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Persistence in the Transmission of Education: Evidence across Three Generations for Chile

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ABSTRACT *This paper is one of the first to document multigenerational educational mobility for a Latin American country. It complements a recent wave of articles that study mobility beyond two generations in developed countries. Specifically, we link data on educational attainment for three generations in Chile. Our main findings indicate that grandparental education influences grandchildren's schooling even after taking the parental factor into account. Accordingly, standard two-generation estimations over-predict intergenerational mobility over three generations. We investigate three potential avenues of transmission. First, we find that upward schooling mobility has moderately increased with younger cohorts, and that such changes may be attributable to institutional reforms. Second, there is important heterogeneity in educational mobility across regions in Chile, which sheds light on how parents' place of origin matters for upward mobility. Third, a gender-specific lineage analysis indicates that having more educated same-sex ancestors matters more for women and suggests that gender-related social roles may be passed along generations within families. All in all, our results suggest that family background effects can be longer lasting than previously believed, affecting the endowments and idiosyncratic capabilities of children.*

KEYWORDS: Intergenerational mobility, Schooling, Multiple generations, Latin America

1. Introduction

Most previous studies of intergenerational transmission of human capital are restricted to parents and their children. There is less direct evidence on mobility across multiple generations, which would better answer questions on how opportunities for economic success evolve in the long run. However, very recent theoretical (Solon 2014, 2015; Stuhler 2012) and empirical work is being developed to address this gap.[1] In fact, a rapidly evolving literature is emerging, studying mobility patterns across three or more generations in developed countries.[2]

The results from this new empirical literature consistently show that multigenerational persistence tends to be high compared to the predictions by seminal theoretical models (Becker and Tomes 1979, 1986), which implied that advantages and disadvantages of ancestors tend to disappear rapidly. That older generations—beyond parents—influence children outcomes has important implications for how we interpret intergenerational

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transmission of human capital. In the absence of direct evidence for more than two generations, the literature previously extrapolated longer term mobility using the available parent–child elasticities. When confronted by the new evidence, this procedure seems to have been mechanically overestimating longer run mobility patterns.

The evidence found for developed countries leads to question whether similar patterns hold for developing countries. Answering this turns to be of particular importance for the Latin American region, where nations have been systematically characterized by low levels of mobility across two generations as documented in Hertz et al. (2007) and Behrman, Gaviria, and Székely (2001).[3] Understanding long-run mobility in developing countries would also help to better track the effectiveness of social policies such as compulsory schooling laws and higher education reforms, and to study whether such policies temporarily mask inequalities among families or have lasting effects on individual's relative fortunes and opportunities.

Despite its importance and due to lack of data, this evidence is rare. This paper is one of the first to examine long-run educational mobility for a Latin American country. We use a Chilean data set that enables us to link information on educational attainment for three generations. To study the intergenerational transmission of schooling, we first estimate standard reduced form equations for two and three generations. To this end, we use years of completed schooling for each generation measured in both absolute and relative terms. Our main findings can be summarized as follows. We find the coefficient between grandparents' education and parents' education to be 0.68, which decreases to 0.46 for parents and children. This indicates that absolute mobility increased across generations, that is, that individuals have consistently attained higher levels of education compared to their ancestors. However, relative educational mobility has remained stable. An increase in one standard deviation (SD) in grandparental education is associated with 0.59 of a SD for parents,[4] while the same estimate for parents and children is 0.58. This suggests that the schooling attainment ranking changes little between generations.

Importantly, our estimates show that grandparental education matters even after taking parental education into account. Accordingly, the standard two-generation extrapolation method under-predicts schooling persistence. This is consistent with the evidence found for developed countries, albeit when estimated at higher levels of immobility. As described by Solon (2015), there are many different processes capable of explaining these higher order coefficient estimates. Grandparents may contribute beyond what is mediated through the parent, either directly via interaction with their grandchildren (Zeng and Xie 2014), or indirectly via genetic transmission.[5] There may also be group effects associated with race or ethnicity (Nybom and Stuhler 2014; Oreopoulos and Page 2006) or even geographical differences (Chetty et al. "Is the United States Still a Land of Opportunity?" 2014, "Where is the Land of Opportunity?" 2014) affecting the mobility patterns.

