Effects of School Reform on Education and Labor Market Performance: Evidence from Chile's Universal Voucher System

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Abstract

This paper studies the effects of school reform in Chile, which adopted a nationwide school voucher program along with school decentralization reforms 28 years ago. Since then, Chile has had a relatively unregulated, competitive market in primary and secondary education and therefore provides a unique setting in which to study how these reforms affected educational attainment and labor market outcomes. This paper develops and estimates a dynamic model of school attendance and work decisions using panel data from the 2002 and 2004 waves of the *Enquesta Proteccion Social* (EPS) survey. Some individuals in the sample completed their schooling before the voucher reforms were introduced, while others had the option of using the vouchers over part or all of their schooling careers. The impacts of the voucher reform are identified from differences in the schooling and work choices made and wage returns received by individuals differentially exposed to the reforms. Simulations based on the estimated model show that the voucher reforms significantly increased the demand for private subsidized schools and decreased the demand for public schools. It increased high school (grades 9-12) graduation rates by 3.6 percentage points and the percentage completing at least two years of college by 2.6 percentage points. An examination of distributional effects indicates that individuals from both poor and non-poor backgrounds on average benefitted from the reforms and that the reform led to a modest reduction in earnings inequality.

1 Introduction

School vouchers were proposed by Milton Friedman (1955, 1962) as a way of improving school quality. Friedman supported a role for government in school funding but 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. 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, 2003a). However, critics caution that voucher programs deplete already poorly funded public school systems of revenue, of their best students and possibly of their best teachers and may increase inequality (e.g., Carnoy, 1997, 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 in the state of Florida. Most of the programs are available only to children from low income families and/or from poor performing schools.[1] There is mixed evidence on the effectiveness of these programs in improving child test scores (e.g., Krueger and Zhu, 2004, Yau, 2004, Peterson, Howell and Greene, 1999). The small-scale of most programs and their selective targeting makes it difficult to draw inferences about the likely effects of vouchers were they to be adopted on a broad scale. Notably, the scale has not been large enough 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 of voucher recipients.

This paper studies the effects of school reform in Chile, which adopted a nationwide school voucher program in 1981. At this time, Chilean economic and social policy was strongly influenced by the Chicago school of economics and its decentralization policies (Valdez, 1995). Under Augusto Pinochet's military government, the control of public schools was transferred to municipal

[1] The Cleveland program is an exception.

authorities and the school funding system was converted to a per capita voucher system, with public and private schools receiving the same voucher amounts. Prior to these reforms, Chile had a long tradition of providing some public support for private (mainly Catholic) schools, but the introduction of the voucher system greatly increased the level of support going to private schools. Two other significant changes accompanying the reforms were that teacher union contracts were revoked, giving public schools greater flexibility in hiring and firing teachers, and national curriculum standards were relaxed, giving schools more leeway in setting their own curriculum.[2] There was no direct attempt to improve quality of instruction in schools, because it was thought that increased competition among schools would be stimulus enough for improvements. Consistent with this view, total federal spending on education actually fell in the decade following the reform, with the largest decline at the secondary school level.[3]

The design of Chile's voucher system is in many ways similar to Friedman's original proposal. As Friedman advocated, vouchers are publicly funded with voucher funds following the child to selected schools. Both government and private schooling sectors coexist with free entry into the private sector and some government monitoring of the quality of all schools.[4] Since 1981, Chile has been a virtual laboratory for a relatively unregulated, decentralized, competitive market in primary and secondary education. It provides a unique opportunity to analyze how voucher and decentralization reforms on a nationwide scale affected school choice and longer-term educational attainment and labor market outcomes. Another question of interest is how the reforms affected inequality by changing 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 broad 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.[5] Private non-subsidized schools, which include

[2] Carnoy (1997).

[3] Carnoy (1996).

[4] For example, schools are required to have licensed teachers. They also do not receive additional voucher payments for class sizes that exceed 45 students.(McEwan and Urquiola, 2005.)

[5] Municipal schools sometimes also receive some additional funding in the form of government transfers when the

both religious (mainly Catholic) and lay schools, are financed from private tuition. Private subsidized schools can be for profit or not for profit; private nonsubsidized schools are usually for profit.[6] Parents are free to choose among municipal and both types of private schools. An important difference between public and private schools' admissions policies is that private schools can be selective, whereas public schools can only be selective if there is excess demand. In 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 parents can compare the performance of their school to that of other locally available schools.

Figure 1 shows the percentage of students attending different kinds of schools from 1981-2004.[7] In the first five years after the voucher reform was introduced, the percentage of students enrolled in private subsidized schools increased rapidly, from 15% to over 30%, with a corresponding decline in public school enrollment. 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 (e.g. Mizala and Romaguera, 2000, Sapelli and Vial, 2002, Contreras, 2001, Hsieh and Urquiola, 2003, 2006, McEwan, 2001, McEwan, Urquiola and Vegas, 2008), which analyze the relationship between standardized test scores and attendance at public and private schools using data collected at the schools. Some studies in the literature find little difference in test score performance between municipal and private subsidized schools after controlling for family background. As Mizala and Romaguera (2000) note, however, all the test score data were gathered many years after the voucher reforms, and the finding of no significant difference in test scores between municipal and private subsidized schools could be consistent with the voucher program having improved performance in both the private and public schooling sectors. Other studies, such as Bravo, Contreras and Sanhueza (1999), and Sapelli and Vial (2002) find evidence of better performance in private schools. A few studies

voucher amounts are not sufficient to cover the school's 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.

[6] About three quarters of private voucher schools are for-profit schools. (Elacqua, 2006).

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

find that public schools are better at serving disadvantaged students and private schools better at serving students from higher socioeconomic backgrounds. With test score data collected in school, one also 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 ways that literature has addressed concerns about selectivity bias in analyzing the effects of vouchers on tests scores.

Rather than study the determinants of test scores, this paper uses household survey data to study the longer term effects of the school voucher reforms on educational attainment, employment, and earnings.[8] Our analysis samples are drawn from the newly available, longitudinal survey in Chile called the *Enquesta Proteccion Social* (EPS), which elicited information from respondents on the primary and secondary schools attended and on educational and labor market outcomes.[9] We use data collected in the 2002 and 2004 waves, which contain rich demographic, labor market and pension-related information for a random sample of working age Chileans. Most relevant for our analysis is the information that was collected on the schools attended, family background, earnings and twenty five years of retrospective work history.

One challenge in estimating the effects of the school voucher reform on education and employment outcomes is that the voucher reform was introduced throughout Chile in 1981 with no explicit variation in the timing of availability of the program. However, Chileans were at different points in their schooling career when the reforms were introducing and were therefore differentially exposed to the reform. Our analysis 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 long time frame covered by the data and our modeling approach allows us to exploit the variation in exposure to evaluate the effects of the school voucher reforms on longer term educational and labor market outcomes. This question has never been previously examined in the literature.

[8] As recently emphasized in work by Heckman, Stixrud and Urzua (2006) and Carneiro, Cunha and Heckman (2003), cognitive ability, as measured on standardized tests, is only one of several factors that determine labor market success.

[9] 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.

To this end, we develop and estimate a dynamic behavioral model of schooling and labor force participation decisions that incorporates multiple channels through which voucher reforms can operate. The model builds on a well developed labor literature analyzing 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.[10] Willis and Rosen (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 we develop also builds on the Heckman and Sedlacek (1985) study of earnings distributions in which 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 (municipal, subsidized private and nonsubsidized private), and make decisions about how long to attend school and whether and when to participate in the labor force. Our modeling 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 by anticipated future returns, and that wage offers represent a price paid to the human capital embodied in a person.[11] In the tradition of Behrman and Birdsall (1983) and Card and Krueger (1992a,b), we allow the returns to schooling depend on the types of primary and secondary school attended and on whether attendance took place in the pre or post voucher regime. Our specification thus allows the voucher reforms to have potentially altered the quality of schooling provided in both the private and public sectors.

The model we estimate allows components of future earnings and of the pay-off to different types

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

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

of schooling to be unknown at the time of making schooling and labor market decisions. It also incorporates permanent unobservable heterogeneity, in the form of discrete types, that are known to individuals but unknown to the econometrician (Heckman and Singer, 1984). Identification of the effects of the voucher reform comes from differences in the schooling and work choices made and wage returns received by individuals differentially exposed to the reform during their schooling careers. Family background is also an important determinant of schooling choices. Labor market experience accumulates endogeneously within the model as a function of past labor supply choices. The model is estimated solely on males, mainly to avoid consideration of fertility choices but also because males in Chile have much stronger labor force attachment than females.

After estimating the model, we use it to assess how the introduction of school voucher reform influenced sorting among different types of schools, educational attainment, earnings and labor market participation. By simulating decisions over the life-cycle with and without the reform, we directly evaluate the cumulative effects of the reform as it operates through schooling and labor market channels. Our parameter estimates indicate that the cost of attending primary and secondary schools declined substantially after the reform, which is consistent with the dramatic post-reform expansion in the availability of schools.[12] Additionally, the wage returns to attending municipal and private subsidized primary schools increased after the reform. At the secondary school level, however, we estimate that the wage return to schooling declined in the post-voucher period relative to pre-voucher levels, which is possibly related to the post-reform decrease in per pupil expenditure.[13]

Given the multi-faceted nature of the effects of the reforms, we study the net effects by simulating the lifetime schooling and labor force participation behavior of individuals with and without the reform. Our model simulations indicate that, on the whole, the combined effects of the elimination of private school tuition, the post-reform decline in the costs of attending schools and the increase in the returns to primary schooling resulted in a dramatic increase in attendance at private subsidized schools and increased schooling attainment for voucher recipients. On net, the voucher reforms

[12] See Parry (1997) for a discussion of the expansion of private schooling sector.

[13] It has also been noted that the newer private schools that entered the market after the voucher reforms tended to be on average of lower quality than the preexisting schools.(Parry, 1997)

increased primary school graduation rates by 0.6% (percentage points), high school graduation rates by 3.6%, college-going rates by 3.1% and the percent completing at least four years of college by 1.8% for individuals exposed to the reform during their entire schooling career. In addition, the reform reduced labor force participation at ages 16-25 by about 2 percentage points, off a baseline of 58.3%, because longer school-going delayed labor force entry. Perhaps surprisingly, the voucher reforms did not lead to increased overall mean wages, because the wage benefits of having more education are partly offset by the post-reform decrease in the returns to secondary schooling. With regard to earnings inequality, however, we find that the reforms led to a modest reduction in inequality.

The paper develops as follows. Second two discusses the existing literature and some of the findings 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-term and long-term effects of large scale school voucher programs in the U.S. on students and teachers, (e.g. Neal, 2002, Hoxby, 2001, 2003a, 2003b, Ferreyra, 2002), the empirical evidence is still scarce. Much of what we know empirically 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, though, because of relatively high attrition rates in the experimental control and treatment 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, Altonji, Elder and Taber, 2005). That literature typically finds 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 vouchers, at least to the extent that urban, minority youth seem to benefit from private schooling.

There have been several previous studies of the Chilean voucher program's effects on student test scores. As previously noted, the test score data were not systematically gathered until long after the voucher reforms were initiated and are therefore not informative about the performance of schools in the pre-voucher period. The test score studies are informative, though, on whether attendance at private schools in the post-voucher era is associated with higher test scores. The original goal of the voucher reform was to improve the performance of all types of schools through increased competition and not to create a superior private schooling sector. However, there is concern that the voucher programs instead increased sorting and benefit high ability students relative to low ability students, which is predicted by some theoretical models (See, e.g., Epple and Romano, 1998).

