucher that partly covered tuition at a private school. A baseline test score was collected along with three years of follow-up test scores. Howell and Peterson (2002) find that African-America children in the treatment group experienced statistically significant test score gains, but do not find significant gains for white or Hispanic children. There remains some controversy regarding their results, in part because of high attrition rates in the experimental control and treatment groups that may have compromised the comparability of the treatment and comparison groups.

A related U.S. literature studies the effects of attending private schools or Catholic schools on student test scores and graduation rates (e.g. Neal, 1997, Grogger and Neal, 2000, Evans and Schwab, 1995). That literature typically find statistically significant positive effects of attending private schools, primarily for urban, African American and Hispanic children/youth. Voucher programs facilitate attendance at private schools, so the evidence on the effects of private schools could be viewed as broadly supportive of voucher programs, at least to the extent that urban, minority youth seem to benefit from private schooling.

There have been several studies of the Chilean voucher program's effects on student test scores. As noted in the introduction, all of the test score data were gathered long after the voucher reforms took place and are therefore not informative about the performance of public/private schools in the absence of vouchers. Nevertheless, these studies are informative on whether attendance at private schools in the post-voucher reform period is associated with higher test scores. With test score data, one also encounters multiple selection problems, primarily that the types of children attending each school are self-selected and, for older children, that test scores are usually unavailable for children not attending school. For

example, if voucher programs induce people to stay in school longer, then not accounting for selectivity in school-going could bias the estimated effects on test scores. Sapelli and Vial (2002) deal with the first selection problem within a static Roy model framework that explicitly models the choice between types of schools in a way that allows for both observed and unobservable sources of heterogeneity. They focus their analysis on second graders for whom the second selection problem (drop-outs) is not severe. Their study finds important gains associated with attendance at private subsidized schools that are largest for those attending those types of schools.[7] They also find that the relative performance of private and municipal schools depends on whether municipal schools receive additional government subsidies. In areas where the municipal schools do not receive extra subsidies, there is a significant test score gain from attending private subsidized schools.

Hsieh and Urquiola (2005) also consider the question of whether the Chilean voucher program resulted in better school performance. Their identification strategy compares communities that experienced a greater increase in private school enrollment to those that experienced less of an increase. Using community level data, they find that average standard test scores did not rise faster in communities where the private sector enrollment expanded more, and that average repetition and grade-for-age actually worsened in such areas relative to other communities.[8]

McEwan and Carnoy (2001) examine the relationship between average fourth grade SIMCE school test scores and the percentage of total enrollment in private schools at the community level (for the period 1988-1996), which they interpret as a measure of school competition. Their study finds that public schools that faced more competition had lower average test scores, mainly because of the mobility of the better students to private schools. They also find that non-religious voucher schools are no more effective than public schools, whereas Catholic voucher schools are more effective. They document that average per pupil

[7] They investigate both the effect of treatment on the treatment (TT) and the average treatment effect (ATE).

[8] A potential limitation of the analysis is that it examines differences in test scores over time, though the tests were not comparable over time prior to 1998, when test equating was introduced.

expenditure is lower in private schools than in public schools, suggesting that these schools are more efficient even if they do not improve relative performance. August and Valenzuela (2003) also analyze the relationship between test scores (in the year 2000) and school competition, using an instrumental variables approach where community population and distance to the closest city serve as instruments for competition. They find positive effects of competition on average test scores.

McEwan (2001) examines the effects of attendance at a public or private voucher school on test score outcomes, using individual level data for eighth graders and using a control function approach to account for selectivity into type of school. He finds no important differences in achievement between public and non-religious voucher schools, but that Catholic voucher schools exhibit a small advantage in test scores over most public schools. Using fourth grade achievement test scores, averaged at the school level, Mizala and Romaguera (2000) and Bravo, Contreras and Sanhueza (1999) examine the gap in test score performance between municipal subsidized private schools and conclude that the test score gap is small or nonexistent after controlling for geographic and socioeconomic characteristics. Lastly, Tokman (2002) examines the relationship between primary school test scores and type of school, allowing the impact of attending private schools to differ by average socioeconomic status (using school-level data). Her results indicate that public schools are neither uniformly worse nor better than private schools. Rather, public schools appear to be relatively more effective for students from disadvantaged family backgrounds, which is a finding reminiscent of Neal (1997) for U.S. Catholic schools.

Although most of the studies on vouchers in Latin America have focused on Chile, there is a small literature on related programs elsewhere in Latin America. Angrist et al. (2002) evaluate the impact in selected Colombian cities of the *Programa de Ampliación de Cobertura de la Educación Secundaria* (PACES) voucher program. The vouchers were introduced in 1991, covered about one-half the cost of private secondary schools, and were renewable with satisfactory academic performance. Evaluation of the PACES program was facilitated by the fact that vouchers were initially awarded by lottery in some municipalities with excess

demand for them. Angrist et. al. (2002) did not find any significant impact of vouchers on enrollment but do find significant positive impacts on grade progression rates, educational attainment after three years, and on standardized test scores.

The most prominent and most-studied recent related educational policies elsewhere in Latin American have been the conditional cash transfer programs that provide scholarships for primary and secondary school enrollment for children from poor families. The most well-known of these programs is the Mexican *Oportunidades* anti-poverty and human resource development program, formerly known as the PROGRESA program. The educational impacts are studied in Schultz (2000,2004), Behrman, Sengupta and Todd 2005, Behrman, Parker and Todd 2006, Todd and Wolpin 2007, and Attanasio, Meghir and Santiago (2001). These papers generally find positive impacts of school subsidy programs on school enrollment and educational attainment.

3 Model

We next describe the dynamic schooling and labor force participation model estimated in this paper. It assumes that the decision process starts at age 6, when parents are assumed to choose the type of primary schooling attended by their child to maximize the child's lifetime utility. The three choices are public municipal (M), private subsidized (S), or private unsubsidized (NS). We assume that once a choice of primary school type is made there is no switching to a different type, in part because the data only record one type of primary and secondary school attended. All children are assumed to attend school through the 2nd grade, which is true in the data. In subsequent years, they decide whether to continue attending school or drop out. Children under the age of 16 are not allowed to work, so if they do not attend school they are assumed to be at home.

At age 14, there is a schooling decision about what type of secondary school to attend, with the same three options. Individuals can choose a secondary school type that is either the same or different from their primary school type. They incur a cost of transitioning from primary to secondary school that depends on the type of secondary school in relation to the

type of primary school. This cost can be thought of as capturing costs of transferring from one school system to another, facing a new environment, having to make new friends, and possibly having to travel longer distances to get to a secondary school (since there are more primary schools than secondary schools). Individuals who complete 12 years of school make a choice of whether to attend college. If they choose to attend college, they make a choice each year about whether to keep attending for up to five years. We assume that once an individual leaves school, they do not return.[9]

Starting at age 16, individuals receive wage offers in every period that depend on their years of education completed so far, on the type and number of years of primary and secondary school attended, on the number of years attended before and after the voucher program was introduced, and on labor market experience, which accumulates endogeneously. Individuals can choose to accept the wage offer or be unemployed, in which case they receive a minimal unemployment consumption benefit. The model does not incorporate a savings decision, both for reasons of simplification and because few individuals in our sample report substantial voluntary savings.[10]

To allow for the possibility of unobservables affecting selection into types of schools and wages, we incorporate unobserved heterogeneity in the form of discrete unobserved types (e.g., Heckman and Singer, 1984). Let μ_k be an indicator variable that equals 1 if the individual is of type k, where $k \in \{1, 2, 3\}$.The probability of being a particular type depends on family background variables that include parents' education, family socioeconomic background when the individual was growing up (as reported in our survey), and the number of siblings. These variables are initial conditions in the model. The state space of the model consists of schooling history (type of primary education, type of secondary education, number of years of primary education pre/post voucher program, number of years of secondary

[9] In the Ben-Porath (1967) model, where individuals choose when to invest in schooling, it is optimal to take schooling at the beginning of the lifetime to maximize the time period over which to reap the returns from schooling. We impose the simplifying assumption that individuals cannot return to school once they left in part because the data record the total years of education completed and not the precise school attendance history.

[10] Chile has a privatized pension system that requires individuals to save 10% in their pension account, which constitutes the primary form of savings for most people.

education pre/post voucher program, number of years of college education and accumulated labor market experience.

During the ages (a) when the individual has the option of attending primary school, the current period alternative specific utility functions (U_{ak}^{i}) associated with the different schooling types for a persion of type k are:

$$U_{ak}^{S} = \Sigma_{k=1}^{K}\mu_k b_{1k}^{S} - T_1^{S}1\left(v_a = 0\right) + \delta_1^{S}1\left(R_1 = 1\right) + \varepsilon_a^{S} \quad (1)$$

$$U_{ak}^{NS} = {}_{k=1}^{K}\mu_k b_{1k}^{NS} - T_1^{NS} + \delta_1^{NS}1\left(R_1 = 1\right) + \varepsilon_a^{NS} \quad (2)$$

$$U_{ak}^{M} = {}_{k=1}^{K}\mu_k b_{1k}^{M} + \delta_1^{M}1\left(R_1 = 1\right) + \varepsilon_a^{M} \quad (3)$$

b_{1k}^{i} $(i = S, NS, M, C)$ is a psychic cost (consumption value) of attending different types of primary school (or of attending college after secondary school) that may vary according to unobserved type, T_1^{S} and $T_1^{NS}$are costs at subsidized and unsubsidized schools and at college respectively (the cost is zero at a municipal school). v_a is an indicator variable that equals 1 if the family is eligible for voucher at the child's age a, in which case the family does not pay the tuition cost at a subsidized private school. R_1 is an indicator for whether the individual lives in the capital city, Santiago, which is home to about half of Chile's population. This is included to reflect the fact that there is greater availability of private schools in Santiago along with good public transportation options. There is a vector of preference shocks $(\varepsilon_a^{S}, \varepsilon_a^{NS}, \varepsilon_a^{M})$ associated with different types of primary schooling. Let $d_1^{S} = 1$ if attended private subsidized primary, and $d_1^{NS} = 1$ if attended private nonsubsidized primary (else the indicator variable equal 0). Similarly, let $d_2^{S} = 1$ if attended private subsidized secondary, and $d_2^{NS} = 1$ if attended private nonsubsidized secondary school.

The utility associated with the different secondary school choices depends on preference parameters, tuition costs (T_2^{S}, T_2^{NS}), costs of switching types of schools ($\rho^{prim,\text{sec}}$, $prim \in \{M, S, NS\}, \text{sec} \in \{M, S, NS\}$), and on region of residence (R_1). In the equations below, $1()$ denotes a function that equals one if the expression in parentheses is true.

$$
\begin{aligned}
U_{ak}^{S} &= \Sigma_{k=1}^{K}\mu_k b_{2k}^{S} - T_2^{S}1\left(v_a = 0\right) + \rho^{M,S}(1-d_1^{S})(1-d_1^{NS})1(E_a=9) + \rho^{S,S}d_1^{S}1(E_a=9) \quad (4)\\
&\quad \rho^{NS,S}d_1^{NS}1(E_a=9) + \delta_2^{S}R_1 + \varepsilon_a^{S} \quad (5)\\
U_{ak}^{NS} &= [\Sigma_{k=1}^{K}\mu_k b_{2k}^{NS} - T_2^{NS}] + \rho^{M,NS}(1-d_1^{S})(1-d_1^{NS})1(E_a=9) + \rho^{S,NS}d_1^{S}1(E_a=9) + \quad (6)\\
&\quad \rho^{NS,NS}d_1^{NS}1(E_a=9) + \delta_2^{NS}R_1 + \varepsilon_a^{NS} \quad (7)\\
U_{ak}^{M} &= \Sigma_{k=1}^{K}\mu_k b_{2k}^{M} + \rho^{M,M}(1-d_1^{S})(1-d_1^{NS})1(E_a=9) + \rho^{S,M}d_1^{S}1(E_a=9) + \quad (8)\\
&\quad \rho^{NS,M}d_1^{NS}1(E_a=9) + \delta_2^{M}R_1 + \varepsilon_a^{M}, \quad (9)
\end{aligned}
$$

with a corresponding vector of preference shocks.