Our data allow us to examine how some of these factors relate to educational mobility. In particular, we address the relationship among the educational mobility patterns and institutional changes, geographical differences, and gender differentials. We first study how the intergenerational transmission of schooling has evolved over time. A birth cohort analysis shows that, in a context of high persistence, educational mobility has moderately increased over time. Auxiliary data from the Chilean Census suggest that such patterns may be attributable to changes in the distribution of education generated by institutional reforms, such as compulsory schooling laws. We then perform a geographical analysis that reveals that the national average educational persistence hides great heterogeneity within the country. Mobility tends to be higher in areas outside the Metropolitan Region (MR), which is the richest and most populated in the country. In addition, more mobile regions have lower levels of income inequality. These facts are in line with the findings for the USA by Chetty et al. ("Where is the Land of Opportunity?" 2014) and for comparisons across countries such as Corak (2013), suggesting that place of birth is important for upward mobility in Chile. The next set of results show interesting gender differentials in the association between three generations of the same family, consistent with the work for the USA by Olivetti, Paserman, and Salisbury (2014). Children learn gender roles from their parents, and it may be the case that children mimic other same-sex family members. Our findings indicate that both grandparents matter for grandsons while only grandmothers influence granddaughters' education. Paternal grandmothers are more influential than maternal ones suggesting that gender plays a role in explaining schooling persistence.

In a nutshell, our findings show high persistence of schooling across three generations and suggest different mechanisms that may explain such multi-dimensional phenomena. The rest of this document proceeds as follows. Section 2 introduces and characterizes our data in the context of the educational system of Chile and presents our methodology. Section 3 describes our basic estimates and the potential avenues through which mobility patterns persist. Section 4 concludes.

2. Data and Methodology

We use the first wave of the Longitudinal Social Protection Survey (LSPS 2002), a representative survey of the Chilean population affiliated with the pension system.[6] The survey was mainly designed to collect information on individuals' employment and social security history. It also collects information for both parents and all children of the interviewee including age and education. This is a particular advantage of using the LSPS compared to other household surveys that only collect data on children currently living in the interviewee's household, which may lead to sample selection bias (Francesconi and Nicoletti 2006). The LSPS 2002 original sample consists of 17 246 respondents drawn from a sampling frame of approximately 8.1 million individuals. We restrict our analysis to living respondents who have at least 1 child of 23 years old or older at the moment of the survey.[7] Our working sample size consists of 4529 respondents born around 1944 (G2 generation), with information on their parents (G1 generation),[8] born around 1925, and all of their offspring (G3 generation), born around 1968. Figure 1 shows the distribution of birth years by generation. Generation 3 is restricted to be at least 23 years old, so its distribution is truncated at birth year 1980.

2.1. Descriptive Statistics

Table 1 presents descriptive statistics for our sample.[9] The first panel shows the average, SD, and number of observations for a set of variables regarding the generation of grandparents (G1). These are variables reported by each interviewed individual about her parents.[10] The average years of schooling for grandparents is 4.4, in a context when Chilean legislation had established 4 years of minimum mandatory education (explained in the next subsection).[11] Grandfathers tend to be more educated than grandmothers with 5.1 and 4.1 years of schooling, respectively. Furthermore, only a small percentage (3%) completed more than 12 years of schooling, which we label as having attended higher education institutions in Table 1.

The next panel describes our sample of interviewed individuals or G2 generation. The sample is 52% male, who are on average 60 years old and have finished 8 years of schooling. The percentage of individuals with more than 12 years of schooling jumps to 15% in this generation, with no evidence of differences in schooling by gender. In addition, 29% of the second generation attended primary school in the MR of Chile.[12]