In analyzing test score differences between public and private schools, one encounters multiple selection problems, namely that the types of children attending each school are self-selected and, for older children, that test scores are usually only available for children attending school. A number of studies analyze test scores at an aggregated level without any explicit control for selectivity into type of school aside from than conditioning on observables. 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. McEwan and Carnoy (2001) examine the relationship between type

of school attended and student achievement, as measured by average fourth grade SIMCE school test scores, (for the period 1988-1996), controlling for family background (SES). They find that non-religious voucher schools are no more effective than public schools in producing achievement, but that Catholic voucher schools are more effective. Tokman (2002) examines the relationship between primary school test scores and type of school using school-level data and allowing the impact of attending private schools to differ by average socioeconomic status. She concludes 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, a finding reminiscent of Neal (1997) for U.S. Catholic schools.

A few studies explicitly control for the selectivity into different types of schools using frameworks that allow for selection on unobservables. For example, Sapelli and Vial (2002) analyze public-private tests score differences within a static Roy model framework that explicitly models the choice between types of schools. Their analysis focuses on second graders and finds important gains associated with attendance at private subsidized schools that are largest for those attending those types of schools.[14] 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 on top of the voucher, meaning that expenditure on students is comparable to that in private subsidized schools, there is a significant test score gain from attending private subsidized schools. 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 a control function approach to account for selection on unobservables 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.

Auguste and Valenzuela (2003) analyze the relationship between test scores (in the year 2000) and school competition, using an instrumental variables approach to address the potential endo-

[14] They investigate both the effect of treatment on the treatment (TT) and the average treatment effect (ATE), and they find the TT effect to be larger.

geneity of the school competition measure, and find that more competition increases test scores.[15] However, Hsieh and Urquiola (2006) reach a different conclusion based on a comparison of average test scores in communities that experienced a greater or lesser increase in private school enrollment. Using community level data, they find that average standardized test scores did not rise faster in communities where private sector enrollment expanded more. Rather, average repetition and grade-for-age worsened in such areas relative to other communities.[16] Another study examining the relationship between test score performance and competition is Gallego (2002), which examines changes in SIMCE scores between 1994 and 1997. Gallego (2002) finds that competition has a positive effect on educational achievement in general, but also that the private subsidized schools attract and accept only the better students. Gallego and Hernando (2009) analyze the determinants of school choice and find that proximity to schools and school test scores are the two most important attributes that families consider when choosing schools.

Parry (1997) provides a good description of many features of the Chilean voucher system and documents the expansion in the supply of private schooling following the voucher reforms. In 1979, there were 1846 private primary schools but by 1982, one year after vouchers were introduced, the number had increased to 2285. The newer subsidized private schools tended to be for-profit as opposed to religious schools and tended to attracted children from lower socioeconomic backgrounds (Hsieh and Urquiola, 2006). Using SIMCE scores for fourth graders, Parry (1997) finds evidence that public schools are more effective for disadvantaged students and private schools more effective for more advantaged students.

Although most of the studies of school vouchers in Latin America have focused on Chile, there is a small literature on related programs in other Latin American countries. 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

[15] Community population and distance to the closest city serve as instruments.

[16] A potential limitation of the analysis is that it examines differences in test scores over time, though the SIMCE tests were not comparable over time prior to 1998, when test equating was introduced. Another potential concern is that the study analyzes school test scores for children age 10-15, and children who dropped out are not included in the testing. If areas with increasing private school enrollment had children at high risk for dropping out staying in school longer, then one might expect to see higher repetition rates and a lower grade-for-age.

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 did 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

This paper analyzes the effects of the school voucher reforms in Chile on educational attainment, wages and labor force behavior. We do so by first estimating a behavioral model of decisions about school attendance and labor force participation over the life-cycle and then using the estimated model to simulate behavior with and without the voucher reforms.

This section describes the model and the parameters to be estimated. The model is partial equilibrium and does not incorporate the dependence of market wage offers on aggregate stocks of individuals of different schooling types or aggregate stocks of physical capital. Arguably, general equilibrium effects on wages could be important given that the voucher reforms were implemented on a nationwide scale. Increases in the aggregate supply of skill due to the reforms may have put downward pressure on the wages of skilled workers. We do not incorporate GE effects into the model, mainly, because of data limitations that restrict our ability to estimate the dependence of skill prices on aggregate skill quantities. Our data contain retrospective information on education and labor force participation but not on wages, with the wage data pertaining only to the survey

years 2002 and 2004. To circumvent this limitation, the model described below assumes that wage offers are stationary within unobserved types. It accommodates some nonstationarity in the overall wage distribution by allowing the distribution of unobserved types to depend on birth cohorts and family background characteristics. A second data limitation is that our data represent a random sample of Chilean men for the survey years and would not be a reliable source of information about aggregate stocks of skills in previous decades. To our knowledge, there are no other datasets for Chile that would provide information on skill stocks of the type needed to estimate a GE model. For these reasons, we estimate a partial equilibrium model.[17]

Our model assumes that the decision process starts at age 6, when parents choose the type of primary schooling attended by their child to maximize the child's lifetime utility.[18] 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 the case 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.[19]

The transition to secondary school occurs at age 14 when individuals decide what type of secondary school to attend, with the same three schooling 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.[20] Individuals who complete 12 years of school then make a choice about whether to attend college. If they choose to attend college, they continue to make choices each year about whether to keep attending for up to five years. We assume that once an

[17] The literature on estimation of dynamic general equilibrium discrete choice schooling models is still in its infancy. There have been some interesting studies using US data that provide mixed evidence on the relative importance of incorporating GE effects. See, for example, Heckman, Lochner and Taber (1998), Lee (2005), and Lee and Wolpin (2006).

[18] A similar assumption is made in a dynamic schooling model developed in Attanasio, Meghir and Santiago (2001).

[19] In our data, it is uncommon for youth below age 16 to work for pay. The value of staying home can include the value of home production.

[20] This cost can be thought of as capturing costs of transfering from one school system to another, facing a new environment, having to make new friends.

individual leaves school, they do not return.[21] We impose the simplifying assumption that individuals cannot return to school, because our data record the total years of education completed and not the entire school attendance history.

Starting at age 16, individuals receive wage offers in every period (annually) that depend on their years of education completed thus 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 get the utility associated with the home option. The model does not incorporate a savings decision, both for reasons of simplification and because few individuals in our sample report substantial voluntary savings.[22]

To allow for the possibility of unobservables affecting selection into types of schools and wages, we incorporate unobserved heterogeneity in the form of three 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 during the time when the individual was growing up, the number of siblings, and the individual's 10-year birth cohort. These variables constitute the model's initial conditions. The state space consists of: type of primary education, type of secondary education, number of years of primary education pre/post voucher program, number of years of secondary 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 $\left(U^i_{ak}\right)$ associated with the different schooling types for a person of type k are:

[21] 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.

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

$$U_{ak}^{S} = \Sigma_{k=1}^{K}\mu_k b_{1k}^{S} - T_1^{S}1\left(v_a = 0\right) + \delta_1^{S}1\left(R_1 = 0\right) + \delta_2^{S}1\left(R_1 = 0\right)1\left(v_a = 0\right) + \varepsilon_a^{S} \quad (1)$$

$$U_{ak}^{NS} = \Sigma_{k=1}^{K}\mu_k b_{1k}^{NS} + \delta_1^{NS}1\left(R_1 = 0\right) + \delta_2^{NS}1\left(R_1 = 0\right)1\left(v_a = 0\right) + \varepsilon_a^{NS} \quad (2)$$

$$U_{ak}^{M} = \Sigma_{k=1}^{K}\mu_k b_{1k}^{M} + \delta_1^{M}1\left(R_1 = 0\right) + \delta_2^{M}1\left(R_1 = 0\right)1\left(v_a = 0\right) + \varepsilon_a^{M} \quad (3)$$

b_{1k}^{i} $(i = S, NS, M)$ is a psychic cost (consumption value) of attending different types of primary school that may vary according to unobserved type (denoted by the k subscript), $T_1^{S}$is the tuition cost at a subsidized primary school. $1\left(v_a = 0\right)$ 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. For nonsubsidized private schools, the tuition cost parameter cannot be separately identified from the utility parameter, so b_{1k}^{NS} represents utility net of the tuition cost. R_1 is an indicator that takes the value one if the individual lives in the capital city, Santiago, which is home to about half of Chile's population. The parameters δ_1^{i} $(i = S, NS, M)$ represent additional costs of attending school for individuals living in the non-Santiago region. Costs are allowed to differ outside the capital, because there is much greater availability of private schools in Santiago along with good public transportation options. We also allow costs of attending different types of schools to vary pre- and post- voucher reforms, because many new private subsidized schools were built in the decade following the introduction of the reforms. There is a vector of preference shocks $(\varepsilon_a^{S}, \varepsilon_a^{NS}, \varepsilon_a^{M})$ associated with the 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 (b_{2k}^{i}), tuition costs (T_2^{S}), 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, $1(\cdot)$ denotes a function that equals one if the expression in parentheses is true.

$$
\begin{aligned}
U_{ak}^{S} &= \Sigma_{k=1}^{K}\mu_k b_{2k}^{S} - T_2^{S}1\left(v_a=0\right) + \rho^{M,S}(1-d_1^{S})(1-d_1^{NS})1(E_a=9) + \rho^{S,S}d_1^{S}1(E_a=9) + \quad (4)\\
&\quad \rho^{NS,S}d_1^{NS}1(E_a=9) + \tau_1\delta_1^{S}1\left(R_1=0\right) + \tau_2\delta_2^{S}1\left(R_1=0\right)1\left(v_a=0\right) + \varepsilon_a^{S}\\
U_{ak}^{NS} &= \Sigma_{k=1}^{K}\mu_k b_{2k}^{NS} + \rho^{M,NS}(1-d_1^{S})(1-d_1^{NS})1(E_a=9) + \rho^{S,NS}d_1^{S}1(E_a=9) + \quad (5)\\
&\quad \rho^{NS,NS}d_1^{NS}1(E_a=9) + \tau_1\delta_1^{NS}1\left(R_1=0\right) + \tau_2\delta_2^{NS}1\left(R_1=0\right)1\left(v_a=0\right) + \varepsilon_a^{NS}\\
U_{ak}^{M} &= \Sigma_{k=1}^{K}\mu_k b_{2k}^{M} + \rho^{M,M}(1-d_1^{S})(1-d_1^{NS})1(E_a=9) + \rho^{S,M}d_1^{S}1(E_a=9) + \quad (6)\\
&\quad \rho^{NS,M}d_1^{NS}1(E_a=9) + \tau_2\delta_1^{M}1\left(R_1=0\right) + \tau_2\delta_2^{M}1\left(R_1=0\right)1\left(v_a=0\right) + \varepsilon_a^{M}.
\end{aligned}
$$

Our parameterization of costs assumes that the cost to attend secondary school is a fixed fraction of the cost of attending primary school for all types of schools, with the fraction denoted by τ_1 in the pre-voucher reform time period and τ_2 in the post-voucher reform time period.[23]

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 also 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 (<9 years, 9-11 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 (home) depends on preference parameters and a 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:

$$U_{ak}^{C} = \Sigma_{k=1}^{K}\mu_k b_k^{C} + \delta_1^{C}1\left(R_1=1\right) + \varepsilon_a^{C},$$

[23] The assumption that the relative cost of attending primary to secondary school is fixed (at potentially different values before and after the reform) was made in the interests of parsimony, to reduce the number of model parameters in the estimation problem. The assumption could be relaxed.

where b_k^C is the psychic benefit from college and δ^C the additional cost of attending incurred by those living outside 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, because of differences in the costs of attendance, 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 secondary 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 capture additional sources of heterogeneity in wage offers.