After the individual completes at least two years of school, there is the option to drop out and stay home (leisure). After age 16, there is the option to work. To better capture the pattern of some periods of unemployment prior to the first job, the model also incorporates a job search cost that is only incurred only with the first job (when experience x_a equals 0), and that depends on the level of educational attainment, E_a (<8 years, 8-11 years and 12 or more years). Denote the job search costs for the different education levels by ψ^{E_a}. The utility from working is the wage minus any job search cost:

$$U_{ak}^{W} = w_{ak} - 1(x_a = 0)\psi^{E_a}$$

The utility from leisure depends on preference parameters and a leisure preference shock:

$$U_{ak}^{L} = \Sigma_{k=1}^{K}\mu_k b_k^{L} + \varepsilon_a^{L}.$$

An individual who finishes high school can work, stay home or attend college. If he attends college, during those periods, he gets the utility:

$$U_{ak}^{C} = \Sigma_{k=1}^{K}\mu_k b_k^{C} - T^{C} + \delta^{C}1\left(R_1 = 1\right) + \varepsilon_a^{C},$$

where T^C is the college tuition cost and δ^C is a transportation cost that may differ in the Santiago region. After completing school, individuals choose between staying at home or working.

In the model, individuals may attend private instead of public schools because they get higher utility and/or because private schooling generates higher future wage returns. Let E_a^P denote the number of years of primary school attended and E_a^S the number of years of secondary education. Some individuals in the sample completed their schooling before the voucher program was introduced, while others had the option of using the vouchers over part or all of their schooling careers. To allow for changes in the returns to all types of education after the voucher program was introduced, we distinguish years of education pre and post voucher. Let $E_a^{P,v=0}$ and $E_a^{S,v=0}$ denote the number of years of primary and secondary education attended prior to the voucher program, and $E_a^{P,v=1}$ and $E_a^{S,v=1}$ the number of years attended after introduction of vouchers. Total years equals:

$$\begin{aligned} E_a^P &= E_a^{P,v=0} + E_a^{P,v=1} \\ E_a^S &= E_a^{S,v=0} + E_a^{S,v=1} \end{aligned}$$

G_a denotes the number of years of college education completed as of age a.

We assume that the amount of human capital embodied in a person depends on the educational attainment, the type of primary and seconday schools attended, how much schooling was obtained before or after the introduction of vouchers, and the amount of labor market experience, x:

$$H_{ak} = \varphi(E_a^{P,v=0}, E_a^{P,v=1}, E_a^{S,v=0}, E_a^{S,v=1}, G_a, x_a, d_1^S, d_1^{NS}, d_2^S, d_2^{NS}, \mu_k).$$

The wage offer equation is the product of the price paid per unit of human capital and the amount of human capital possessed by the person. We also introduce a stochastic term ε_a^W to reflect additional sources of heterogeneity in the amount of human capital and measurement error. The prices are allowed to vary depending on the regional labor market (here, whether the individual lives in the capital city).

$$w_a = p_H H_a \tilde{\varepsilon}_a^W$$

Taking logs and assuming that the log human capital production equation is linear in years

of schooling and quadratic in work experience, we obtain the log wage equation:

$$\begin{aligned}
\ln w_a &= \alpha + \Sigma_{k=1}^{K} \mu_k \beta_{0k} + && (10)\\
&\beta_1 E_a^P + \gamma_1 E_a^{P,v=1} + && (11)\\
&\beta_1^S E_a^P d_1^S + \gamma_1^S E_a^{P,v=1} d_1^S + && (12)\\
&\beta_1^{NS} E_a^P d_1^{NS} + \gamma_1^{NS} E_a^{P,v=1} d_1^{NS} + && (13)\\
&\beta_2 E_a^S + \gamma_2 E_a^{S,v=1} + && (14)\\
&\beta_2^S E_a^S d_{2a}^S + \gamma_2^S E_a^{S,v=1} d_{2a}^S + && (15)\\
&\beta_2^{NS} E_a^S d_{2a}^{NS} + \gamma_2^{NS} E_a^{S,v=1} d_{2a}^{NS} + && (16)\\
&\beta_3^{M,S} G_a + \beta_3^{NS} G_a + \beta_4 x_a + \beta_5 x_a^2 + \varepsilon_a^W. && (17)
\end{aligned}$$

The intercept of the log wage equation, β_{0k}, which is allowed to depend on unobserved type to capture unobservable heterogeneity in human capital. The coefficients β refer to the returns to different types of education prior to the introduction of the voucher program. The specification is more general than a standard Mincer-type specification, because it allows returns to primary, secondary and college years of schooling to differ. The γ coefficients represent the difference in the return after the introduction of the voucher (i.e. the return to schooling post voucher is given by $\beta + \gamma$). The γ coefficients are introduced to allow for the possibility that the voucher program potentially changed the quality of all types of schools. For example, increased competition may have improved the quality of both public and private schools. On the other hand, the voucher program could have drawn some of the better teachers out of the public school system, lowering public school quality. Thus, the coefficient γ could be either positive or negative. Below, we present evidence that individuals educated in the post-voucher period receive higher returns to their schooling.

Individuals differ in terms of the timing of the voucher program with respect to their schooling career. For example, an individual may have attended 5 years of primary school pre-voucher and 3 years primary and all of secondary post-voucher. β_1^{NS} and β_1^S (γ_1^{NS} and γ_1^S) capture the premium that individuals receive in the labor market for attending a private

primary school, which is allowed to differ by type of school (non-subsidized verses subsidized). The coefficients β_2^{NS} and β_2^{S} (γ_1^{NS} and γ_1^{S}) capture the premium for having attended either a subsidized or non-subsidized private secondary school. If an individual attends secondary school, then there are nine different schooling type choices possible: public primary and secondary, public primary and private subsidized secondary, public primary and nonsubsidized private secondary, subsidized private primary and public secondary, subsidized private primary and private subsidized secondary, subsidized private primary and private nonsubsidized secondary, nonsubsidizied private primary and public seconday, nonsubsidizied private primary and subsidized secondary, subsidized secondary and nonsubsidizied secondary. The coefficients $\beta_3^{M,S}$ and β_3^{NS} is the earnings return for each year of college attended, which is allowed to differ depending on whether an individual attended a nonsubsidized private secondary school.[11] β_4 and β_5 represent the market return to actual labor market experience.

The maximized present discounted value of lifetime utility at t, the value function, is given by

$$V(\Omega(a), a) = \max_{d_j(a) \in K(a)} E\{\sum_{\tau=a}^{A} \beta^{\tau-t} U_a^j | \Omega(a)\},$$

where U_a^j is the maximum of the alternatives available to the individual at age t, denoted $K(a)$. A is the terminal age of the model, assumed to be age 62 (the standard retirement age in Chile for men). The expectation is taken over the distribution of preference and wage shocks.

4 Model Solution and Estimation

The solution to the optimization problem is a set of decision rules that relate the optimal choice at any age a, from among the feasible set of alternatives, to elements of the state space. Recasting the problem in a dynamic programming framework, the value function can be written as the maximum over alternative-specific value functions, $V^j(\Omega(a), a)$, i.e., the

[11] Individuals who attended nonsubsidized private secondary schools are more likely to be admitted to the most elite universities in Chile, which are University of Chile and Catholica University.

expected discounted value of alternative $j \in K(a)$ that satisfies the Bellman equation

$$\begin{aligned} V(\Omega(a), a) &= \max_{j \in K(a)} [V^j(\Omega(a), a)] \\ V^j(\Omega(a), a) &= U^j(a, \Omega(a)) + \beta E(V(\Omega(a+1), a+1 | d_j(a) = 1, \Omega(a)) \text{ for } a < A, \\ &= U^j(A, \Omega(A)) \quad \text{for } a = A. \end{aligned}$$

The solution of the optimization problem is not analytic, so the model is solved numerically. The solution consists of values of $E(V(\Omega_{t+1}, t+1 | d_j(a), \Omega(a))$ for all j and elements of $\Omega(a)$. We refer to this function as the Emax. The solution method is by backwards recursion, beginning with the last period, A. The multivariate integrations necessary to calculate the expected value of the maximum of the alternative-specific value functions at each state point are performed by Monte Carlo integration over the shocks. The state space is manageable, so that we evaluate the value of the Emax function at every possible state point without having to use interpolation methods.

The model is estimated by maximum likelihood. Let O_{it} represent the outcomes (education choices, work choices, observed wages) of individual i and age a. Also, let I_i denote the set of initial conditions for that individual (family background variables, type of primary school attended). The contribution to the likelihood of individual i is given by:

$$L_i = \sum_{k=1}^{K} \Pr(O_{ia}, O_{ia-1}, ..., O_{ia_0}; \mu_k = 1, I_i) \Pr(\mu_k = 1 | I_i)$$

where $\Pr(\mu_k = 1 | I_i)$ denotes the type probability which depends on initial conditions, which in our application represent family background socioeconomic status, parental education levels and numbers of siblings. The unobserved type is assumed to be known to the individual but not to the econometrician; the outside summation integrates over the type probabilities. The likelihood can be written as the product over the age-specific choice probabilities:

$$L_i = \sum_{k=1}^{K} \Pi_{a=a_0}^{A} \Pr(O_{ia} | O_{ia-1}, ..., O_{ia_0}; \mu_k = 1, I_i) \Pr(\mu_k = 1 | I_i).$$

To illustate the calculation of the likelihood, suppose that the jth alternative chosen by individual i is to work, so that we observe a wage at age a. The probability of observing

that choice and wage outcome conditional on the state space (which includes $O_{ia-1}, ..., O_{ia_0}$, I and *type*) is:

$$\Pr(d^j(a) = 1, w_a|\Omega(a), I, \mu_k = 1) = \Pr(d^j(a)|w_a, \Omega(a), I) f(w_a|\Omega(a), I, \mu_k = 1),$$

where $f(w_a|\Omega(a), I, \mu_k = 1)$ is the wage density.

The overall likelihood for $i = 1..N$ individuals is the product over the individual likelihoods:

$$L = \Pi_{i=1}^{N} L_i.$$

To complete the description of the model, we need to specify the functional form for the type probabilities. They are assumed that type depends on parents' education, number of siblings, and family socioeconomic status (the initial conditions, denoted I_i) in the following way.

$$P\left(type = k|I_i\right) = \frac{\exp(I_i'\tau)}{1 + \exp(I_i'\tau)}$$

To estimate the probilities, $\Pr(O_{it}|O_{it-1}, ..., O_{it_0}; \mu_k = 1)$ in a way that improves the empirical performance of the estimator, we use the kernel smoothed frequency simulator proposed by McFadden (1989). For each set of error term draws, the kernel of the integral is

$$\frac{\exp\{\frac{V^i(a) - \max(V^j(a))}{\tau}\}}{\Pi_{l=1}^{J} \exp\{\frac{V^l(a) - \max(V^j(a))}{\tau}\}},$$

times the density of the observed wages. Here, $V^i(a)$ is the value function associated with the choice that person i made at age a, $\max(V^j(a))$ is the value function associated with the maximal choice, and τ is a smoothing parameter.

The model parameters enter the likelihood through the choice probabilities that are computed from the solution of the dynamic programming problem. Subsets of parameters also enter through the wage offer function. The maximization of the likelihood function iterates between solving the dynamic program and calculating the likelihood.

5 Empirical Results

6 Data

In 2002, the Microdata Center of the Department of Economics of the Universidad de Chile, conducted a new household survey called *Historia Laboral y Seguridad Social (HLLS)*; in 2004, it administered a follow-up survey, the *Enquesta Proteccion Sociale (EPS)*. The data from the 2002 survey contain demographic and labor market information on 17,246 individuals age 15 or older, including information on household characteristics, education, training and work history, pension plan participation, savings, as well as more limited information on health, assets, disability status and utilization of medical services. Of particular relevance to this project are the questions on labor force and participation in training/education, which include retrospective information back to 1981, questions on educational attainment, family background (number of siblings, parent's education, poverty status during adolescence), type of primary and secondary school attended, and location (geographic region) of schools attended. Appendix A contains a detailed description of the sampling frame for the 2002 and 2004 surveys.