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

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:

$$\begin{aligned}
\ln w_a \;=\; & \alpha + \Sigma_{k=1}^{K}\mu_k\beta_{0k} + \Sigma_{k=1}^{K}\mu_k\pi_{0k}1\left(R_1=1\right) + \\
& \beta_1 E_a^P + \gamma_1 E_a^{P,v=1} + \\
& \beta_1^S E_a^P d_1^S + \gamma_1^S E_a^{P,v=1} d_1^S + \\
& \beta_1^{NS} E_a^P d_1^{NS} + \gamma_1^{NS} E_a^{P,v=1} d_1^{NS} + \\
& \beta_2 E_a^S + \gamma_2 E_a^{S,v=1} + \\
& \beta_2^S E_a^S d_{2a}^S + \gamma_2^S E_a^{S,v=1} d_{2a}^S + \\
& \beta_2^{NS} E_a^S d_{2a}^{NS} + \gamma_2^{NS} E_a^{S,v=1} d_{2a}^{NS} + \\
& \beta_3^{M,S} G_a + \beta_3^{NS} G_a + \beta_4 x_a + \beta_5 x_a^2 + \varepsilon_a^W .
\end{aligned} \tag{7}$$

In logs, the price of human capital is incorporated into the intercept, β_{0k}. The intercept is also allowed to depend on unobserved type to capture permanent unobservable heterogeneity across individuals. The parameter π_{0k} captures the difference in wage level between the Santiago and non-Santiago regions. The β coefficients 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 wage equation in that the returns to primary, secondary and college years of schooling may differ. The γ coefficients represent the change in the schooling return after the introduction of the voucher reform, that is, the return to schooling post reform is given by $\beta+\gamma$. The γ coefficients allow for the possibility that the voucher reforms 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 also have drawn some of the better teachers out of the public school system, lowering public school quality. Therefore, the coefficient γ could be either positive or negative.[24]

Individuals differ in terms of the timing of the voucher program with respect to their schooling

[24] Our specification allows for a discrete change in the return to schooling at the time of the voucher reform. It is of course plausible that some quality changes within the schools took place more gradually, but we adopt the discrete change specification mainly to minimize the need for additional parameters and to faciliate the interpretation of the voucher reform impacts. In support of our specification, as noted in section one, there were radical changes to the education sector that took place in the year 1981 and the supply of private education responded fairly immediately after the reform.

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 combinations 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, nonsubsidized private primary and public secondary, nonsubsidized private primary and subsidized secondary, subsidized secondary and nonsubsidized secondary. The coefficients $\beta_3^{M,S}$ and β_3^{NS} represent 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.[25] β_4 and β_5 represent the market return to actual labor market experience, where the experience x_a equals min(actual experience,15).[26]

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 (a typical retirement age in Chile). 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

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

[26] This specification assumes that returns to experience are increasing up to 15 years and constant after that. It was chosen so that the returns to experience do not decrease.

maximum over alternative-specific value functions, $V^j(\Omega(a), a)$, i.e., the 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 we evaluate the value of the Emax function at every possible state point without having to use Emax approximation methods.

The model is estimated by simulated 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 illustrate 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:

$$\begin{aligned} & \Pr(O_{ia}|O_{ia-1}, ..., O_{ia_0}; \mu_k = 1, I_i) \\ = \; & \Pr(d^j(a) = 1, w_a|\Omega(a), I, \mu_k = 1) = \Pr(d^j(a)|w_a, \Omega(a), I) f(w_a|\Omega(a), I, \mu_k = 1), \end{aligned}$$

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.

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

To estimate the probabilities, $\Pr(O_{it}|O_{it-1}, ..., O_{it_0}; \mu_k = 1)$ 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

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

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 η is a smoothing parameter, which is set equal to 50.[27]

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 density. The maximization of the likelihood function iterates between solving the dynamic program and calculating the likelihood. Solving the model and optimizing over the 108 parameters is computationally intensive. For this reason, computation was done on a parallel linux cluster with 56 processors using the APPSPACK Asynchronous Parallel Pattern Search Algorithm. (See Gray

[27] The value functions are on the order of 50,000.

and Kolda, 2004.) We obtain standard errors of the parameter estimates by the inverse of the average of the product of the score matrices, where the derivatives of the log likelihood are evaluated numerically.[28]

5 Empirical Results

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 and changed its name to the *Enquesta Proteccion Sociale (EPS)*, or Social Protection Survey. The data from the 2002 and 2004 surveys 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 our analysis are the questions on labor force and participation in training/education, which include retrospective information back to 1981, as well as 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 description of the sampling frame for the 2002 and 2004 surveys.

Our analysis sample consists of 3910 male individuals who were at most 21 years old in 1981 and for whom we observe educational attainment and an entire labor force participation history. We have a total of 107394 person-year observations on these individuals. Each individual was asked the type of primary and secondary school they attended. As noted in section four, our model assumes that individuals start attending school at age 6 (the standard age) and attend continuously until the end of their schooling career.[29]

[28] This estimator is known as the BHHH estimator (Berndt et. al., 1974). To obtain the numerical derivatives needed to implement the estimator, we use a step size parameter equal to 1% of the parameter estimate.

[29] The assumption of continuous schooling was made because the data do not contain information on the exact schooling progression pattern.

5.1 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 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 average annual earnings of our sample is \$4901[30], 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 (\$9767 on average).

Table 1 also provides information on the family background of the individuals. As described in section 4, family background enters into the behavioral model as a determinant of the unobserved type probabilities. 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 2 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. Individuals who attend private schools are less likely to report their background as indigent or poor. On average, the individuals in our sample have

[30] We throw out wages below \$1140 which is worth 1000 hours of work at the minimum wage rate prevailing in Chile in 2002. This implies that we ignore 366 wage observations out of a total of 9191 observations. Since we are looking at adult males only extermely low wage observations are most likely ersult of reporting error.

3.7 siblings, with slightly fewer (3.3 on average) for private school attendees.

Figure 2 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. Of this group, 31% complete exactly 12th grade and 25% go beyond. Individuals who attend private subsidized primary schools are more likely to finish 12th grade (34%) or go beyond (46%), but their educational attainment is not nearly as high as that of individuals attending nonsubsidized primary schools, 68% of whom go to some college.

Figure 3 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 73% of private subsidized primary attendees and only 54% 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 4 graphs the age-earnings relationship by educational attainment categories and type of primary school attended. The age-earnings curves are smoothed using local regression.[31] Among those completing less than 8 years of education, municipal school attendees have a flatter age-earnings relationship than private school attendees. For individuals completing 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 nonsubsidized private schools. This difference is most likely

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

attributable to differences in the types of colleges attended, with a higher proportion of private nonsubsidized secondary schools attending the premiere universities. Earnings also increase with age with a rate of increase that is higher for those with higher schooling completion levels.

As described in the previous section, our specification of the wage offer equation allows the returns to schooling to depend on type of school attended and whether attended before or after the voucher reform to accommodate potential quality differences between the different types of schools as well as changes in quality arising from the reforms. Although we do not have time series data on empirical measures of school quality that date back to the time of the voucher reforms, we have some recent information on the characteristics of teachers who teach in the different types of schools that we obtained from a 2006 survey of teachers. Table 2(a) compares the characteristics of teachers in municipal schools, subsidized private schools, and non-subsidized private schools. Teachers at municipal schools have the highest rate of postgraduate education and are more likely to have received training over the previous five years. According to several measures of job satisfaction, teachers at private schools report higher rates of satisfaction. The table shows two measures of satisfaction: whether teachers think they are given sufficient time to prepare their classes and whether they participate in curriculum development. Teachers at public schools are more likely to have had a medically related absence and are much less likely to have access to or use a computer to do their work. Table 2(b) compares the median hourly wage by type of establishment and by age of the teacher. Public schools offer the lowest starting wages but have the greatest increase in wage with age. Private subsidized schools offer higher starting wages then public schools, but have less growth with age than public schools. The overall median wage is lower for private subsidized schools than for public schools, which partly reflects the relatively younger ages of private school teachers. Nonsubsidized private schools pay wages that are 10-20% higher than other types of schools. These comparisons suggest that there are important differences in the characteristics of teachers who teach in different types of schools, although it is not obvious how these differences might translate into quality differences.

5.2 Reduced form estimated decision rule models

In Tables 3, 4 and 5, we present estimates of choice models that relate the decision variables in the behavioral model (school attendance, type of school attended, educational attainment and work) to the state variables. These choice models are reduced form in that they do not impose the structure of the behavioral model and do not account for unobservable heterogeneity. They are useful, though, for establishing correlations between the decision variables and the state variables. Table 3 shows the estimated coefficients from regressing educational attainment on the state variables. The specification reported in the first column includes two indicator variables for whether the voucher program was available during primary and secondary school ages. The second column includes instead the total number of years the individual was exposed to the voucher program at any point over ages 6-18.[32]

Individuals who attended school when vouchers were available, ceteris paribus, have substantially higher educational attainment. The first specification shows that exposure in primary school, prior to making secondary school type choices, is most predictive of higher educational attainment. Conditional on primary exposure, exposure during secondary school is not significantly associated with higher attainment. Not surprisingly, individuals whose parents (mothers and/or fathers) have more education also tend to achieve higher educational attainment levels, with the estimated coefficient on mother's education being about fifty percent larger that on father's education. Also, individuals from less poor families have significantly higher educational attainment levels than individuals from indigent families (the omitted category). 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 1.3 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 attending a subsidized or nonsubsidized private primary school relative to a municipal school. Having the voucher available during primary or secondary school years is associated with a statistically significant increase in the probability of choosing the subsidized primary private school type, without any significant change in the prob-

[32] For example, if the individual was in second grade when the program was introduced, the exposure is 10 years.

ability of choosing the nonsubsidized primary school type. Mothers' and father's education are statistically significant determinants of the probability of choosing a private unsubsidized school. Also, individuals with more siblings are less likely to attend private schools. Residing in Santiago while growing up makes it much more likely that an individual attends private primary school. The other family background variables are not significant determinants of the choice of primary school type.

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. Ceteris paribus, 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, but being exposed only in secondary school years has no statistically significant effect. Having more siblings is associated with increased probabilities of working, whereas being from a less poor family is associated with a lower probability of working. 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. Residing in Santiago substantially increases the probability of working.

5.3 Empirical Results

5.3.1 Parameter Estimates

As described in section four, our specification of the wage offer equation allows the wage returns from schooling to depend on type of school attended (primary and secondary) and on whether attending prior to or after the voucher reforms. Table 6a shows the estimated wage returns to primary, secondary and college education (along with standard errors), where the primary school returns correspond to two-year returns, and the secondary and college returns to one-year returns. The wage return to secondary school is more than twice as high as the return to primary school. A comparison of returns associated with the pre- and post- voucher reform periods shows that the wage returns to primary schooling increased after the reform in municipal and subsidized private schools. At the secondary school level, however, the estimated returns are about one percentage point lower in the post-voucher period than the pre-voucher period in all types of schools. As

previously noted, the private secondary schools that were built after the reform were thought to be of lower quality than the preexisting schools. Also, per pupil expenditure declined in the decade following the reform, with the largest decline in secondary schools. Both factors might account for the observed decrease in the estimated return to secondary education.[33] With regard to post-secondary education, the estimated returns are surprisingly low for individuals who did not attend nonsubsidized private schools and are 3% per year for those who attended the nonsubsidized private schools.

As a point of comparison, Table 7 presents estimated coefficients obtained from an OLS wage regression that was estimated outside the model without controlling for unobserved heterogeneity. The OLS estimated rates of return to schooling are much higher than those reported in Table 7(a), a pattern that is consistent with other reported findings in the empirical literature on structural estimation of dynamic schooling choice models.[34] The pattern suggests that much of the return to schooling estimated from an OLS regression is accounted for by unobservable heterogeneity. Table 6a also reports estimates of the wage intercept parameters and of the returns to labor market experience. Interestingly, the estimated returns to experience obtained from the structural estimation are higher than those from the OLS regression (Table 7).

Table 6b reports estimates of the utility function parameters, which vary with the unobserved type. There is substantial heterogeneity across types in the value associated with different kinds of schooling. Types 2 and 3 have higher valuation of all types of schooling, with type 2 having the highest valuation for primary, secondary and college. All types tend to get higher utility from municipal primary relative to subsidized primary.[35] At the secondary level, the utility associated with municipal and subsidized secondary is fairly comparable for types 2 and 3, while type 1 gets the highest relative utility from subsidized school. Type 2 has the highest valuation from staying home and type 1 the lowest.

[33] The decline might also be related to a general equilibrium effect of rising stocks of skills lowering the returns to skill, although the model does not incorporate this sort of dependence for reasons described in section four.

[34] See, for example, estimated return to schooling parameteres presented in Keane and Wolpin, 1997, and Belzil, 2007.

[35] The nonsubsidized primary estimated cannot be directly compared to the other types, because the nonsubsidized estimated utility incorporates any tuition costs. For the other types, the tuition costs are separately identifiable because of the presence of the voucher only in the post reform time period.

Table 6c reports estimates of the model parameters associated with the costs of attending schools for individuals outside of urban Santiago.[36] The costs of attending municipal schools are substantially lower than the cost of attending other types of schools, as might be expected given their wider availability. A comparison of the estimated costs pre- and post-voucher reform shows that the costs of attending schools decreased substantially following the reform and fell by about one half. This decrease is most likely attributable to the expansion in school availability. As indicated by the estimated τ_1 and τ_2 coefficients, which represent the cost of secondary schooling as a fixed fraction of the cost of primary schooling, the relative cost of attending secondary schooling also declined in the post-voucher reform time period.

Table 6c also reports estimated school-type switching costs, for the primary-secondary school transition. As expected, the cost of staying in the same type of school (municipal, private subsidized or private nonsubsidized) is estimated to be substantially lower than the cost of switching schools. The highest switching costs are associated with the transition from private subsidized or unsubsidized primary to municipal secondary and also with the transition from municipal primary to nonsubsidized primary. The costs are relatively lower for transiting from one type of private primary to another type of private secondary.

In addition, Table 6c reports the estimated preceived monetary benefit from the voucher (above the value of attending the respective types of schooling). The estimated benefit to the individual is substantially lower than the actual voucher amount[37], at \$105 at the primary level (for two years) and \$38/year at the secondary level. There is, however, no reason to expect the estimated benefit of the voucher in the individual optimization problem to be equal to the voucher payment amount. The voucher payments were not directly paid to the students, but were transferred directly to the schools based on their enrollment numbers, and the students had no option of using the voucher to pay for anything other than attending school. The estimated voucher benefit might be expected to be close to the cost of private school tuition,after accounting for the governmental subsidies to private schools before the reform, that were equivalent to about 50% of per-pupil costs of municipal

[36] For people living inside Santiago, costs would be incorporated into the net utility of attending school.

[37] The actual voucher transfer amount exhibited year to year fluctuatation in real terms and some variation by type of school attended (e.g, primary vs. secondary). It was about \$210 per year on an average.

schools (Gallego and Hernando 2009). This would imply that the estimated voucher benefit would be lower than the voucher amount, as we find.

The costs of finding a first job are reported in the bottom three rows of Table 6c and are estimated to be substantial. The costs are higher for individuals with more years of education. Table 6(d) reports estimates of the standard errors of the five shocks in the model: the wage shock, preference shocks for the three schooling types and a preference shock for staying home. Lastly, Table 6(e) reports estimates of the parameters associated with the type probabilities. Recall from the estimated wage coefficients that type II individuals have the highest wage constant and type I individuals the lowest. An increase in parents' education increases the probability of being type II. A smaller number of siblings, higher family wealth and living in Santiago also increase the probability of being type II.

5.4 Model Goodness of Fit

Table 8a and 8b presents the goodness-of-fit for the educational attainment distribution for the subsample that was and was not exposed to the voucher program from beginning of primary school (age six). 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 the simulated and actual choices. As seen in the table, the simulation captures the much higher relative educational attainments for the sample that was exposed to the voucher program since age six. Relative to those that were not fully exposed, their mean years of schooling is higher, 11.8 years verses 10.7 years in the data and 11.7 verses 10.8 years in the simulation. The simulation also accurately predicts the differences between the groups at the 25th percentile, median and 75th percentile of the distribution.

A closer look at the education distribution (Table 8b) reveals that model simulation does a reasonably good job at reproducing the distribution. The percentage of individuals completing primary education is 68.5% in the data and 72.2% in the simulation for the subsample not fully exposed to the voucher reform in comparison to 84.7% in the data and 84.4% in the simulation for the exposed since age six subsample. The predicted percentage completing 12th grade is fairly

accurate for the not exposed subsample. For the exposed since age six sample, the model accurately predicts the percentage of individuals finishing 11th grade and starting college but underpredicts somewhat the high school graduation rate. For both subsamples, the simulation underpredicts the percentages dropping out of college after one year and has a larger fraction going for two years. We speculate that the steeper drop of rates during college predicted by the model may be due to the fact that the model does not incorporate specific types of college degree requirements, which may lead individuals to go to college for additional years. In general, though, the simulation does capture the features of the educational distribution as well as the large observed differences in the distributions for the subsamples that were and were not exposed to the voucher program from an early age.

Table 9a and 9b report the fit of the estimated model to the primary to secondary school transition for the same two subsamples. In the tables, the simulated unconditional cell percentage appears in parentheses under the actual percentage. The model simulation replicates the decline in the share of individuals who get an all municipal school education from 50.3% to 45.3% (47.7% to 43.8% in the data) for the subgroup fully exposed to the voucher reform. It also replicates the increase in the share of individuals who get an all subsidized school education from 4.5% to 12.8% (5.5% to 12.7% in the data). The model predicts a large increase in mobility (those who go to a different type of secondary school from primary) for the group exposed to vouchers from age six relative to the not exposed group, as seen in the data. For the group that was not exposed to voucher from age six, only 13.3% (12.3% in the simulation) attended a secondary school that is different from their primary school but for the group that was exposed to voucher from age six 23.9% (23.3% in the simulation) attended a secondary school that is different from their primary school. The percentage of the students who stayed in the same type of school also increased from 55.2% to 60.8% (57.3% to 61.2% in the simulations) but the increase for this group (stayers) was proportionately lower than the other group (changers). Thus the share of changers increased from 19.4% to 28.2% (17.7% to 27.6% in simulations).

Table 10 reports evidence on how the model fits the labor force participation patterns, disaggregated by type of primary and secondary schools attended and by age categories. The numbers in

parentheses indicate the number of person-year observations in that cell, in part because the predictions are usually more accurate for larger size cells. The simulations capture 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). The average predicted labor force participation rates over all educational categories (shown in the last row of the table) are fairly accurate.

Figure 5 shows the life cycle employment fit. The model accurately replicates the labor force participation pattern observed in the data, although the model slightly overpredicts labor force particpation rate in the early part of lifecycle. The data also exhibits a discrete decline in the labor force participation rates at age 44 (maximum age observed in the data), but that may be due to a data anomaly as there are less 200 observation at that age.

Table 11 shows the model fit to mean wages within cells defined by type of education categories. The mean overall annual wages predicted by the model is $5012, which is lower than the actual mean of $4901. Disaggregating by school types, we see that the simulated model reproduces the pattern of lower wages for people who attended only municipal schools or for people who did not attend secondary schools. It also generates the pattern of higher wages for those who attended non-subsidized primary and secondary schools, although the simulated wages in this category understate the actual wages.

Figure 6 shows the life cycle wage fit. The model mimics the general life-cycle wage patterns observed in the data, although the model slightly underpredicts average wage rate in the early part of lifecycle and does not replicate some of the age-by-age fluctuations observed in the data (that are likely due to small samples at some ages).

5.5 Counterfactual Policy Evaluation

We next use the estimated behavioral model to explore how the school voucher reforms affect school attendance and labor market decisions and earnings outcomes. To evaluate the impacts of the voucher reforms, we simulate school and labor force choices and wage outcomes with and

without the reform for the subgroup of individuals exposed to the voucher program over their entire schooling career. The simulation without the reform is performed by (i) modifying the budget constraint to reflect the additional tuition cost that would have to be paid to attend private school, (ii) adjusting the returns to schooling to pre-voucher levels, and (iii) adjusting the costs of attending school for all school types to pre-voucher levels.[38] Each person's behavior is simulated 2000 times (i.e. for 2000 sets of draws of the model shocks) and the results we report below are the averages from those simulations.

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 influenced the wage returns to schooling. Table 12 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.[39] 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 the existing stock of 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.[40] 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

[38] We do not have data on the actual tuition costs that would have had to be paid at the schools attended by individuals in our sample. Instead, we use our estimate of the voucher benefit (See discussion above and the estimates reported in Table 6c). The estimated voucher benefit is somewhat lower than the average private school tuition cost.

[39] The teacher's union reassumed its role as a bargaining unit after the military regime was replaced by the democratic government in 1990.

[40] 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.

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

5.5.1 Effects of voucher program on educational outcomes

Table 13 reports the effect of exposure to the voucher reform on educational outcomes for the subsample that was exposed to vouchers during their primary and secondary school years. To explore distributional effects of the program, we report results for both 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.[41] As seen in the first row of Table 13, the voucher program increases attendance at private subsidized primary schools by 8.8 percentage points. There is similarly a substantial increase in attendance at subsidized secondary private schools of 9.4 percentage points, which is slightly larger for the non-poor subsample than the poor subsample. The voucher program also modestly increased the attendance rate at nonsubsidized private schools, because it increased school-going in general. The simulations indicate that the reforms increased attendance at college by 3.1 percentage points.

Table 14 shows how the voucher program affects the entire education distribution for the same three subsamples. There is a clear shift of the educational attainment distribution to the right, with especially large effects of the reform on the probability of completing 11-13 grades. A comparison for the poor and non-poor subsamples reveals similar impacts by family background. The last four rows of Table 14 show the effects of the voucher program on the college completion rate, which are also all positive.