Our analysis sample consists of 4517 male individuals for whom we observe the educational attainment and labor force participation dating back up to 35 years (the year 1970) until 2004. We have a total of 94411 person-year observations on these individuals. Each individual was asked the type of primary and secondary school they attended. We assume that they started attending school at age 6 (the standard age) and attended continuously until the end of their schooling career.[12]

6.1 Descriptive Statistics

Table 1 shows the means of variables used in our analysis, for the complete sample and by type of primary school attended. The average age is 30.6 years and the average education level 11.0

[12]The assumption of continuous schooling was made in part because we do not have information on the exact schooling progression pattern, only on the final attainment.

years. A comparison of the last three columns shows that individuals who attended municipal primary attain on average 10.5 years of schooling. Those who attend private primary schools complete substantially more education, with an average of 12.8 years for those attending private subsidized primary and 14.1 years for those attending private nonsubsidized primary. Roughly a third of our sample resided in Santiago (the capital city) at the time of attending school. School attendance patterns are different in Santiago, in part because of the wider availability of all types of schools as well as good public transportation options. More than half of people who report attending private primary schools (subsidized or nonsubsidized) did so in Santiago. The annual earnings of our sample is $3835, in 2002 US Dollar-equivalents. Average earnings are roughly comparable for those attending municipal or subsidized primary school, but are nearly double for those attending nonsubsidized private school ($6691 on average).

Table 1 also provides information on the family background of the individuals in our sample. The men in our sample attain much higher average education levels than did their parents; on average, the mothers' have 7.1 years of education and the fathers' 7.8 years. The parental education levels are higher by 0.3-0.5 years for individuals who attended private subsidized primary school than for municipal school attendees, and almost two years higher for private unsubsidized primary school attendees. Respondents were also asked about the poverty status of their family while growing up, which was reported in four categories: indigent, poor, good and very good. Only a small proportion (2.5%) report their family background as indigent. The majority report their family's socioeconomic status as being poor (34.8%) or good (59.2%), and a small proportion (3.4%) report very good. As seen in the table, individuals who attend private schools are less likely to report their background as indigent or poor. On average, the individuals in our sample have 3.7 siblings, with a slightly fewer (3.3 on average) for private school attendees. In the model we estimate, family background and numbers of siblings are determinants of the type probability.

As seen in Figure 1, following the introduction of vouchers in 1980, the percentage of individuals attending municipal schools decreased dramatically. The decrease was most pro-

nounced in the first five years, but continued thereafter. Correspondingly, the percentage of individuals attending private subsidized primary schools increased. The percentage attending private nonsubsidized schools exhibits an increase over the 1990-2000 period followed by a slight decline. The percentage choosing private nonsubsidized schools is overall much smaller, ranging from a low of 5.1 in 1981 to a high of 9.5 in 1996.

Tables 2a and 2b examine how the choice of primary school type relates to the choice of secondary school type, for subsamples who were (Table 2a) and were not (Table 2b) exposed to school vouchers prior to age 15 (when individuals typically start secondary school). Each cell shows both unconditional and conditional (on primary school type) probabilities of choosing certain secondary schooling types. Among those not exposed to vouchers by age 15, 34.9% of those who attended municipal primary school did not attend secondary school. Among those exposed, the percentage not attending secondary goes down to 19.7%. Those who attend a municipal primary school and continue on in secondary are most likely to transition to a subsidized secondary school. Conditional on having attended a private primary school (either subsidized or nonsubsidized), the probability of attending a private nonsubsidized secondary school remains the same regardless of whether exposed to vouchers. However, the probability of attending a municipal school declines and the probability of attending a private subsidized school increases. In summary, the sample exposed to vouchers is much more likely to continue on to secondary school and more likely to attend private subsidized primary and secondary schools.

Figure 2 examines how school attendance patterns differ by types of schools attended. In particular, it shows the percentage of individuals still in school at a given age, by type of primary and secondary schools attended. The top panel shows the school-going patterns for individuals that attended municipal primary school, by type of secondary attended. The notation "M,." refers to municipal primary and no secondary; "MM" to municipal primary, municipal secondary; "M,S" to municipal primary, subsidized private secondary"; "M,N" to municipal primary, nonsubsidized secondary. Regardless of primary school attended, individuals who attend nonsubsidized secondary schools show the highest attendance rates by

age and are also most likly to attend college. Individuals who attend nonsubsidized primary and secondary schools have the highest attendance rates during college-age years, with about two-thirds still in school at age 20. Among those who do not attend secondary schools, individuals enrolled in subsidized primary school have higher primary school attendance rates.

Figure 3 shows the educational attainment distribution, overall and by type of primary school attended. Individuals who attended municipal schools are much more likely to be in the lowest education categories or to have dropped out of primary school. Only 31% complete 12th grade and only 17% go beyond. Individuals who attend private subsidized primary schools are more likely to finish 12th grade (35%) or go beyond (44%), but their educational attainment is not nearly as high as that of individuals attending nonsubdizied primary schools, 67% of whom go to some college.

Figure 4 graphs the percentage working by age and by type of primary school attended, where the sample is restricted to individuals who have completed their schooling and are legally permitted to work (age 15 and older). The differences in working rates are most pronounced in the 20's, when those who attended municipal schools exhibit the highest rates of working. For example, at age 24, 86% of municipal school attendees are working in comparison to 74% of private subsidized primary attendees and only 58% of private nonsubsidized. Starting at around the mid 30's, though, the working rates of individuals who attend nonsubsidized private schools surpass those of the other groups and reach close to 100%, while those who attended either municipal or private subsidized primary schools have lower rates of around 93%. There is a decline in working rates in the late 40's among those who attended municipal or subsidized private primary schools.

Figure 5 graphs the age-earnings relationship by educational attainment categories and type of primary school attended. The age-earnings curves are smoothed using local regression.[13] Among those completing less than 8 years of education, municipal school attendees have a flatter age-earnings relationship than private school attendees. For individuals com-

[13] A bandwidth of 5 years was used for the plots.

pleting 8 to 11 years of school or who complete high school only (12 years), the age-earnings relationship is comparable across the three different schooling types, with no clear evidence of an earnings premium for having attended a private primary school. For those who complete more than 12 years of schooling, earnings are comparable for those who attended municipal or subsidized private schools but are much higher for those who attended pnonsubsidized private schools. This difference is most likely attributable to differences in the types of colleges attended, with a higher proportion of private nonsubsidized secondary schools attending the premiere universities (Catholica University and Universidad de Chile).

6.1.1 Reduced form estimated decision rule models

In Tables 3, 4 and 5, we present estimates of choice models that relate the decision variables in our model (school attendance, type of school attended, educational attainment and work) to the state variables. These estimates are reduced form in that they do not impose the structure of the model and also do not account for unobservable heterogeneity; they are, however, useful for exploring correlations in the data. Table 3 shows the estimation results where the outcome measure is educational attainment. In the first column, the specification includes two indicator variables for whether the voucher program was available during primary and secondary school ages (ages 6-14 and ages 15-18). The second column of estimates includes a variable that indicates the total number of years the individual was exposed to the voucher program at any point over ages 6-18. For example, if the individual was in second grade when the program was introduced, the exposure is 10 years. Under both specifications, individuals who attended school during a period when vouchers were available, ceteris paribus, have substantially higher years of education. The first specification shows that exposure starting in primary school, prior to making secondary school type choices, is most important. Conditional on primary exposure, exposure to vouchers during secondary school is not associated with significantly higher years of education. Individuals whose parents (mothers and/or fathers) have more education also achieve higher educational attainment levels, with the estimated coefficient on mother's education being twice as large as that on

father's education. Also, individuals from less poor families have higher educational attainment levels (the omitted category is "indigent"). The number of siblings is not a significant predictor of educational attainment, conditional on the other included variables. Residing in the city of Santiago at the time of attending school is associated with 1.33 years higher attainment.

Table 4 presents estimates from a multinomial logit model for the choice of primary school type, where the estimates refer to the probability of choosing a subsidized or nonsubsidized private primary school relative to a municipal school. Having the voucher available during primary school years is associated with a statistically significant increase in the probability of choosing the subsidized primary private school type (the only private school type that accepts the voucher), without any significant change in the probability of choosing the nonsubsidized primary school type. The coefficient associated with voucher exposure during secondary school years is not statistically significantly different from zero. Mothers' and father's education are statistically significant determinants of the probability of choosing a private unsubsidized school. Individuals with more siblings are less likely to attend private schools. The family background variables are not significant determinants of the choice of primary school type, conditional on the other included regressors. Residing in Santiago makes it much more likely that an individual attends private primary school.

Table 5 presents estimates from a probit model of the probability of working, where the subsample includes all person-year observations for those 15 or older who are not in school. More years of education increases the probability of working in a given year. Being exposed to the voucher program during primary school years decreases the probability of working, and being exposed only in secondary school years has no significant effect. Having a father with more years of education and having more siblings are both associated with increased probabilities of working (statistically significant at 5% level). Not surprisingly, more previous labor market experience increases the probability of working in the current period. The probability of working also increases with age at a decreasing rate. Lastly, residing in Santiago substantially increases the probability of working.

6.2 Empirical Results

6.3 Parameter Estimates and Model fit

Table 6a and 6b report the fit of the estimated model to the actual schooling choice distributions for the subsamples who were and were not exposed to vouchers by age 15. To generate these fits, we use the estimated model to simulate choices for all the individuals in our sample, starting from their initial conditions, and we compare simulated and actual choices. In the tables, the simulated cell percentage appears in parentheses under the actual percentage. The model predicts a large difference in the schooling choice distribution for the two groups that differ in their voucher exposure, as is present in the data. The model underpredicts somewhat the percentage of individuals attending municipal primary school who do not go on to secondary school for the subgroup not exposed to vouchers (prior to age 15). The model is fairly accurate in predicting the distribution of school choices for those who attend private subsidized primary school. The predictions are less accurate for attending private unsubsidized primary school who were exposed to vouchers, but these individuals constitute only about 5% of the individuals exposed. Aggregating across all secondary school types, the model predicts fairly well the proportions attending different kinds of primary schools, for both subsamples (the last column of the tables).

Table 7 presents the goodness-of-fit for the educational attainment distribution. The model fits reasonably well the distribution for the subsample exposed to vouchers, except that too many people are simulated to drop out of highly at grade 11 rather than at complete grade 12 (the final year of highschool). For the subsample not exposed to vouchers, too many people are predicted to continue schooling after primary school and to complete 9, 10 and 11 years of education. However, the prediction of the percentage completing 12 or more (about 43%) is accurate. The simulation generates a substantial difference in education attainment between the sample exposed and not exposed to vouchers, as is observed in the data, although the predicted differences understate somewhat the actual differences. When the two samples (those exposed and not exposed to vouchers during primary school) are

combined, in the last two columns, the fit of the model to the education distribution is good.

Table 8 reports evidence on how the model fits the labor force participation patterns, disaggregated by type of primary and secondary schools attended. The numbers in parentheses indicate the number of person-year observations in that cell. The model captures the general pattern of rising labor force participation rates with age (over the age ranges indicated), although the age increase is a little steeper in the data than in the simulation. The predicted patterns also capture the fact that individuals who attend private schools have lower participation rates over younger ages (age 16-25). There are some categories, such as individuals who attend municipal primary only, for which the predicted participation is low relative to the data.

Table 9 shows the model fit to wages. The mean overall annual wages predicted by the model is $4712, which is close to the actual mean of $4815. Disaggregating by school types, we see that the simulated model reproduces the pattern of lower wages for municipal school attendees and higher wages for private school attendees, as observed in the data. It also generates the pattern of higher wages for those who attended nonsubsidized primary and secondary schools, although the simulated wages in this category understate the actual wages. The simulation also yields that wages are lowest for those who do not attend secondary school, particularly for those who attended only municipal primary, who earn about three quarters of the overall average wage.

6.4 Counterfactual policy evaluation

We next use the estimated model to explore how the school tuition vouchers affect school attendance and labor market decisions and whether vouchers contributed to declining inequality in educational attainment and earnings outcomes. To perform this policy simulation, we use the model to simulate choices and outcomes with and without the voucher program in place. The simulation without the program modifies the budget constraint to reflect the additional tuition cost that would have to be paid for private schooling and adjusts the return to years of schooling for all school types to correspond to pre-voucher levels. The effects of

the voucher program on the returns to schooling are identified from differences in the wages paid to those who received education in the pre and post voucher periods, controlling for actual labor market experience.[14]

One potential concern in performing these simulations is that there may have been other improvements in the quality of schools in the post-voucher period that also influence the wage returns to schooling. Table 10 summarizes the major schooling reforms that took place in Chile since 1980. As seen in the table, a number of reforms were instituted in 1990, most notably an expansion in the value of the voucher, an increase in school resources (in part implemented through the increase in the value of the voucher), and an almost doubling of the public school teacher wage that was negotiated by the teacher's union. The change in the teacher's wage is unlikely to dramatically affect the quality of the schooling over the short term, because it takes some time to become a licensed teacher and to replace existing teachers. Over the longer-term, however, the higher wage would be expected to attract more qualified entrants into the teaching profession and improve school quality.[15] Some additional schooling reforms were instituted in later years, including a competitive school funding program called SNED (implemented in 1996), an increase in the length of the school day along with a school expansion program (implemented in year 2000), and the introduction of a new teacher evaluation and certification program in 2002 and 2003.