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

5.5.2 Impacts on labor market outcomes

Tables 15a and 15b examine the effects of the voucher reforms on earnings and labor force participation. As seen in Table 15a, the time spent in the labor force decreases for the younger age groups due to the longer time spent in school, which delays their labor force entry. For older age workers (36-45), labor force participation increases slightly. Despite the longer time spent in school, however, there are almost no effects of the voucher reform on average earnings. The lack of increase in earnings occurs because the earnings benefits from higher levels of education are offset for some individuals by the decline in the returns to secondary education (noted in Table 7a). Table 15b examines how the distribution of earnings was affected by the reforms. There is a modest increase in earnings at the bottom percentiles and a decrease at the top percentiles, leading to an overall decline in the earnings variance.[42] Thus, the voucher reform led to a modest reduction in earnings inequality.

6 Conclusions

This paper uses a newly available dataset from Chile to study the longer term effects of a nationwide school voucher reforms on educational and labor force outcomes over the life-cycle. The previous literature on the voucher reforms in the Chilean context focused on test score impacts using test score data that were collected many years after the reforms were introduced. Our study uses household survey data on individuals who obtained their education before, during and after the voucher reforms and therefore has the potential to capture reform-related changes in both public and private sector schools.

After estimating a dynamic model of school attendance and work decisions, we use the model to evaluate how the school voucher reforms affected school choice, educational attainment, earnings and labor market participation for the people exposed to the vouchers. Simulating schooling and labor supply choices over the life-cycle with pre and post reform estimated model parameters permits a direct assessment of the impacts of the reform as it operates through multiple channels

[42] Individuals at the bottom of the earnings distribution would tend to have completed only primary schooling and would benefit from the increase in the the returns to primary schooling after the voucher reform.

over the life-cycle.

We find that the wage returns to municipal and to private subsidized primary schooling increased substantially in the post-voucher period, which is consistent with improvements in the quality of primary schooling. At the secondary school level, however, the returns to schooling fell relative to pre-voucher levels. The decline likely reflects that the newer secondary schools that entered the secondary school market after the reform were not as high quality as the preexisting schools and that per pupil expenditure declined, particularly in secondary schools, in the decade following the introduction of the vouchers.

Our model estimates indicate that the voucher reforms had a substantial impact on educational attainment and more modest effects on wages. The combined effects of (i) the decreased costs of attending school, (ii) the tuition voucher and (iii) changes in the returns to schooling, on net induce higher school attendance rates with a larger fraction of individuals attending at private schools. The voucher reforms increased primary school graduation rates by 0.6% percentage points, high school graduation rates by 3.6%, college-going rates by 3.1% and the percentage completing at least four years of college by 1.8% percentage points. In addition, the reforms reduced labor force participation at younger ages (16-25) by about 2 percentage points, off a baseline of 58.3%, because longer school-going delayed labor force entry.

With regard to wages, we find that the voucher reform did not lead to increased overall average wages, because the wage benefits of higher educational attainment are partly offset by the post-reform decrease in the returns to secondary schooling. An examination of the wage distribution, though, shows that wages increased at lower percentiles of the distribution and decreased at upper percentiles, generating a modest reduction in earnings inequality. Lastly, we find that the impacts of the voucher reform are similar in magnitude for individuals from both poor and non-poor backgrounds, alleviating concerns that the reforms only benefitted children from wealthier 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.

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Table 1
Descriptive Statistics
(Std. Deviation in Parentheses)

	Overall	Municipal Primary	Private subsidized primary	Private unsubsidized primary
Age	30.6	31.3	27.1	29.2
	(7.2)	(7.1)	(7.0)	(7.6)
Years of education	11.0	10.5	12.8	14.1
	(3.4)	(3.3)	(2.6)	(2.8)
Attended primary in Santiago	35.3	30.3	57.0	55.6
	(0.48)	(46.0)	(49.6)	(49.8)
Attended secondary in Santiago	31.1	25.6	54.1	56.1
	(46.3)	(43.7)	(49.9)	(49.8)
Annual earnings (in 2002 dollars)	4901	4565	5477	9767
	(4515)	(3963)	(4075)	(9381)
Mother's education	7.1	6.9	7.3	8.7
	(3.77)	(3.60)	(4.1)	(4.9)
Father's education	7.8	7.7	8.2	9.7
	(4.1)	(3.9)	(4.3)	(5.1)
Family				
Indigent	2.5	2.6	2.4	2.6
	(15.7)	(15.8)	(15.2)	(16.1)
Poor	34.8	35.7	30.7	31.2
	(47.6)	(47.9)	(46.2)	(46.4)
Good	59.2	58.5	63.0	60.3
	(49.2)	(49.3)	(48.3)	(49.1)
Very good	3.4	3.2	4.0	5.8
	(18.3)	(17.7)	(19.6)	(23.5)
Number of siblings	3.7	3.8	3.2	3.3
	(2.7)	(2.7)	(2.6)	(2.8)
Number of observations	3910	3168	553	189

Table 2a
Characteristics of Teachers by Type of Establishment
Sample: Teachers in the Longitudinal Teacher Survey

	Municipal	Private Subsidized	Private Non-subsidized
% of Teachers with postgraduate studies	38.5	33.7	37.5
% of Teachers receiving training in years 2000-2005	81	79.1	72.9
% of Teachers with sufficient time for class preparation	19	31	41
% of Teachers participating in curriculum development	26	31	46
% of Teachers absent for medical reasons (in 2004)	37	31	27
% of Teachers who work regularly with computers as part of their job	60	74	76
% of Teachers who have access to a computer for teaching work	61	73	81

Table 2b
Median Hourly Wage by Type of Establishment and Teacher Age*

	Age 20-29	Age 30-39	Age 40-49	Age 50-59	Age 60+	All Ages
Municipal	7,666	9,090	10,681	12,666	14,000	11,363
Private subsidized	8,823	9,642	10,250	10,978	11,538	10,000
Private non-subsidized	10,833	11,250	13,589	14,583	16,666	12,500

*Wages are in Chilean pesos. The exchange rate is approximately 500 pesos per U.S. dollar

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

Variable†	(1) Estimated Coefficient	(2) Estimated Coefficient
Intercept	7.87	7.78
	(0.39)	(0.37)
Voucher available during primary school years	1.13	…
	(0.15)	
Voucher available during secondary school years	-0.03	…
	(0.20)	
Years exposed to voucher††	…	0.09
		(0.01)
Mother's education	0.06	0.06
	(0.02)	(0.02)
Father's education	0.04	0.04
	(0.02)	(0.02)
Number of Siblings	-0.05	-0.04
	(0.02)	(0.02)
Family background poor	0.96	0.94
	(0.34)	(0.33)
Family background good	1.38	1.34
	(0.33)	(0.33)
Family background very good	1.06	1.04
	(0.43)	(0.43)
Resided in Santiago during primary or secondary school years	1.36	1.30
	(0.11)	(0.11)
Number of observations	3910	3910
R-squared	0.10	0.10

† 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	-2.95	-4.22
	(0.39)	(0.58)
Voucher available during primary school years	1.04	0.02
	(0.19)	(0.22)
Voucher available during secondary school years	0.42	-0.24
	(0.24)	(0.31)
Mother's education	0.009	0.09
	(0.02)	(0.03)
Father's education	0.01	0.06
	(0.02)	(0.03)
Number of Siblings	-0.06	-0.04
	(0.02)	(0.03)
Family background poor	-0.11	-0.11
	(0.32)	(0.49)
Family background good	-0.02	-0.25
	(0.32)	(0.48)
Family background very good	0.05	0.13
	(0.39)	(0.58)
Resided in Santiago during primary or secondary school years	1.05	1.11
	(0.09)	(0.15)
Number of observations	3910	

† 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	-5.36
	(0.12)
Years of education	0.08
	(0.003)
Attended subsidized primary	-0.12
	(0.02)
Attended nonsubsidized primary	-0.11
	(0.04)
Voucher available during	-0.49
primary school years	(0.08)
Voucher available during	0.19
secondary school years	(0.12)
Labor force experience (in years)	0.31
	(0.003)
Age	0.49
	(0.008)
Age squared	-0.01
	(0.0002)
Mother's education	-0.007
	(0.003)
Father's education	0.005
	(0.003)
Number of Siblings	0.009
	(0.003)
Family background poor	-0.04
	(0.04)
Family background good	-0.07
	(0.02)
Family background very good	-0.06
	(0.06)
Resided in Santiago during primary or secondary	0.07
school years	(0.02)
Number of observations	64302

† 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 6 (a)
Estimated wage offer parameters

Parameter	Estimate	Parameter	Estimate
Return to municipal primary education		Rental rate on years of college education	0.0035
pre-voucher (β_1)	0.0587	(β_5)	(0.00044)
post-voucher $(\beta_1 + \gamma_1)$	(0.007)		
	0.0681		
	(0.009)		
Return to private subsidized primary education		Extra Rental rate on years of college education for non-subsidized school attendees	0.033
pre-voucher $(\beta^S{}_1)$	0.0512	(β_5)	(0.0046)
post-voucher $(\beta^S{}_1 + \gamma^S{}_1)$	(0.007)		
	0.0585		
	(0.009)		
Return to private nonsubsidized primary		Labor market experience (β_3)	0.095
pre-voucher $(\beta^{NS}{}_1)$	0.0543		(0.014)
post-voucher $(\beta^{NS}{}_1 + \gamma^{NS}{}_1)$	(0.007)	Experience squared (β_4)	-0.0028
	0.0466		(0.00035)
	(0.007)		
Return to municipal secondary education		Ln Wage constant	6.87 (0.866)
		Type 1	7.87 (0.941)
pre-voucher (β_2)	0.0779	Type 2	7.19 (0.828)
post-voucher $(\beta_2 + \gamma_2)$	(0.010)	Type 3	
	0.0631		
	(0.008)		
Return to private subsidized secondary education		Ln Wage constant penalty for non-Santiago region	
pre-voucher $(\beta^S{}_2)$	0.0812	Type 1	-0.071 (0.009)
post-voucher $(\beta^S{}_2 + \gamma^S{}_2)$	(0.011)	Type 2	-0.040 (0.005)
	0.0712	Type 3	-0.042 (0.006)
	(0.10)		
Rental rate on private nonsubsidized secondary			
pre-voucher $(\beta^{NS}{}_2)$	0.0736		
post-voucher $(\beta^{NS}{}_2 + \gamma^{NS}{}_2)$	(0.009)		
	0.0654		
	(0.009)		

Table 6(b)
Estimated utility function parameters

Parameter	Estimate	Parameter	Estimate
Utility from attending municipal primary school (b_{1k}^{M})		Utility from attending subsidized secondary school (b_{2k}^{S})	
Type 1	845.6 (114.0)	Type 1	279.3 (29.8)
Type 2	5635.4 (677.3)	Type 2	3996.6 (503.2)
Type 3	3010.7 (415.8)	Type 3	2240.2 (302.6)
Utility from attending subsidized primary school (b_{1k}^{S})		Utility from attending nonsubsidized secondary school (net of any costs) (b_{2k}^{NS})	
Type 1	374.3 (49.2)	Type 1	79.0 (9.8)
Type 2	5519.9 (696.5)	Type 2	3821.6 (443.6)
Type 3	2862.5 (376.7)	Type 3	2102.5 (270.3)
Utility from attending nonsubsidized primary school (net of any costs) (b_{1k}^{NS})		Utility from attending college (b_{k}^{C})	
Type 1	81.3 (10.1)	Type 1	-531.2 (72.6)
Type 2	5402.9 (679.7)	Type 2	3843.4 (479.8)
Type 3	2724.4 (305.5)	Type 3	1335.1 (194.5)
Utility from attending municipal secondary school (b_{2k}^{M})		Utility from Staying Home (b_{k}^{L})	
Type 1	185.9 (28.6)	Type 1	320.6 (43.6)
Type 2	3991.1 (534.9)	Type 2	4996.3 (671.2)
Type 3	2166.5 (266.1)	Type 3	1552.3 (195.7)

Table 6(c)
Estimated parameters related to costs of schooling and finding first job

Parameter	Estimate	Parameter	Estimate
Cost of attending primary municipal school from outside of Santiago (δ_2^M)		Switching cost of changing from subsidized primary to municipal secondary	-847.0 (107.1)
Pre-voucher	-225.6 (29.2)	($\rho^{S,M}$)	
Post-voucher	-100.0 (12.0)		
Cost of attending primary subsidized school from outside of Santiago (δ_2^S)		Switching cost of changing from subsidized primary to subsidized secondary	-11.0 (1.44)
Pre-voucher	-439.6 (58.8)	($\rho^{S,S}$)	
Post-voucher	-281.6 (31.2)		
Cost of attending non- primary subsidized school from outside of Santiago (δ_2^{NS})		Switching cost of changing from subsidized primary to non-subsidized secondary	-562.4 (75.2)
Pre-voucher	-431.2 (53.6)	($\rho^{S,NS}$)	
Post-voucher	-243.5 (28.7)		
Net cost of primary subsidized school (T_1^S)	-105.6 (12.7)	Switching cost of changing from non-subsidized primary to municipal secondary ($\rho^{NS,M}$)	-959.3 (127.6)
Net cost of secondary subsidized school (T_2^S)	-38.8 (5.2)	Switching cost of changing from non-subsidized primary to subsidized secondary ($\rho^{NS,S}$)	-338.0 (46.3)
Ratio of secondary school cost to primary school cost		Switching cost of changing from non-subsidized primary to non-subsidized secondary ($\rho^{NS,NS}$)	-74.0 (9.57)
Pre-voucher (τ_1)	1.031 (0.142)		
Post-voucher (τ_1)	0.589 (0.073)		
Switching cost of changing from municipal primary to municipal secondary ($\rho^{M,M}$)	-3.87 (0.514)	Cost of finding first job if less than 9 years in school ($\psi^{Ea<9}$)	-5020.4 (695.3)
Switching cost of changing from municipal primary to subsidized secondary ($\rho^{M,S}$)	-370.2 (52.1)	Cost of finding first job if 9-12 years of school ($\psi^{Ea=9-12}$)	-8257.5 (1061.8)
Switching cost of changing from municipal primary to nonsubsidized secondary ($\rho^{M,NS}$)	-800.0 (112.6)	Cost of finding first job if more than 12 years of school ($\psi^{Ea>12}$)	-7947.1 (1051.7)

Table 6(d)
Estimated standard errors of shocks

Parameter	Estimate
Std. error of ln wage error term	0.380
	(0.049)
Std. error of preference shock for public school	955.2
	(118.0)
Std. error of preference shock for private subsidized school	535.5
	(62.3)
Std. error of preference shock for private nonsubsidized school	253.3
	(31.2)
Std. error of preference shock for home utility	1606.0
	(187.2)

Table 6(e)
Estimated parameters of the multinomial unobserved type probabilities (relative to Type III)

Type I		Type II	
Parameter	Estimate	Parameter	Estimate
Constant	0.498 (0.067)	Constant	0.725 (0.091)
Father's education	0.015 (0.002)	Father's education	0.618 (0.008)
Mother's education	0.008 (0.001)	Mother's education	0.00006 (7.52E-06)
Family Poor	-0.201 (0.022)	Family Poor	-0.0195 (0.0029)
Number of siblings	0.072 (0.012)	Number of siblings	-0.0074 (0.0010)
Born in 1970's	-0.90 (0.093)	Born in 1970's	-0.250 (0.031)
Born in 1980's	-2.745 (0.358)	Born in 1980's	-1.587 (0.214)
Outside Santiago	0.195 (0.027)	Outside Santiago	-0.740 (0.102)

Table 7
Estimated coefficients from OLS Wage Regression

	OLS		
Variable	Coef.	Robust Std. Err.	T
Experience	.065	.005	12.50
Experience squared	-.002	.0002	-9.33
College	.171	.010	17.70
Municipal primary before reform	.112	.025	4.54
Subsidized primary before reform	.121	.030	4.09
Nonsubsidized primary before reform	.170	.034	5.04
Municipal primary after reform	.138	.025	5.56
Subsidized primary after reform	.139	.026	5.32
Nonsubsidized primary after reform	.116	.032	3.66
Municipal secondary before reform	.124	.014	8.90
Subsidized secondary before reform	.106	.030	3.59
Nonsubsidized secondary before reform	.197	.038	5.14
Municipal secondary after reform	.091	.008	11.78
Subsidized secondary after reform	.111	.010	10.84
Nonsubsidized secondary after reform	.155	.020	7.86
Constant term	6.874	.102	67.62

Table 8a
Actual and Simulated Schooling Attainment

Years of schooling	Subsample not exposed to vouchers from age six		Subsample exposed to vouchers from age six	
	Actual	Simulated	Actual	Simulated
Mean years of education	10.7	10.8	11.8	11.7
25th percentile years of education	8	8	10	10
Median years of education	12	11	12	12
75th percentile years of education	12	12	14	13

Table 8b
Actual and Simulated Schooling Attainment

	Subsample not exposed to vouchers from age six		Subsample exposed to vouchers from age six	
Years of schooling	Actual	Simulated	Actual	Simulated
5 or more	94.4	95.9	98.1	98.1
6 or more	94.4	95.9	98.1	98.1
7 or more	87.2	92.0	95.2	96.0
8 or more	87.2	92.0	95.2	96.0
9 or more	68.5	72.2	84.7	84.4
10 or more	63.4	66.9	80.7	80.4
11 or more	54.9	59.5	74.4	74.4
12 or more	50.4	49.1	70.5	64.2
13 or more	22.4	22.4	32.5	30.1
14 or more	19.5	15.1	25.7	20.3
15 or more	14.3	10.1	17.0	13.7
16 or more	9.7	6.3	11.0	8.6
17	4.9	3.3	5.6	4.7

Table 9a

Actual and simulated transition from primary to secondary school subsample not exposed to vouchers from age six (2501 individuals) (simulated choices in parentheses)

Primary school type	STAYERS (stays with same type of school)	CHANGERS (changes school type)
Municipal	47.7 (50.3)	8.8 (5.3)
Subsidized	5.5 (4.5)	2.7 (4.0)*
Non-subsidized	2.0 (2.5)	1.8 (2.9)*
Total	55.2 (57.3)	13.3 (12.3)

Table 9b

Actual and simulated transition from primary to secondary school subsample exposed to vouchers from age 6 (1409 individuals) (simulated choices in parentheses)

Primary school type	STAYERS (stays with same type of school)	CHANGERS (changes school type)
Municipal	43.9 (45.3)	12.8 (9.6)
Subsidized	12.9 (12.8)	8.9 (10.6)*
Non-subsidized	4.0 (3.0)	2.2 (3.1)*
Total	60.8 (61.2)	23.9 (23.3)

Table 10
Actual and Simulated Labor Force Participation Rates
by Primary-Secondary Schooling Choice and Age

	Age 16-45	
Primary-secondary schooling type	Actual	Simulated
M-M	74.3	75.9
S-M	59.5	61.9
NS-M	62.8	64.8
M-S	68.4	73.1
S-S	60.4	66.5
NS-S	61.7	63.6
M-NS	64.6	66.1
S-NS	40.2	50.0
NS-NS	49.5	57.8
M primary only	87.8	90.7
S primary only	83.0	83.1
NS primary only	84.4	73.3
All Educational categories	75.2	77.0

Table 11
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
Municipal-Municipal	4982	5347
Subsidized-Municipal	5469	5529
Nonsubsidized-Municipal	7206	6997
Municipal-Subsidized	5970	5478
Subsidized-Subsidized	5707	5765
Nonsubsidized-Subsidized	3703*	6264
Municipal-Nonsubsidized	6407	6861
Subsidized-Nonsubsidized	6033*	5655
Nonsubsidized-Nonsubsidized	13671	7363
Municipal only	3069	3163
Subsidized only	3288	3513
Nonsubsidized only	4287	4353
All Educational categories	4901	5012

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

Table 12

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 13
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	26.1	17.3	8.8	25.3	16.7	8.6	26.5	17.6	8.9
% Attending private nonsubsidized primary	6.7	9.4	-2.7	6.4	8.9	-2.5	6.9	9.6	-2.7
% Attending private subsidized secondary	22.4	13.0	9.4	21.6	12.3	9.3	22.8	13.2	9.6
% Attending private nonsubsidized secondary	5.7	5.5	0.2	5.3	5.0	0.3	5.7	5.6	0.1
% Attending college	30.1	27.0	3.1	29.1	25.8	3.3	30.9	27.6	3.3
25% quantile years of education	10	10	0	10	10	0	11	10	1
Median years of education	12	12	0	12	12	0	12	12	0
75% years of education	13	13	0	13	13	0	13	13	0

†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 14
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
5	98.1	97.5	0.6	97.9	97.2	0.7	98.2	97.6	0.6
6	98.1	97.5	0.6	97.9	97.2	0.7	98.2	97.6	0.6
7	96.0	95.2	0.8	95.6	94.7	0.9	96.2	95.4	0.8
8	96.0	95.2	0.8	95.6	94.7	0.9	96.2	95.4	0.8
9	84.4	81.4	3.0	83.0	80.0	3.0	85.1	82.2	2.9
10	80.4	77.0	3.4	78.8	75.3	3.5	81.1	77.8	3.3
11	74.4	70.8	3.6	72.6	68.9	3.7	75.3	71.7	3.6
12	64.2	60.6	3.6	62.2	58.6	3.6	65.1	61.6	3.5
13	30.1	27.0	3.1	28.9	25.8	3.1	30.7	27.6	3.1
14	20.3	17.7	2.6	19.5	16.9	2.6	20.8	18.1	2.7
15	13.7	11.4	2.3	13.0	10.8	2.2	14.0	11.6	2.4
16	8.6	6.8	1.8	8.2	6.5	1.7	8.8	7.0	1.8
17	4.7	3.4	1.3	4.4	3.3	1.1	4.8	3.5	1.3

†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 15a
Voucher Program Impact on Labor Market Outcomes
(Labor Force Participation)

	Complete sample†		Poor Subsample††		NonPoor Subsample‡	
	With Program	Without Program	With Program	Without Program	With Program	Without Program
Earnings of Workers	3153	3168	3040	3054	3211	3227
ages 16-25						
ages 26-35	4672	4733	4565	4619	4727	4791
ages 36-45	5258	5263	5129	5129	5324	5331
ages 16-45	4361	4388	4245	4267	4421	4550
Percent of time participate in the labor force						
ages 16-25	58.3	60.2	59.6	61.5	57.6	59.5
ages 26-35	92.8	92.7	93.0	93.0	92.7	92.6
ages 36-45	93.8	93.5	94.0	93.7	93.7	93.4
ages 16-45	81.6	82.1	82.2	82.7	81.3	81.8