Most of these reforms come after the individuals in our sample have already completed their schooling. In fact, only 5% of our sample was potentially exposed to the 1996 reform while in primary school, and none were exposed to the year 2000 or subsequent reforms. Roughly 15% of our sample was attending primary and secondary school in 1990, so these individuals might have been affected by the 1990 schooling reform that expanded the value of the voucher and increased the teacher wage. For reasons of parsimony, our model specification does not allow for changes in the return to education for individuals attending in the

[14] Recall that the wage data pertain to years 2002 and 2004, so the wage data are measured at the same time for everyone.

[15] There is a college entrance exam given in Chile analogous to the SAT in the US. These reforms corresponded with a reversal in a long-term declining trend in the average test scores of new teachers, suggesting that the higher pay did increase the quality of new entrants into the teaching profession.

post 1990 time period for part of their schooling career, although such an extension would potentially be feasible.

6.4.1 Effects of voucher program on educational outcomes

Table 10 reports the effect of vouchers on educational outcomes for the subsample that was exposed to vouchers at any point during their primary education years. To explore distributional effects of the program, results are reported for the whole sample and by whether the individual reports being from a poor family or not, where poor family corresponds to having reported either being indigent or poor when growing up.[16] As seen in the first row of table 10, the voucher program increases attendance at private subsidized primary schools by 4.7%. The increase in subsidized private primary school attendance is a little larger for the non-poor subsample (5.0%) than for the poor subsample (4.2%). There is similarly a substantial increase in attendance at subsidized secondary private schools, which is again greater for the non-poor subsample (6.4%) than for the poor sample (5.8%). The voucher program reduces the attendance rate at nonsubsidized primary private schools by around -0.7% and at nonsubsidized secondary private schools (-0.1%), suggesting that some of the students attending the nonsubsidized private schools are induced by the voucher tuition incentive to attend the subsidized school.

We would expect the greater incentives for education operating through vouchers to stimulate college-going as well, because completing highschool is a prerequisite for attending college. The simulation indicates a 5% increase in college attendance, which is again slightly greater for the nonpoor (5.3%) than the poor subsamples (4.2%). The simulation indicates that the 25th percentile, the median, and the 75th percentile educational attainment levels increase by one year in the non-poor sample, with no increase for the median years for the poor sample.

Table 11 shows how the voucher program affects the entire education distribution for the same three subsamples. The impacts are most substantial around the grade 9-12 range; the

[16] Family background socioeconomic status was reported in four categories and we take the first two categories as poor.

percentage of individuals completing those grades increases in the range of 5.7-7.8 percentage points. Smaller impacts are observed for earlier and later grades. The simulation shows that the percentage of students graduating from college (which lasts 3-5 years for most degree programs) is also increased.

Overall, the results in this table suggest that the voucher program simulated schoolgoing and lead to higher educational attainment levels overall. We observe a higher highschool graduation rate (by 7.4%), a higher rate of college attendance (by 4.9%) and a higher rate of college completion. Both children from poor and nonpoor families experience positive impacts of the program, but the children from non-poor families experience a somewhat greater benefit.

6.4.2 Effect of voucher program on labor market outcomes

In Table 12, we simulate the effect of the voucher program on earnings and labor force participation. The increase in educational attainment alone would be expected to increase wage offers, which in turn would tend to increase labor force participation. An additional source of increase in wage offers comes from the fact that post-voucher education returns are estimated to be higher than pre-voucher education returns. As seen in Table 13, mean earnings are higher with the voucher program by more than $300 for both the poor and nonpoor subsamples, over age ranges 16-45. This represents about a 7% increase in earnings, measured against the benchmark mean earnings of 3847 (see Table 1). The effect of the program on mean earnings is comparable in the poor and non-poor subsamples.

As expected, the higher wage offers leads to an increase in the labor force participation rate, with the largest impact on labor force participation rates of about three percentage points occuring over the age 26-35 range. The increase in participation is lower at younger ages, because the stimulus from higher wage offers is mitigated by longer time spent in school, which delays their labor force entry.

In future research, we also plan to evaluate the effects of alternative programs to universal vouchers, that include (i) targeting the vouchers selectively at poor households, (ii)

providing school attendance subsidies instead of vouchers, and (iii) implementing high school graduation and college attendance bonuses.

7 Conclusions

This paper develops and estimates a dynamic model of schooling and labor supply and uses it to study the longer term effects of school vouchers in Chile on educational and labor force outcomes over the life-cycle. The previous literature on vouchers in the Chilean context has focused on test score impacts using test score data collected many years after the voucher reform was introduced. Our study focuses on a longer time horizon using information on individuals who obtained their education before or during the reform period and therefore has the potential to capture reform related changes in both public and private sector schools.

We find that returns to education are lowest in the municipal schools and highest in the private subsidized schools, both at the primary and secondary levels. However, the gap in the returns between public and private sector education decreased after the introduction of vouchers. When we simulate schooling and labor force behavior with and without vouchers, we find substantial effects on educational attainment, high school graduation rates, college attendance, college graduation rates, wages, and labor supply. The largest impacts on labor supply are not observed until after age 25, because the program at first delays labor force entry as individuals complete more schooling. Positive impacts on educational attainment are observed over the entire education distribution, with the most substantial impacts observed around grades 9-12. The percentage of individuals completing those grades increases in the range of 5.7-7.8 percentage points. We also observe a substantial effect of the program on earnings outcomes. Average wages of workers increase, on average by about \$300 per year, which represents about a 7% increase.

In considering the distributional consequences of the voucher program, we find that individuals from both poor and nonpoor families benefit from the program. However, the education and wage benefits appear to be somewhat greater for individuals from nonpoor families.

Appendix A

The sampling frame of the 2002 HLSS survey consists of individuals enrolled in the social security system for at least one month during the 1981-2001 time period, which included individuals who in 2002 were working, unemployed, out of the labor force, receiving pensions, or deceased (in which case the information was collected from surviving relatives). The sample was drawn from a sampling frame of approximately 8.1 million current and former affiliates compiled from official databases (which covers approximately 75% of the population). The sampling frame for the EPS in 2004 was augmented to include individuals not affiliated with the social security system, so that the sample is representative of the entire Chilean population over the age of 15. Individuals who were interviewed in 2004 but were not interviewed in 2002 were asked questions pertaining both to the 2002 and 2004 time period. In our analysis, we use the longitudinal data collected by both the 2002 and 2004 surveys.

References

[1] Altonji, Joseph, Todd Elder, and Christopher Taber (2005): "Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools," *Journal of Political Economy*, 2005.

[2] Angrist, Joshua D., Eric Bettinger, Erik Bloom, Elizabeth King and Michael Kremer (2002): "Vouchers for Private Schooling in Colombia: Evidence from a Randomized Natural Experiment," *American Economic Review* 92:5 (December), 1535-59.

[3] Attanasio, Orazio, Costas Meghir and Ana Santiago (2001): "Education Choices in Mexico: Using a Structural Model and a Randomized Experiment to Evaluate Progresa," manuscript, University College London.

[4] Becker, Gary (2002): "Happy Birthday, Milton Friedman," *Business Week*, July 1st, 2002.

[5] Behrman, Jere R., Susan W. Parker and Petra E. Todd (2006): "Long-Term Impacts of the Oportunidades Conditional Cash Transfer Program on Rural Youth in Mexico," in Stephan Klasen, ed., *Poverty, Inequality, and Policy in Latin America*, Cambridge, MA: MIT Press.

[6] Behrman, Jere R., Piyali Sengupta and Petra Todd (2005): "Progressing through PROGRESA: An Impact Assessment of Mexico's School Subsidy Experiment," *Economic Development and Cultural Change* 54:1 (October 2005) 237-275.

[7] Behrman, Jere R. and Barbara L. Wolfe (1984): "The Socioeconomic Impact of Schooling in a Developing Country," *Review of Economics and Statistics* 66:2 (May), 296-303.

[8] Behrman, Jere R. and Barbara L. Wolfe (1987b): "Investments in Schooling in Two Generations in Pre- Revolutionary Nicaragua: The Roles of Family Background and School Supply," *Journal of Development Economics* 27:1-2 (October), 395-420 (reprinted in International Trade, Investment, Macro Policies and History: Essays in Memory of Carlos

F. Diaz-Alejandro (eds., Pranab Bardhan, Jere R. Behrman, and Albert Fishlow), Amsterdam: North-Holland, 1987), 395-420.

[9] Behrman, J. and N. Birdsall (1983): "The Quality of Schooling: Quantity Alone Is Misleading", *American Economic Review*, 73, 928-46.

[10] Ben-Porath (1969): "The Production of Human Capital and the Life Cycle of Earnings", *Journal of Political Economy*, 75, 1, 352-65.

[11] Bravo, David, 1999, "Competencia y calidad de la educación en Chile: una revisión de la literatura", in P.Cariola and J.Vargas (eds), Educación Particular Subvencionada. Un aporte a la modernización de la Educación Chilena. Santiago, CONACEP

[12] Bravo, David, Dante Contreras, and Claudia Sanhueza, 1999, "Rendimiento escolar, desigualdad y brecha de desempeño privado/público: Chile 1982-1997". Documento de Trabajo N°163, Departamento de Economía, Universidad de Chile.

[13] Brighouse, Harry (2000): *School Choice and Social Justice*, Oxford University Press, Oxford: U. K.

[14] Card, D. and A. Krueger (1992a): "School Quality and Black-White Relative Earnings: A Direct Assessment", *Quarterly Journal of Economics*, 107.

[15] _____, (1992b) "Does School Quality Matter: Returns to Education and the Characteristics of Public Schools in the United States", *Journal of Political Economy*, 100, 1, 1-40.

[16] Cox, Cristián (2005), Políticas educacionales en el cambio de siglo. La reforma del sistema escolar de Chile. Editorial Universitaria, Santiago.

[17] Espínola, V. (1995), "The Decentralization of the Education System in Chile (1980-1994)". Draft.

[18] Ferreyra, Maria (2002): "Estimating the Effects of Private School Vouchers in Multi-District Economies," Ph.D. Dissertation, University of Wisconsin.

[19] Figlio, David N. And Cecilia E. Rouse (2005): "Do Accountability and Voucher Threats Improve Low-Performing Schools," NBER working paper #11597.

[20] Friedman, Milton (1955): "The role of government in education," In R. A. Colo (ed.) *Economics and the public interest* (pp.123-144). New Brunswick, NJ: Rutgers University Press.

[21] Friedman, Milton, 1962, *Capitalism and Freedom*, Princeton, NJ: Princeton University.

[22] Gauri, V. (1994), "Market Forces in the Public Sector: Chilean Educational Reform 1980-93". Draft of unpublished thesis, Princeton University.

[23] González, Pablo (2005), "Estructura institucional, recursos y gestión en el sistema escolar chileno", en C.Cox (ed), Políticas educacionales en el cambio de siglo. La reforma del sistema escolar de Chile. Editorial Universitaria, Santiago.

[24] Gould, Eric (2002): "Rising Wage Inequality, Comparative Advantage, and the Growing Importance of General Skills in the United States," *Journal of Labor Economics*, Volume 20, 105-147.

[25] Grogger, Jeffrey and Derek Neal (2000): "Further Evidence on the Effects of Catholic Secondary Schooling," in Brookings-Wharton Papers on Urban Affairs, W. G. Gale and J.R. Pack, eds. Washington, D.C.: Brookings Institution, 151-93.

[26] Hanushek, Eric A, (1986): "The Economics of Schooling," *Journal of Economic Literature* 24, 1141-77.

[27] Hanushek, Eric A. (1995): "Interpreting Recent Research On Schooling in Developing Countries," *The World Bank Research Observer* 10:2 (August), 227-246.

[28] Hanushek, Eric A. (2003): "Does Public School Competition Affect Teacher Quality," in *The Economics of School Choice*, edited by Caroline Hoxby, University of Chicago Press: Chicago, p. 23-47.