†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 15b
Voucher reform impact on earnings distribution of workers
(Earnings)

	Full sample	
Percentile	With reform	Without reform
1	1960	1899
5	2491	2438
10	2833	2798
50	4526	4515
90	5794	5914
95	6183	6312
99	6696	6839
Mean	4361	4388
S.D	1105	1145
90-10 ratio	2.04	2.11
50-10 ratio	1.59	1.61

Figure 1: Percentage Attending Different Types of Schools by Year

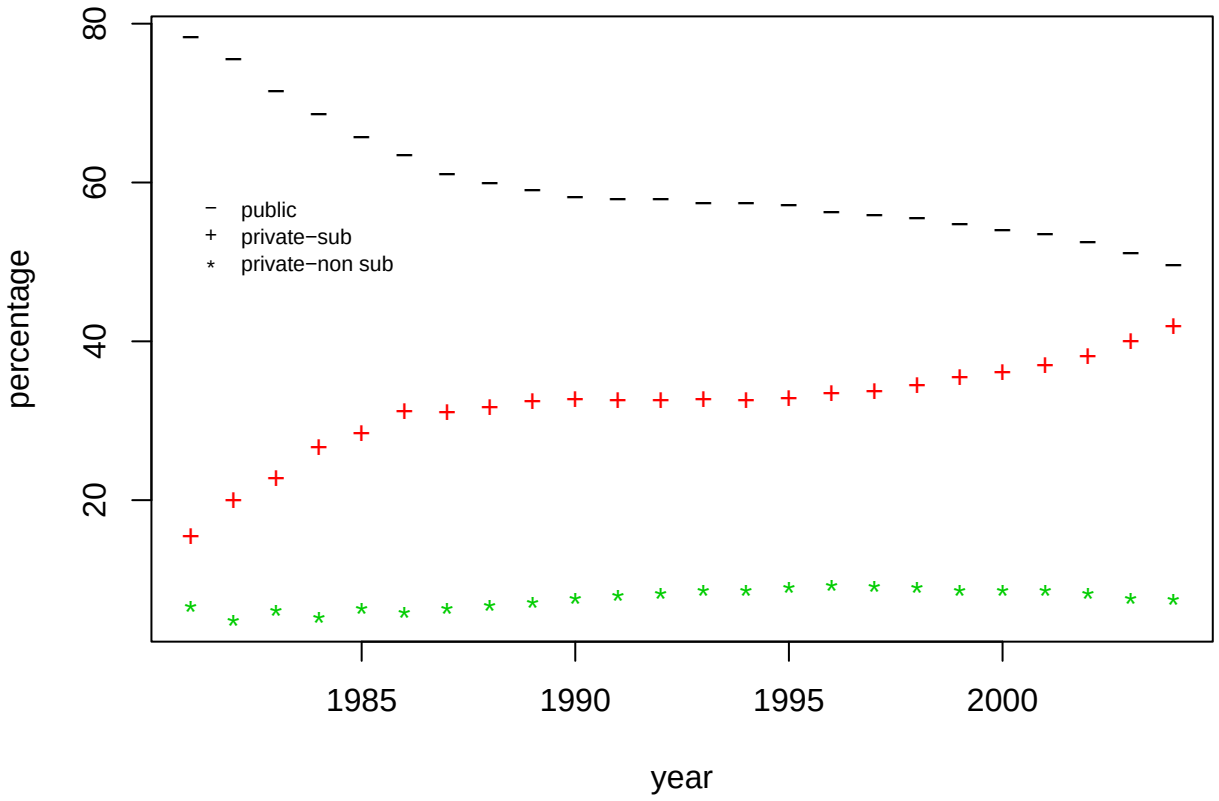


Figure 2: Education Distribution, Overall and By Type of Primary Attended

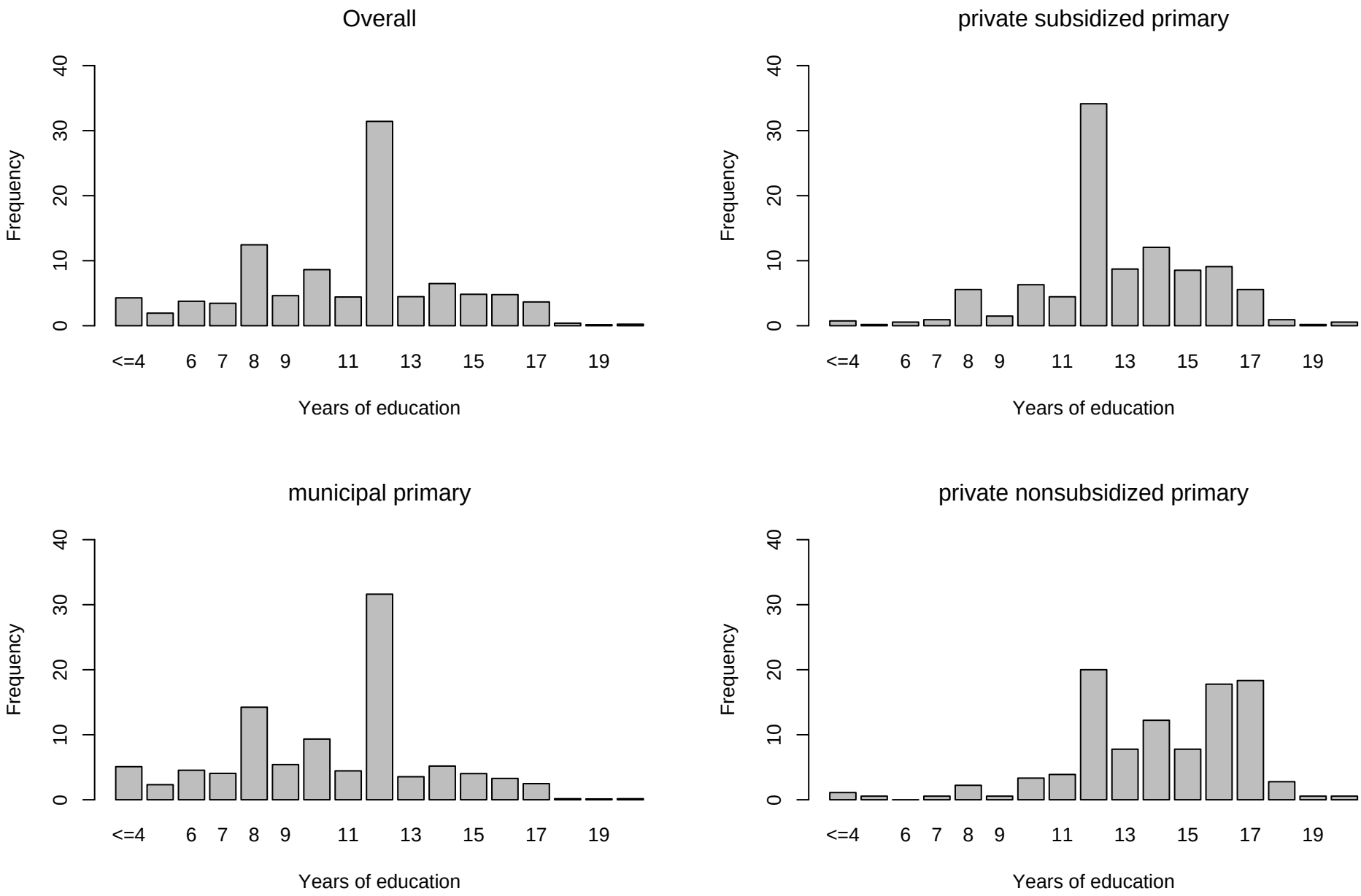


Figure 3: Perc. Working by Age and Type of Primary School

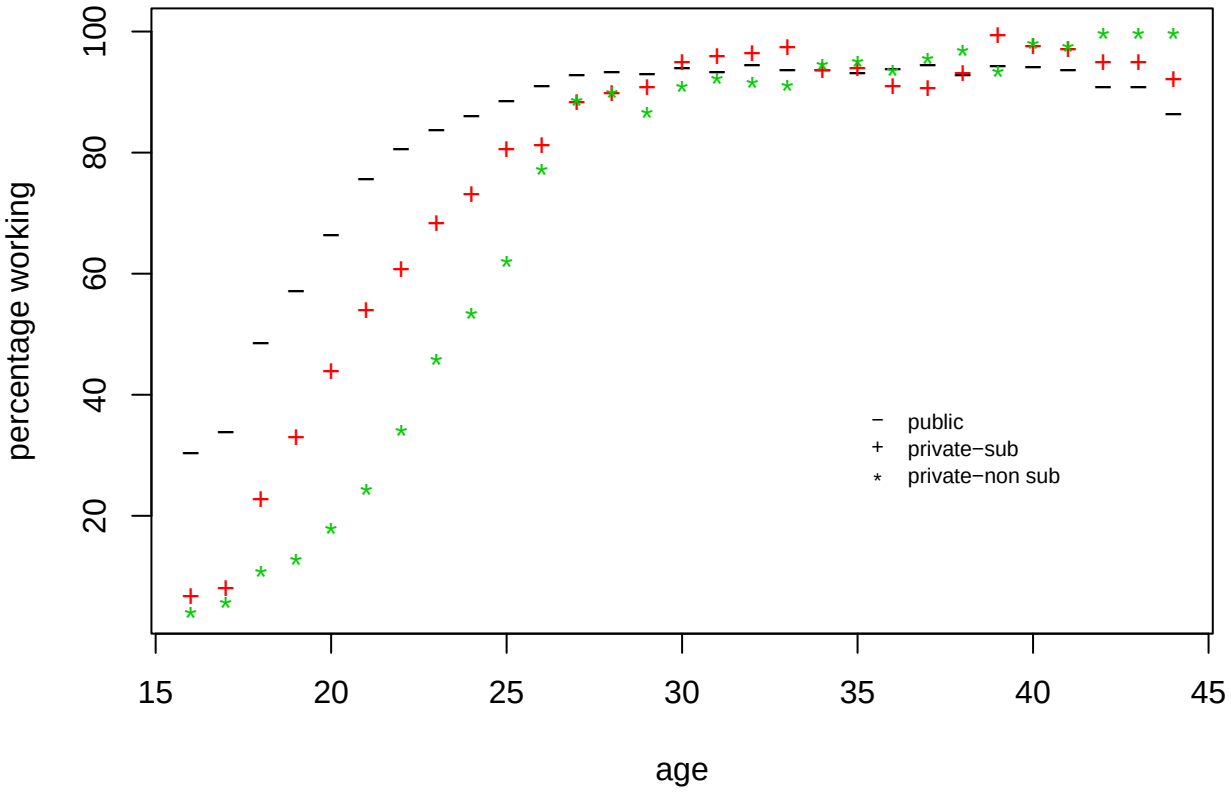
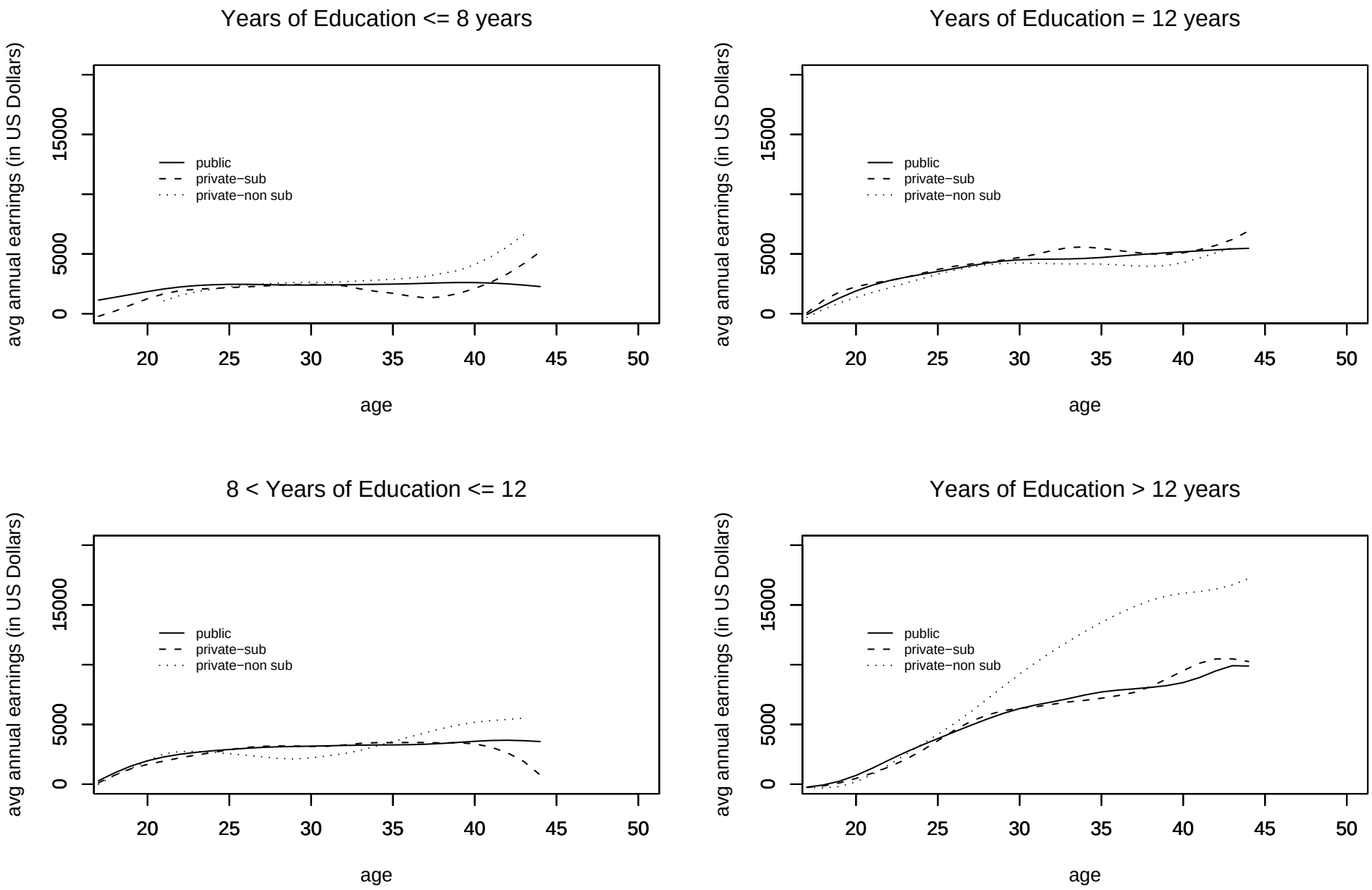