[29] Hanushek, Eric A., Kaine, John F., Steven G. Rivkin (2004): "Why Public Schools Lose Teachers," *Journal of Human Resources*, 39(2), pp. 326-54.

[30] Heckman James, J. and Burton Singer (1984): "A Method for Minimizing the Impact of Distributional Assumptions in Econometric Models for Duration Data," Econometrica, 52, 271-320.

[31] Heckman, James J., Anne Layne-Farrar and Petra Todd (1996): "Human Capital Pricing Equations with an Application to Estimating the Effect of Schooling Quality on Earnings" in *Review of Economics and Statistics*, Nov.

[32] Heckman, James J., Anne Layne-Farrar and Petra Todd, "Does Measured School Quality Really Matter?" in Does Money Matter? The Link Between Schools, Student Achievement and Adult Success, ed. Gary Burtless, Brookings Institution, Washington, DC, 1996.

[33] Heckman James, J. and Burton Singer (1984): "A Method for Minimizing the Impact of Distributional Assumptions in Econometric Models for Duration Data," *Econometrica*, 52, 271-320.

[34] Heckman, J. and Honore, B. "The Empirical Content of the Roy Model" *Econometrica*, 58, Sept. 1990

[35] Heckman, J. and Sedlacek, G. "Heterogeneity, Aggregation and Market Wage Functions" *Journal of Political Economy*, 93, 1985.

[36] Heckman, James, Lance Lochner and Petra Todd (2005): "Earnings Functions, Rates of Return and Treatment Effects: The Mincer Equation and Beyond" forthcoming in Handbook of Education Economic, (also NBER paper #11544).

[37] Heckman, James, Anne Layne-Farrar and Petra Todd (1996): "Human Capital Pricing Equations with an Application to Estimating the Effect of Schooling Quality on Earnings" in *Review of Economics and Statistics*, November.

[38] Heckman, James J. and Salvador Navarro (2005): "Dynamic Discrete Choice and Dynamic Treatment Effects," *Journal of Econometrics*, December.

[39] Hoxby, Caroline (2003): "Introduction,"in The Economics of School Choice, edited by Caroline M. Hoxby, University of Chicago Press: Chicago, p. 1-22.

[40] Hoxby, Caroline (2001): "Would School Choice Change the Teaching Profession," *Journal of Human Resources*, Vol. 37, No. 4, (Autumn, 2002), pp. 846-891.

[41] Hoxby, Caroline (2001): "School Choice and School Productivity: Could School Choice be a Tide that Lifts all Boats?," working paper.

[42] Howell, William and Paul Peterson (2002): *The Education Gap*, Washington, D. C.: Brookings Press.

[43] Hsieh, Chang-Tai and Miguel Urquiola (2005): "When Schools Compete, How Do They Compete? An Assessment of Chile's Nationwide School Voucher Program," *American Economic Review*, December.

[44] Jofré, G. (1988), "El Sistema de Subvenciones en Educación: la Experiencia Chilena2, Estudios Públicos

[45] Keane, Michael P. and Kenneth I. Wolpin (1994): "The Solution and Estimation of Discrete Choice Dynamic Programming Models by Simulation: Monte Carlo Evidence," *Review of Economics and Statistics* (November).

[46] Keane, Michael P.. And Kenneth I. Wolpin (1997): "The Career Decisions of Young Men," *Journal of Political Economy* 105:3, 473-522.

[47] Keane, Michael P. and Kenneth I. Wolpin (2000a):. "Equalizing Race Differences in School Attainment and Labor Market Success," *Journal of Labor Economics* 18:4, 614-652.

[48] Keane, Michael P. and Kenneth I. Wolpin (2002b) "Estimating Welfare Effects Consistent with Forward Looking Behavior, Part I: Lessons from a Simulation Exercise," *Journal of Human Resources* 37:3 (Summer), 570-599.

[49] Keane, Michael P. and Kenneth I. Wolpin (2002c): "Estimating Welfare Effects Consistent with Forward Looking Behavior, Part II: Empirical Results.," *Journal of Human Resources* 37:3 (Summer), 600-622.

[50] Keane, Michael and Kenneth I. Wolpin (1994): "The Solution and Estimation of Discrete Choice Dynamic Programming Models by Simulation and Interpolation: Monte Carlo Evidence," *Review of Economics and Statistics,* 1994(4), 648-672. .

[51] Keane, Michael and Kenneth I. Wolpin(1997): "Career Decisions of Young Men" *Journal of Political Economy*, 105, 473-522.

[52] Keane, Michael and Kenneth I. Wolpin (2000): "Eliminating Race Differences in School Attainment and Labor Market Success" *Journal of Labor Economics*, 18, 614-652.

[53] Keane, Michael and Kenneth I. Wolpin (2001): "The Effect of Parental Transfers and Borrowing Constraints on Educational Attainment" *International Economic Review*, 42, 1051-1101.

[54] Krueger, Alan and P. Zhu (2004): "Another Look at the New York City School Voucher Experiment," *The American Behavioral Scientist*, 47,5,p. 58..

[55] McEwan, Patrick J., "The Effectiveness of Public, Catholic, and Non-Religious Private Schools in Chile's Voucher System," *Education Economics*, Vol. 9, No. 2 (2001), 103-128.

[56] McFadden, Daniel (1989): "A Method of Simulated Moments for Estimation of Discrete Response Models without Numerical Integration" *Econometrica*, 57, 5, 995-1026.

[57] Ladd, Helen (2002): "School vouchers: a critical view," *Journal of Economic Perspectives*, 16(4), 3-24, 2002.

[58] Larrañaga, Osvaldo, 2004, "Competencia y Participación Privada: la Experiencia Chilena en Educación", Documento de Trabajo N°207, Departamento de Economía, Universidad de Chile.

[59] McEwan, Patrick J. (2001): "The Effectiveness of Public, Catholic, and Non-Religious Private Schools in Chile's Voucher System," *Education Economics* 9:2, 103-128.

[60] McEwan, Patrick J. and Martin Carnoy, (2000): "The effectiveness and efficacy of private schools in Chile's voucher system," *Educational Evaluation and Policy Analysis*, 22(3), 213-239.

[61] Mizala, P. J. and P. Romaguera (1999): "School performance and choice: the Chilean experience," *Journal of Human Resources*, 35:2, 392-417.

[62] Mizala, A and P. Romaguera (2004), "Teachers' Salary Structure and Incentives in Chile", Working paper N^o 193, Center for Applied Economics, University of Chile.

[63] Neal, Derek (2002): "How Vouchers Would Change the Market for Education," *Journal of Economic Perspectives*, 16:4, 25-44.

[64] Neal, Derek (1997): "The Effect of Catholic Secondary Schooling on Educational Achievement," *Journal of Labor Economics*, January, 15:1, 98-123.

[65] Parker, Susan W., Petra E. Todd and Kenneth I. Wolpin (2005): "Within-Family Treatment Effect Estimators: The Impact of Oportunidades on Schooling in Mexico," manuscript, University of Pennsylvania.

[66] Peterson, P., Howell, W. and Greene, J. (1999): "An Evaluation of the Cleveland Voucher Program After Two Years," Cambridge, MA, Program on Educational Policy and Governance, Harvard University.

[67] Peterson, Paul E., William G. Howell, Patrick J. Wolf and David E. Campbell (2003): "School Vouchers: Results from Randomized Experiments" in *The Economics of School Choice*, edited by Caroline Hoxby, University of Chicago Press: Chicago, p. 1-22.

[68] Rouse, Cecilia (1998): "Private School Vouchers and Student Achievement: The Effect of the Milwaukee Parental Choice Program," in *Quarterly Journal of Economics*, 113:553-602.

[69] Rounds, T. (1994), "The Impact of Decenralization and Competition on the Quality of Education. An Assessment of Education Reform in Chile". Draft. University of Georgia, Athens, GA.

[70] Roy A.D. (1951): "Some Thoughts on the Distribution of Earnings" in *Oxford Economic Papers*, Vol. 3, 135-146.

[71] Schultz, T. Paul (2004):. "School Subsidies for the Poor: Evaluating the Mexican Progresa Poverty Program," *Journal of Development Economics* 74:2 (June), 199-250.

[72] Schultz, T. Paul, 2000, "Impact of PROGRESA on school attendance rates in the sampled population," February. Report submitted to PROGRESA. International Food Policy Research Institute, Washington, D.C.

[73] Schultz, T. Paul, 2004, "School subsidies for the poor: Evaluating a Mexican strategy for reducing poverty," *Journal of Development Economics*, (Revision of June 2000 Report submitted to PROGRESA. International Food Policy Research Institute, Washington, D.C. http://www.ifpri.org/themes/progresa.htm

[74] Steinbrickner, Todd E.(2001): "Compensation Policies and Teacher Decisions" International Economic Review, 42(3), 751-780.

[75] Todd, Petra and Kenneth Wolpin, 2007, " Assessing the Impact of a School Subsidy Program in Mexico: Using a Social Experiment to Validate a Dynamic Behavioral Model of Child Schooling and Fertility," forthcoming in American Economic Review.

[76] Todd, Petra E. and Kenneth I. Wolpin (2002): "Assessing the Impact of a School Subsidy Program in Mexico: Using a Social Experiment to Validate a Dynamic Behavioral Model of Child Schooling and Fertility," manuscript, University of Pennsylvania.

[77] Todd, Petra and Kenneth I. Wolpin, "On the Specification and Estimation of the Production Function for Cognitive Achievement," *Economic Journal*, Feb., 2003.

[78] Todd, Petra E. and Kenneth I. Wolpin (2004): "The Production of Cognitive Achievement in Children: Home, School and Racial Test Score Gaps," Philadelphia, PA: University of Pennsylvania, PIER Working Paper 04-019.

[79] Todd, Petra and Kenneth I.Wolpin (2005): "Using a Social Experiment to Validate a Dynamic Behavioral Model of Child Schooling and Fertility: Assessing the Impact of a School Subsidy Program in Mexico," Philadelphia, PA" University of Pennsylvania, processed.

[80] Tokman, Andrea Ramos (2002): "Is Private Education Better? Evidence from Chile," working papers Central Bank of Chile 147, Central Bank of Chile.

[81] Valdes, J. G. (1995): *Pinochet's economists: The Chicago School in Chile.* Cambridge: Cambridge University Press.

[82] Willis, R. and S. Rosen "Education and Self-selection" *Journal of Political Economy*, 1979.

[83] Yau, Jeffrey (2004): "Estimating the Impact of Vouchers when the Impact Depends on the Duration of Program Participation," PhD Dissertation, University of Pennsylvania.

Table 1
Descriptive Statistics
(Std. Deviation in Parentheses)

	Overall	Municipal Primary	Private subsidized primary	Private unsubsidized primary
Age	32.4	33.2	28.3	31.2
	(8.2)	(8.0)	(8.1)	(8.8)
Years of education	10.8	10.3	12.7	14.1
	(3.4)	(3.3)	(2.7)	(2.8)
Attended primary in Santiago	34.6	30.0	56.3	54.8
	(0.48)	(45.8)	(49.6)	(50.0)
Attended secondary in Santiago	30.0	24.7	52.9	55.3
	(45.8)	(43.2)	(50.0)	(50.0)
Annual earnings (in 2002 dollars)	3847	3776	3765	7485
	(4660)	(4081)	(4149)	(10556)
Mother's education	7.0	7.0	7.3	8.8
	(3.61)	(3.6)	(4.1)	(4.8)
Father's education	7.7	7.7	8.2	9.7
	(3.9)	(3.9)	(4.3)	(5.1)
Family				
Indigent	2.6	2.6	2.7	2.3
	(16.0)	(16.0)	(0.16)	(15.0)
Poor	35.7	36.6	30.7	33.6
	(47.9)	(48.2)	(46.2)	(47.4)
Good	58.3	57.6	62.6	59.0
	(49.3)	(49.4)	(48.4)	(49.3)
Very good	3.3	3.1	4.0	5.1
	(17.9)	(17.3)	(19.7)	(22.0)
Number of siblings	3.8	3.9	3.3	3.4
	(2.7)	(2.7)	(2.6)	(2.9)
Number of observations	4515	3705	593	217

Table 2a
Choice of Primary and Secondary School Types
Sample not exposed to vouchers before age 15 (1818 individuals)
(conditional probabilities in parentheses)