Figure 4: Smoothed Earnings−Age Relationship by Education Class and Schooling Type



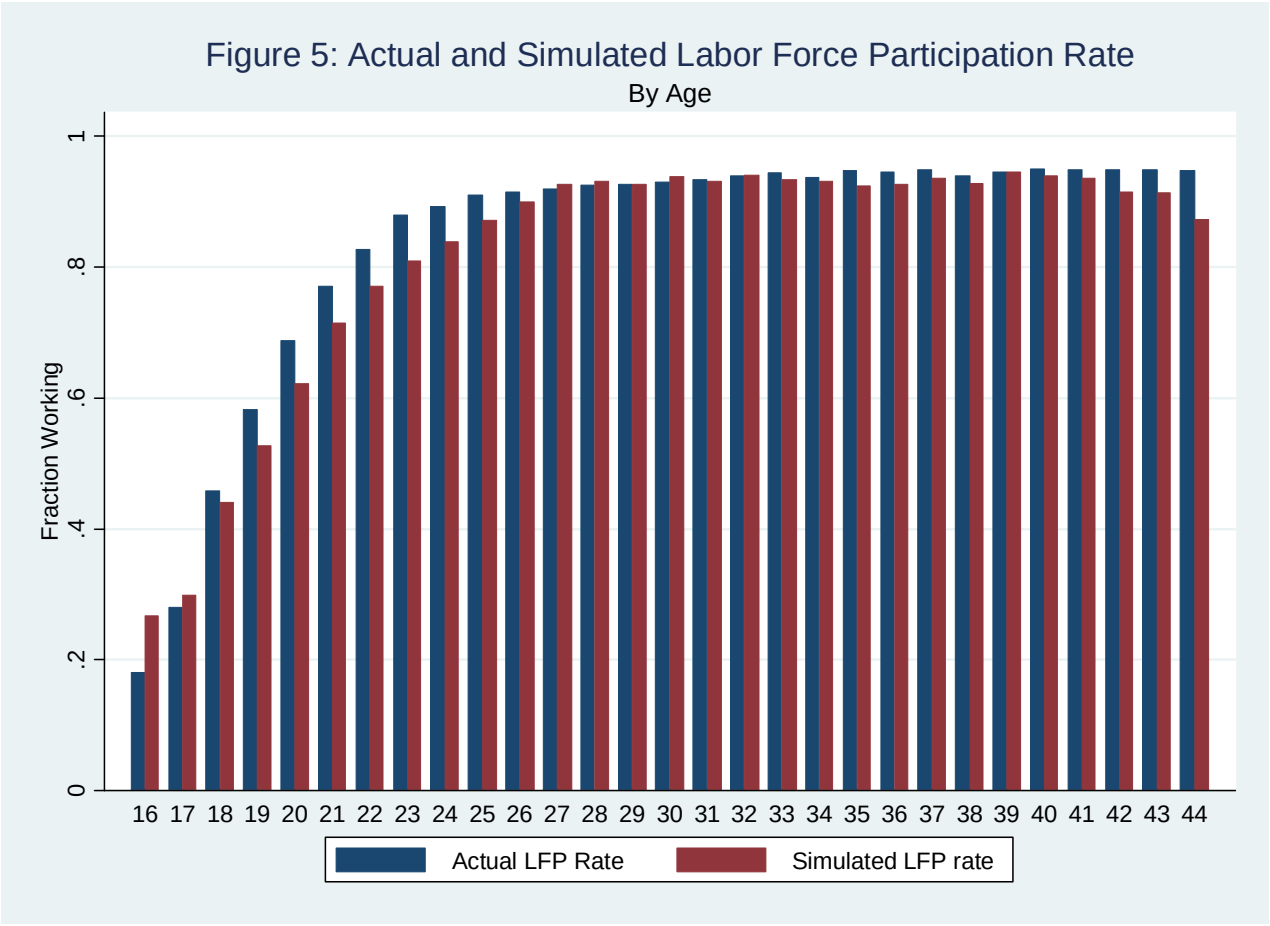


Figure 5: Actual and Simulated Labor Force Participation Rate
By Age
Fraction Working
0
.2
.4
.6
.8
1
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Actual LFP Rate
Simulated LFP rate

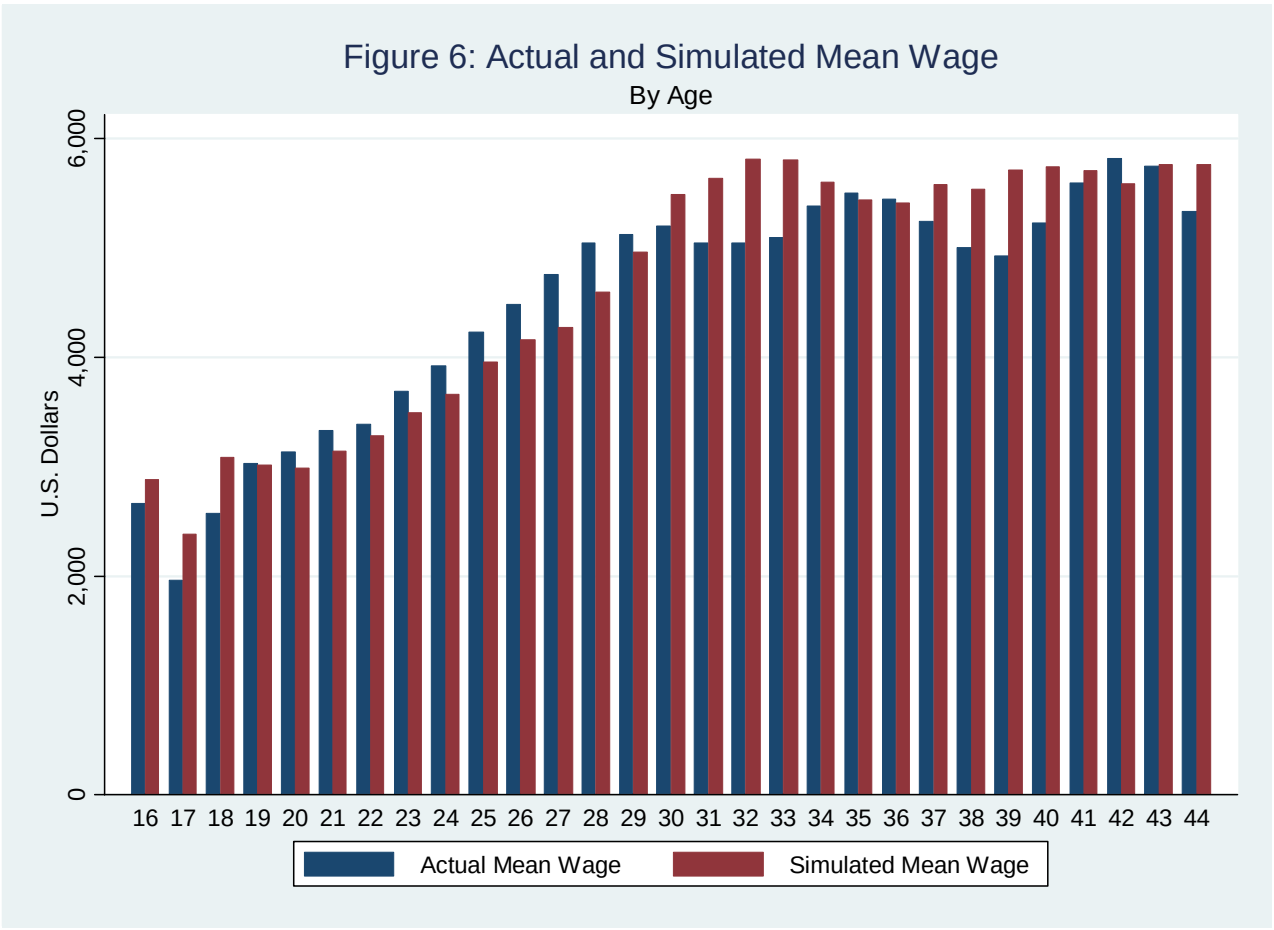


Figure 6: Actual and Simulated Mean Wage
By Age
U.S. Dollars
0
2,000
4,000
6,000
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Actual Mean Wage
Simulated Mean Wage