		Secondary School Type				
		None	Municipal	Subsidized	Nonsubsidized	All Secondary types
Primary Type	Municipal	36.07 (40.9)	46.9 (53.2)	4.46 (5.1)	0.77 (0.9)	88.2
	Subsidized	1.21 (16.3)	2.53 (34.1)	3.52 (47.4)	0.17 (2.2)	7.5
	Nonsubsidized	0.22 (5.1)	1.65 (38.0)	0.50 (11.4)	1.98 (45.6)	4.3
		37.50	51.10	8.48	2.92	

Table 2b
Choice of Primary and Secondary School Types
Subsample exposed to vouchers before age 15 (2830 individuals)
(conditional probabilities in parentheses)

		Secondary School Type				
		None	Municipal	Subsidized	Nonsubsidized	All secondary types
Primary Type	Municipal	19.71 (25.3)	45.94 (64.0)	10.78 (9.2)	1.48 (1.5)	77.9
	Subsidized	1.04 (9.8)	5.19 (32.0)	9.78 (52.9)	0.96 (5.9)	17.0
	Nonsubsidized	0.15 (9.5)	0.93 (28.5)	0.89 (9.5)	3.15 (48.0)	5.1
		20.9	52.06	21.49	5.59	

Table 3
Decision Rule Model for Years of Education
(standard errors in parentheses)

Variable†	(1) Estimated Coefficient	(2) Estimated Coefficient
Intercept	7.61	7.24
	(0.35)	(0.43)
Voucher available during primary school years	1.34	…
	(0.11)	
Voucher available during secondary school years	0.16	…
	(0.17)	
Years exposed to voucher††	…	0.13
		(0.02)
Mother's education	0.07	0.07
	(0.02)	(0.03)
Father's education	0.04	0.02
	(0.02)	(0.02)
Number of Siblings	-0.03	-0.01
	(0.02)	(0.02)
Family background poor	0.83	1.02
	(0.31)	(0.39)
Family background good	1.31	1.39
	(0.31)	(0.39)
Family background very good	1.15	1.12
	(0.40)	(0.52)
Resided in Santiago during primary or secondary school years	1.34	1.67
	(0.10)	(0.14)
Number of observations	4415	4515
R-squared	0.10	0.09

† In addition, the specification includes indicator variables for whether information on mother's education, father's education, region of residence is missing.

†† Total number of years exposed to voucher prior between ages 6 and 18.

Table 4
Multinomial Logit Model for the Probability of Choosing Subsidized or Non-subsidized Primary Relative to Municipal Primary Choice
(standard errors in parentheses)

	Estimated Coefficients	
Variable†	Subsidized Primary Choice	Non-subsidized Primary Choice
Intercept	-2.82	-4.55
	(0.34)	(0.55)
Voucher available during primary school years	1.00	0.09
	(0.13)	(0.17)
Voucher available during secondary school years	0.37	-0.17
	(0.20)	(0.27)
Mother's education	0.006	0.09
	(0.02)	(0.02)
Father's education	0.01	0.06
	(0.02)	(0.02)
Number of Siblings	-0.06	-0.03
	(0.02)	(0.03)
Family background poor	-0.24	0.10
	(0.29)	(0.48)
Family background good	-0.12	-0.06
	(0.29)	(0.48)
Family background very good	-0.01	0.21
	(0.37)	(0.57)
Resided in Santiago during primary or secondary school years	1.04	1.10
	(0.09)	(0.14)
Number of observations	4515	

† In addition, the specification includes indicator variables for whether information on mother's education, father's education, region of residence is missing.

Table 5
Decision Rule Model for Working
Probit Model
(standard errors in parentheses)

Variable†	Estimated Coefficient
Intercept	-4.45
	(0.09)
Years of education	0.09
	(0.002)
Attended subsidized primary	-0.12
	(0.02)
Attended nonsubsidized primary	-0.06
	(0.03)
Voucher available during	-0.38
primary school years	(0.06)
Voucher available during	0.09
secondary school years	(0.10)
Labor force experience (in years)	0.29
	(0.003)
Age	0.39
	(0.006)
Age squared	-0.01
	(0.0001)
Mother's education	-0.005
	(0.003)
Father's education	0.006
	(0.002)
Number of Siblings	0.011
	(0.002)
Family background poor	0.01
	(0.04)
Family background good	0.01
	(0.04)
Family background very good	0.03
	(0.05)
Resided in Santiago during primary or secondary	0.08
school years	(0.01)
Number of observations	83377
R-squared	0.37

† In addition, the specification includes indicator variables for whether information on mother's education, father's education, family background poverty status, region of residence or number of siblings is missing.

Table 6a
Actual and simulated schooling choice distribution
subsample not exposed to vouchers before age 15 (1818 individuals)
(simulated choices in parentheses)

		Secondary School Type				
		None	Municipal	Subsidized	Nonsubsidized	Total across all secondary Types
Primary Type	Municipal	40.9 (31.8)	53.2 (61.6)	5.1 (5.7)	0.9 (1.0)	88.2 (85.1)
	Subsidized	16.3 (14.8)	34.1 (38.6)	47.4 (40.6)	2.2 (5.9)	7.5 (10.1)
	Nonsubsidized	5.1 (12.5)	38.0 (33.3)	11.4 (6.3)	45.6 (48.0)	4.3 (4.8)

Table 6b
Actual and simulated schooling choice distribution
subsample exposed to vouchers before age 15 (2699 individuals)
(simulated choices in parentheses)

		Secondary School Type				
		None	Municipal	Subsidized	Nonsubsidized	Total across all secondary Types
Primary Type	Municipal	25.5 (25.3)	59.0 (64.0)	13.8 (9.2)	1.9 (1.5)	77.9 (80.5)
	Subsidized	6.1 (9.8)	30.6 (32.0)	57.6 (52.9)	5.7 (5.9)	17.0 (15.3)
	Nonsubsidized	2.9 (9.5)	18.12 (28.5)	17.4 (9.5)	61.6 (48.0)	5.1 (4.2)

Table 7
Actual and Simulated Schooling Attainment
by whether exposed to voucher program before secondary school

	Subsample without vouchers		Subsample with vouchers		Full sample	
Years of schooling	Actual	Simulated	Actual	Simulated	Actual	Simulated
5 or more	92.1	91.5	96.9	93.7	94.6	92.8
7 or more	83.1	84.9	92.8	88.8	88.9	87.2
9 or more	62.5	71.1	79.1	77.7	72.4	75.1
10 or more	56.3	67.3	74.9	74.4	67.4	71.5
11 or more	47.4	56.1	67.8	64.2	59.6	60.9
12 or more	42.7	42.9	63.5	51.1	55.0	47.8
13 or more	16.4	20.7	29.7	26.3	24.3	24.0
14 or more	14.1	10.8	24.5	15.1	20.2	13.4
15 or more	10.6	7.3	16.9	10.5	14.3	9.2
16 or more	7.2	4.9	11.4	7.0	9.6	6.1
17 or more	4.3	2.8	5.6	4.1	5.0	3.6

Table 8
Actual and Simulated Labor Force Participation Rates
by Primary-Secondary Schooling Choice and Age
(Number of person-year observations in parentheses)

	Age 16-25		Age 26-35		Age 36-45	
Primary-secondary schooling type	Actual	Simulated	Actual	Simulated	Actual	Simulated
M-M	60.2 (19669)	64.3	93.9 (13801)	84.6	94.6 (6268)	89.1
S-M	45.6 (1648)	63.3	93.4 (775)	83.4	95.6 (325)	87.8
NS-M	40.6 (529)	52.5	90.5 (412)	77.1	97.5 (246)	83.6
M-S	52.9 (3413)	57.8	94.1 (1926)	85.5	93.2 (536)	88.5
S-S	42.9 (2943)	56.3	93.2 (1405)	85.1	96.5 (439)	88.4
NS-S	41.9 (286)	48.6	91.6 (155)	82.4	100 (65)	85.8
M-NS	48.1 (480)	61.0	90.2 (298)	88.5	95.3 (108)	91.4
S-NS	30.3 (241)	55.0	85.5 (69)	82.7	69.2 (26)	86.6
NS-NS	25.2 (1118)	46.1	92.6 (607)	81.7	97.7 (268)	87.2
M primary only	86.9 (11266)	66.9	91.3 (9246)	77.1	89.6 (4905)	81.5
S primary only	80.8 (449)	68.7	88.8 (297)	74.5	82.5 (160)	78.5
NS primary only	85.9 (78)	55.6	84.4 (58)	67.1	80.6 (31)	70.2
All Educational categories	63.6 (42120)	63.2	92.8 (29049)	82.6	92.8 (13377)	86.9

M: municipal, S: subsidized private, NS: nonsubsidized private

Table 9
Actual and Simulated Mean Wages of Workers (in 2002 US Dollars)
By Primary-Secondary Schooling Type and Age

Primary-Secondary Schooling Type	Age 16-45	
	Actual	Simulated
All education types	4815	4712
Municipal-Municipal	5040	4960
Subsidized-Municipal	5555	6543
Nonsubsidized-Municipal	9736	6192
Municipal-Subsidized	5739	4473
Subsidized-Subsidized	5651	5856
Nonsubsidized-Subsidized	4301(64)†	5818
Municipal- Nonsubsidized	6252	4376
Subsidized- Nonsubsidized	5739 (49) †	6936
Nonsubsidized- Nonsubsidized	12882	7039
Municipal-no secondary	2924	3112
Subsidized-no secondary	3364	2843
Nonsubsidized-no secondary	4287	2855

† These cells have relatively small numbers of observations (less than 100).

Table 10

Summary of Major educational reforms in Chile since 1980

	Reform	Detailed Description
1981	Introduction of nationwide school voucher program	Private subsidized schools have to accept amount of voucher as full payment of tuition. Voucher amount changes somewhat over the years. It decreased in real terms until 1990, when it increased.
1990	Union negotiated increase (almost doubling) of mandatory minimum wage for teachers, applicable for 1990-2004.	Both public and private teachers are members of the Teacher's Union, which negotiates over min teacher wage applicable to both public and private sector. Teachers in private schools can also form a school level union that negotiate wages over a min. level, but teachers in public schools cannot. At the end of the 1990's, there was an increase in the entrance exam scores (like SAT) of new teachers, which reversed a previous long-term downward trend in scores.
1990-2004	Increase in school resources	Achieved through increasing voucher amount and through special programs for schools.
1994	Change in rules to allow public and private schools to impose a small tuition charge on top of the voucher	This was allowed for private subsidized schools and, with some restrictions, for municipal schools. They cannot impose the charge on poor families.
1996	Introduction of SNED program – National System of Student Performance Evaluation	Within groups of comparable schools (in terms of student family background), identifies best 25% of schools according to the student results. These schools gain extra funds which are divided equally between the teachers of the school. Schools are designated "excellence" schools for two years.
2000	Increase of 20% in the length of the school day (about 6-7 hours per week) with no change in the number of days per year.	This reform required an expansion of many schools, because students had previously attended either morning or afternoon classes, which was no longer possible with the extended school day. Both public and private schools could apply for public school expansion funds and the program was gradually implemented. Information is available on which schools obtained these funds.
2002	Introduction of a new federal teacher certification program.	Teachers in public and private subsidized schools voluntarily submit a teaching portfolio (that includes video of classroom time) and take an exam. Teachers who receive the certification get an extra month of pay per year for ten years, paid for by the government. Currently, about 5% of all teachers receive this certification.
2003	New teacher evaluation program	Mandatory evaluation of all public school teachers every four years that be used for teacher dismissal. Public school teachers hired at the municipality level.

Table 11
Simulated effect of voucher program on education outcomes
by family background status

	Complete sample†			Poor Subsample††			NonPoor Subsample‡		
	With Program	Without Program	Diff	With Program	Without Program	Diff	With Program	Without Program	Diff
% Attending private subsidized primary	15.3	10.6	4.7	14.2	10.0	4.2	15.9	10.9	5.0
% Attending private nonsubsidized primary	4.3	5.0	-0.7	3.9	4.6	-0.7	4.5	5.3	-0.8
% Attending private subsidized secondary	15.8	10.0	5.8	14.5	9.3	5.2	16.8	10.4	6.4
% Attending private nonsubsidized secondary	4.1	4.0	-0.1	3.6	3.7	-0.1	4.3	4.4	-0.1
% Attending college	26.3	21.3	5.0	23.8	19.6	4.2	27.7	22.4	5.3
25% quantile years of education	9	8	1	9	8	1	9	8	1
Median years of education	12	11	1	11	11	0	12	11	1
75% years of education	13	12	1	12	12	0	13	12	1

†Refers to sample of individuals exposed to voucher program at any point in their schooling careers.
†† Refers to subsample that reported family background as indigent or poor.
‡Refers to subsample that reported family background as good or very good.

Table 12
Voucher Impact on Education Distribution
Percent Completing at least x years of schooling

	Complete sample†			Poor Subsample††			NonPoor Subsample‡		
Years of schooling	With Program	Without Program	Diff	With Program	Without Program	Diff	With Program	Without Program	Diff
4	96.5	95.3	1.2	96.6	95.5	1.1	96.6	95.2	1.4
5	93.7	91.4	2.3	93.7	91.7	2.0	93.7	91.2	2.5
6	93.7	91.4	2.3	93.7	91.7	2.0	93.7	91.2	2.5
7	88.8	84.9	3.9	88.6	85.1	3.5	88.9	84.7	4.2
8	88.8	84.9	3.9	88.6	85.1	3.5	88.9	84.7	4.2
9	77.7	71.5	6.2	76.8	71.1	5.7	78.2	71.7	6.5
10	74.4	67.7	6.7	73.3	67.1	6.2	75.1	68.0	7.1
11	64.2	56.7	7.5	62.1	55.2	6.9	65.4	57.6	7.8
12	51.1	43.7	7.4	48.2	41.5	6.7	52.7	44.9	7.8
13	26.3	21.4	4.9	23.8	19.6	4.2	27.7	22.4	5.3
14	15.1	11.4	3.7	13.1	10.0	3.1	16.2	12.2	4.0
15	10.5	7.8	2.7	8.9	6.7	2.2	11.4	8.4	3.0
16	7.0	5.2	1.8	5.9	4.4	1.5	7.6	5.6	2.0
17	4.1	3.0	1.1	3.4	2.5	0.9	4.5	3.3	1.2

†Refers to sample of individuals exposed to voucher program at any point in their schooling careers, over ages 15-45.
†† Refers to subsample that reported family background as indigent or poor
‡Refers to subsample that reported family background as good or very good.

Table 13
Voucher Program Impact on Labor Market Outcomes
(Earnings and Labor Force Participation)

	Complete sample†		Poor Subsample††		NonPoor Subsample‡	
	With Program	Without Program	With Program	Without Program	With Program	Without Program
Mean earnings						
ages 16-25	3019	2772	2943	2726	3065	2799
ages 26-35	6422	5885	6295	5818	6496	5924
ages 36-45	6879	6463	6690	6317	6990	6549
ages 25-45	4975	4615	4842	4521	5053	4670
Percent of time participate in the labor force						
ages 16-25	63.3	62.5	65.7	65.1	61.9	60.9
ages 26-35	83.7	80.7	85.0	82.5	82.9	79.7
ages 36-45	86.8	85.1	87.8	86.3	86.3	84.5
ages 15-45	77.9	76.1	79.5	77.9	77.0	75.0

†Refers to sample of individuals exposed to voucher program at any point in their schooling careers, over Ages 16-45.
†† Refers to subsample that reported family background as indigent or poor.
‡Refers to subsample that reported family background as good or very good.

Table
Estimated Parameter Values

Parameter	Estimate		Estimate
Ln Wage constant Type 1 Type 2 Type 3	6.31 6.93 5.625	Rental rate on municipal secondary post-voucher $(\beta_2 + \gamma_2)$	0.073
Rental rate on municipal primary pre-voucher (β_1)	0.009	Rental rate on private subsidized secondary pre-voucher $(\beta^S{}_2)$	0.0845
Rental rate on municipal primary post-voucher $(\beta_1 + \gamma_1)$	0.0175	Rental rate on private subsized secondary post-voucher $(\beta^S{}_2 + \gamma^S{}_2)$	0.0904
Rental rate on private subsidized primary pre-voucher $(\beta^S{}_1)$	0.021	Rental rate on private nonsubsidized secondary pre-voucher $(\beta^{NS}{}_2)$	0.086
Rental rate on private subsized primary post-voucher $(\beta^S{}_1 + \gamma^S{}_1)$	0.0305	Rental rate on private nonsubsized secondary post-voucher $(\beta^{NS}{}_2 + \gamma^{NS}{}_2)$	0.0921
Rental rate on private nonsubsidized primary pre-voucher $(\beta^{NS}{}_1)$	0.027	Experience (β_3)	0.1435
Rental rate on private nonsubsized primary post-voucher $(\beta^{NS}{}_1 + \gamma^{NS}{}_1)$	0.034	Experience squared (β_4)	0.003
Rental rate on municipal secondary pre-voucher (β_2)	0.067	Rental rate on years of college education (β_5)	0.0957
		Additional rental rate on years of college education if non-sub primary and secondary schooling	0.002

Table
Parameter Estimates

Parameter	Estimate		Estimate
Utility public primary school Type 1 Type 2 Type 3	832 439 295	Utility (Net cost) of attending college Type 1 Type 2 Type 3	-200 935 1180
Utility subsidized primary school Type 1 Type 2 Type 3	4164 3668 3519	Utility from Staying Home Type 1 Type 2 Type 3	-227 3850 1276
Utility nonsubsidized primary school Type 1 Type 2 Type 3	2209 2131 2055	Net cost of primary nonsubsidized school	-22.5
		Net cost of primary subsidized school	-42.5

Table
Parameter Estimates Related to Schooling and Job Finding Costs

Parameter	Estimate	Parameter	Estimate
Cost of attending municipal school from outside of Santiago	-31.5	Cost of finding first job if did not attend college	1038
Cost of attending subsidized school from outside of Santiago	-170.5	Cost of finding first job if did attend college	-1200
Cost of attending non-subsidized school from outside of Santiago	-167.5	Cost of attending college from outside of Santiago	-86.5

Table
Costs of changing from primary to secondary

Primary secondary	Municipal	Subsidized	Non-subsidized
Municipal	-1273	-600	-650
Subsidized	-1400	-10	-500
Non-subsidized	-1450	-200	10

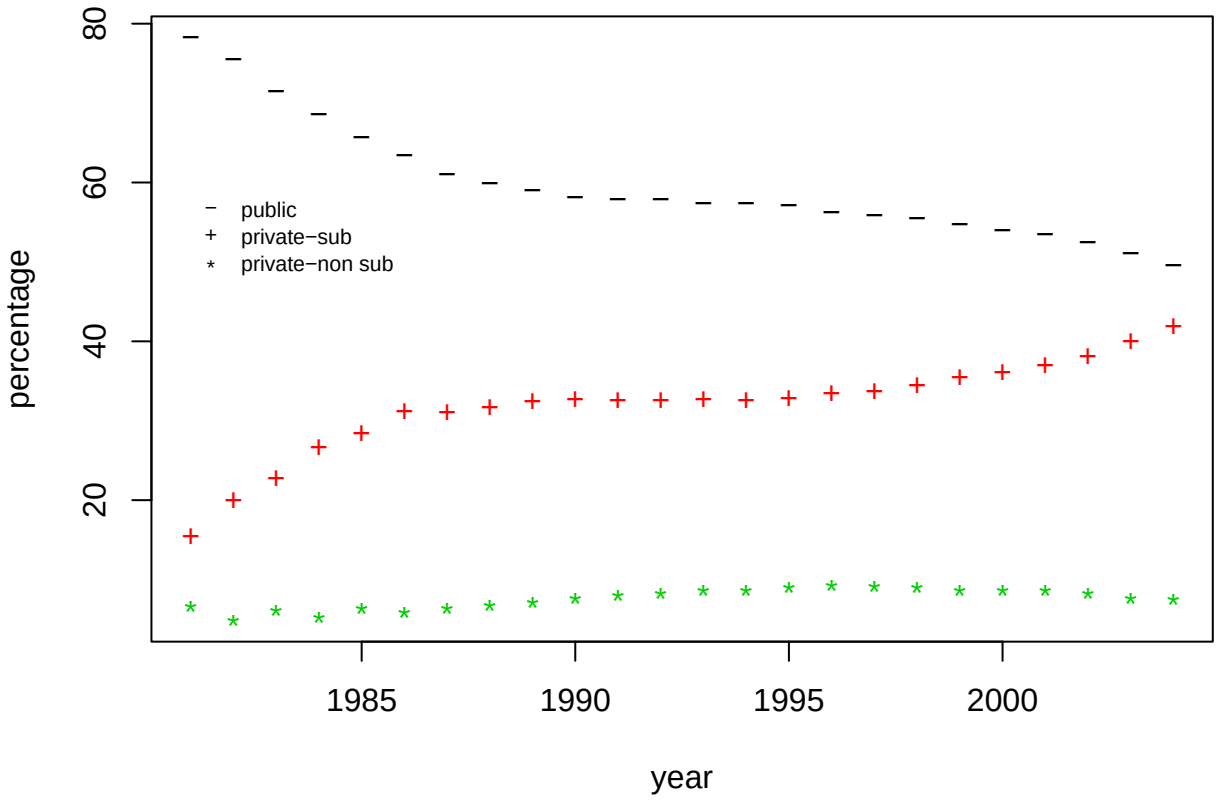
Table
Parameter Estimates Related to Variances of Shocks

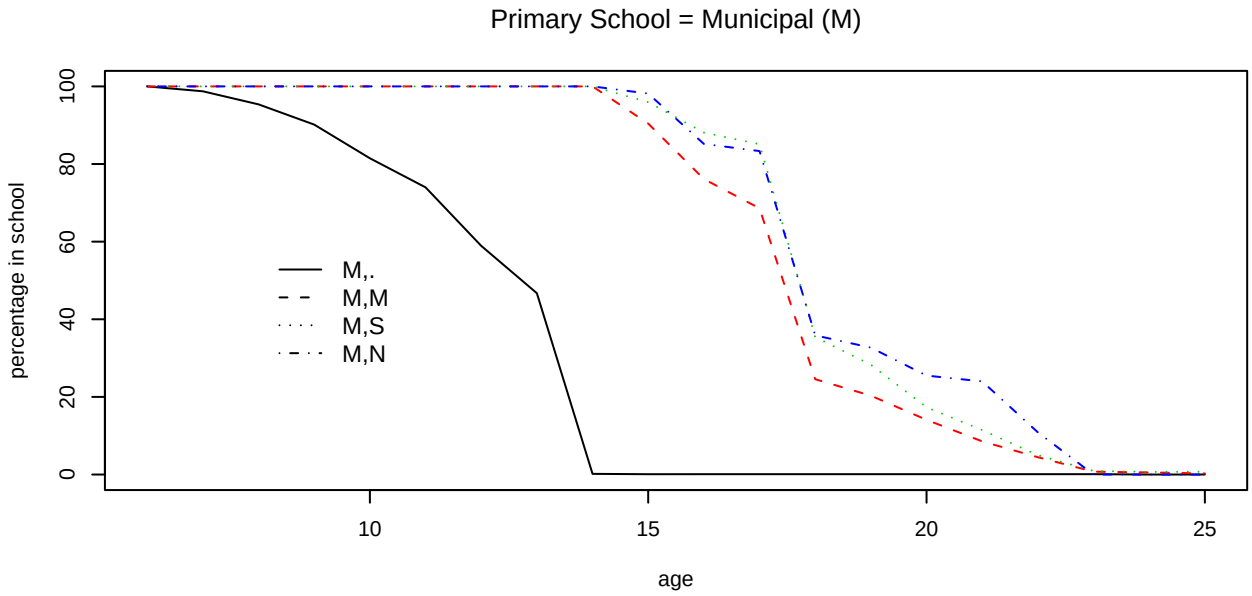
Parameter	Estimate
Std. error of ln wage error term	0.54
Std. error of preference shock for public school	549
Std. error of preference shock for private subsidized school	290
Std. error of preference shock for private nonsubsidized school	197
Std. error of preference shock for college	1810

Table
Estimated Coefficients Related to Determinants of Type Probabilities

Type 1 Probability		Type 2 Probability	
Parameter	Estimate	Parameter	Estimate
Constant term	3.04	Constant term	2.39
Father's education	-0.039	Father's education	-0.050
Mother's education	-0.091	Mother's education	0.080
Numbers of siblings	-0.21	Numbers of siblings	0.185
Family background	0.11	Family background	0.051

Figure 1: Percentage Attending Different Types of Schools by Year




Primary School = Municipal (M)
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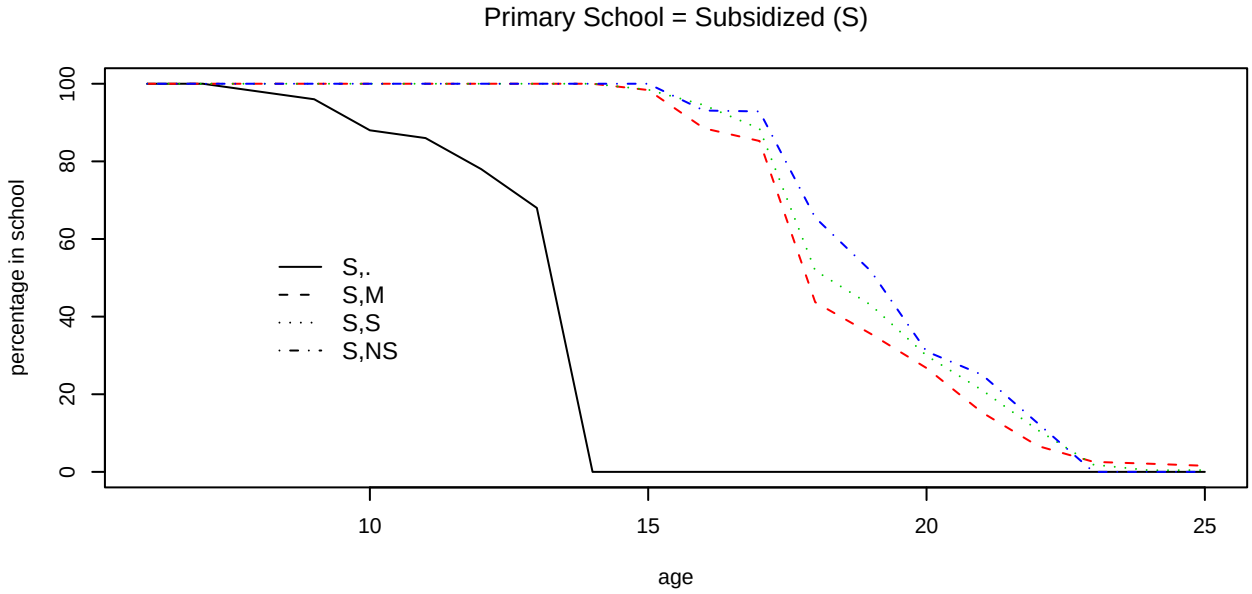
20
40
60
80
100
10
15
20
25
age
M,.
M,M
M,S
M,N


Primary School = Subsidized (S)
percentage in school
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20
40
60
80
100
10
15
20
25
age
S,.
S,M
S,S
S,NS

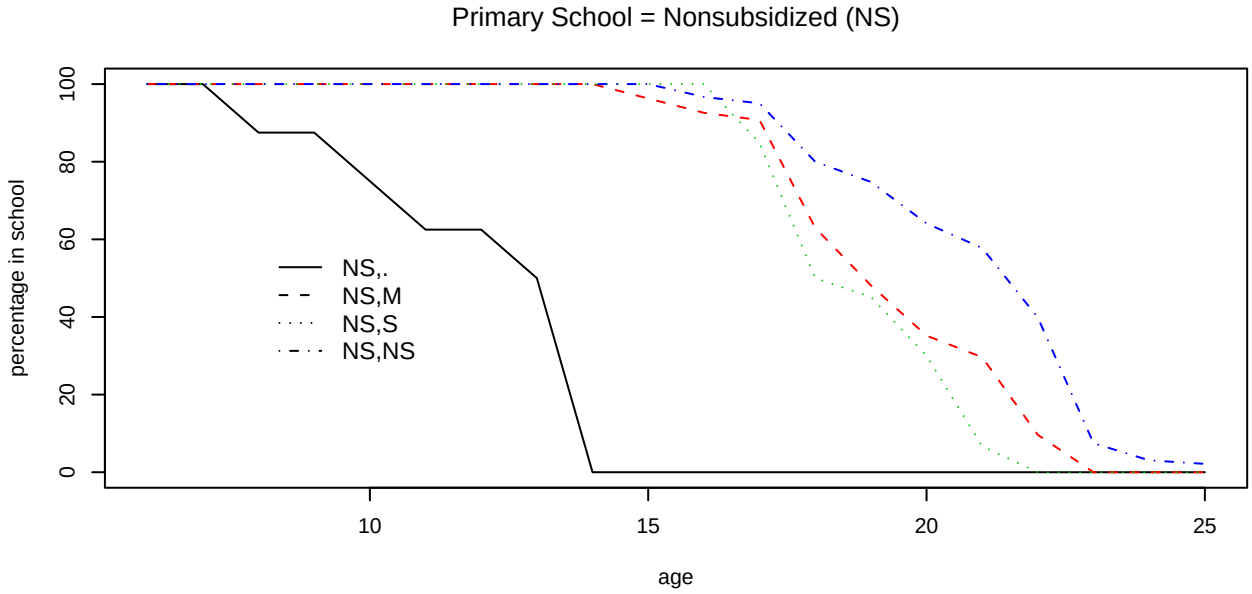
Primary School = Nonsubsidized (NS)
percentage in school
0
20
40
60
80
100
10
15
20
25
age
NS,.
NS,M
NS,S
NS,NS

Figure 3: Education Distribution, Overall and By Type of Primary Attended

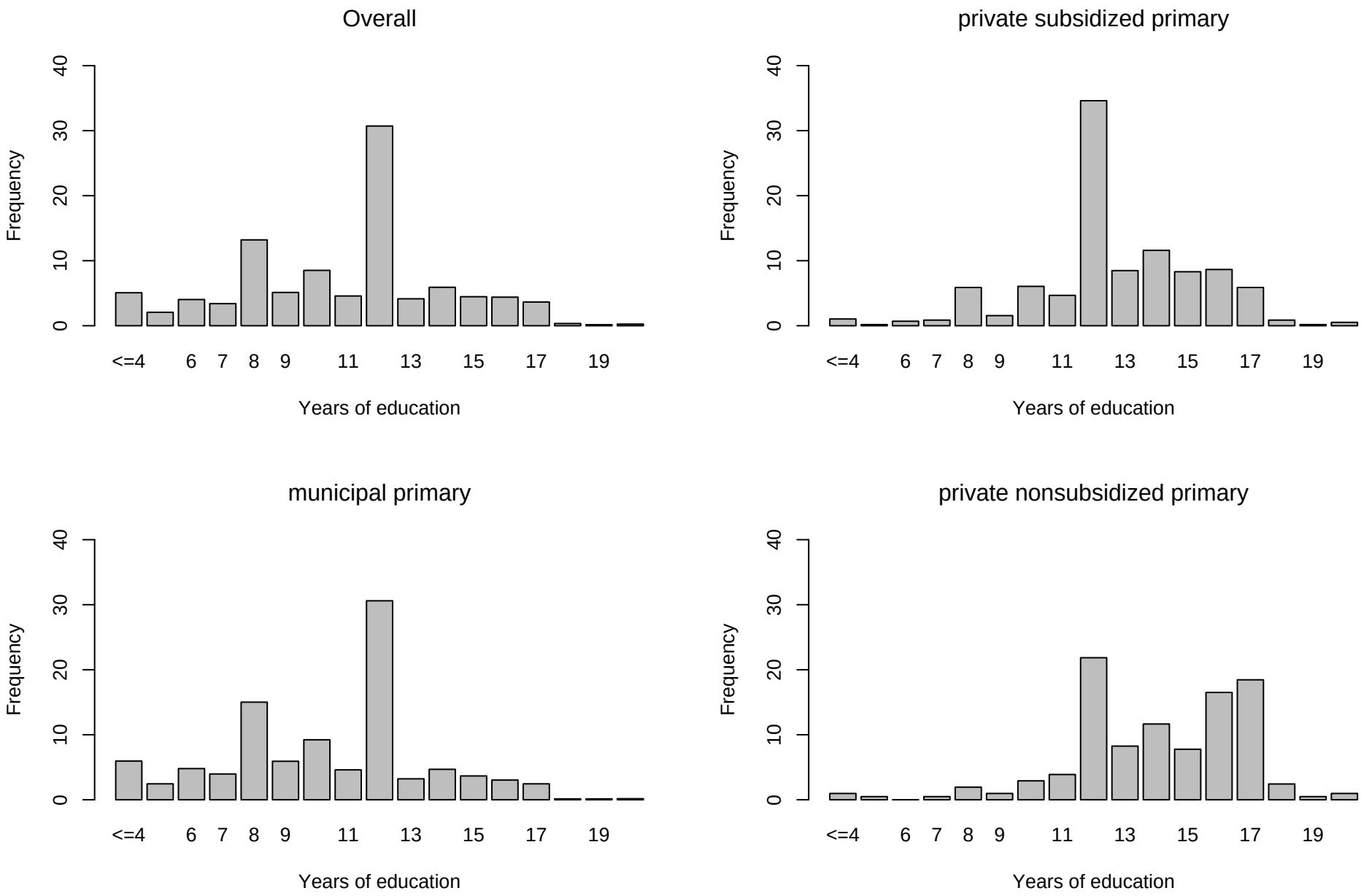

Figure 4: Perc. Working by Age and Type of Primary School

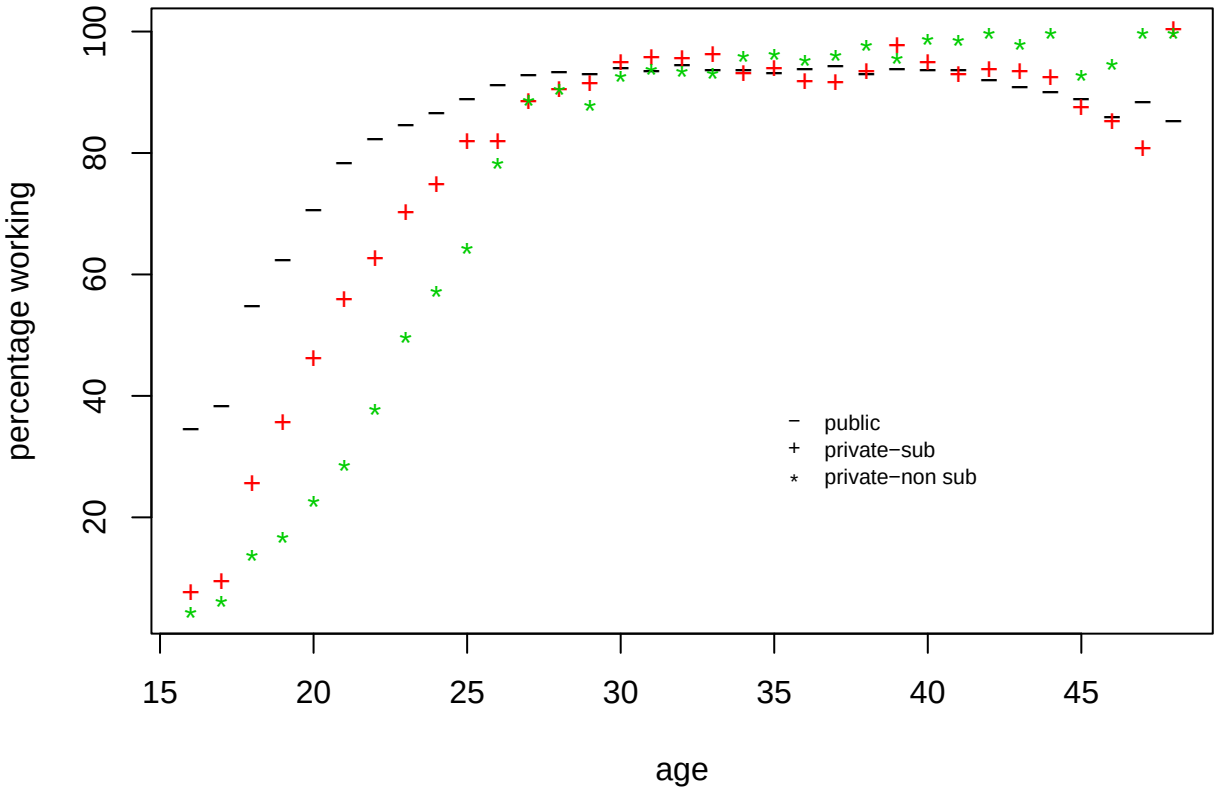

Figure 5: Smoothed Earnings−Age Relationship by Education Class and Schooling Type