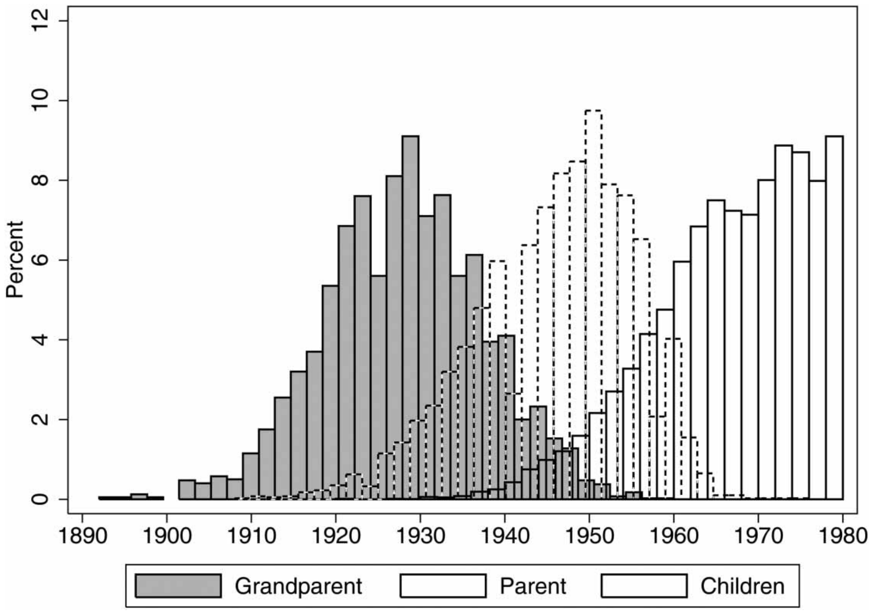

Figure 1. Birth cohorts by generation.
Notes: This figure shows the distribution of the years of birth by generation. Generation 3 is restricted to be 23 years old or older, so its distribution is truncated at birth year 1980. For the G1 generation, the precise information is not available in the survey for all of G1 individuals.

The following rows display information for G3, the child generation. There are a total of 12 648 observations in this generation, 51% of them are male, and they are 36 years old on average. Regarding their schooling, they completed 11.3 years of education, and 27% of them continued on to higher education. When comparing education by gender, both sons and daughters achieve the same years of schooling on average. By a simple comparison of means, Table 1 illustrates a steady increase in education over generations. This is the case in both years of schooling and, more sharply, in higher education attendance. Next, we will contextualize these schooling increments within Chile's institutional changes.

2.2. Educational Changes in Chile

We need to provide some context regarding the Chilean educational system to describe the basic features of our data. This will give the reader a better understanding of the results we present in Section 3.

By 1920, the Chilean legislation had established four years of minimum mandatory education, which was increased to six years by 1929. Through 1965, primary education consisted of six years of schooling, while the secondary level required students to complete six additional years of education. The 1965 reform extended primary education to 8 mandatory years, ideally for ages 6–14, while secondary school required 4 more years of schooling. These reforms had the expected effect on school coverage; by 1970, there was universal coverage (97%) in primary education, while secondary schooling increased sharply from 18% to 50% of the population between 1964 and 1970. Over the next decades, coverage in secondary schooling continued to increase to 65% in 1982 and 77% in 1990 (see Elacqua 2011).

Figure 2 shows the distribution of years of schooling for the three generations. G1s have a median of 4 years of schooling, while G2s have 6 years and G3s 12 years. Consistent with

Table 1. Descriptive statistics of the sample

Generation	Variable	Obs.	Mean	SD	Min	Max
Grandparents (G1)	G1 Schooling	4529	4.38	4.08	0	19
	G1 Higher Education (= 1)	4529	0.03	0.17	0	1
	Grandfather schooling	3778	5.13	4.66	0	20
	Grandmother schooling	4233	4.05	4.03	0	19
	Grandfather alive	4219	0.17	0.38	0	1
	Grandmother alive	4509	0.33	0.47	0	1
	Any in G1 alive	4529	0.38	0.49	0	1
Parents (G2)	G2 Schooling	4529	7.99	4.72	0	20
	G2 Higher Education (=1)	4529	0.15	0.36	0	1
	G2 Age	4529	59.75	11.47	38	99
	G2 Male (=1)	4529	0.52	0.50	0	1
	G2 Prim. Sch. in MR (=1)	4529	0.29	0.45	0	1
	G2 Schooling (Father)	2134	7.92	4.67	0	20
	G2 Schooling (Mother)	2395	8.05	4.77	0	20
Children (G3)	G3 Schooling	12 648	11.34	3.75	0	20
	G3 Higher Education (=1)	12 648	0.27	0.44	0	1
	G3 Age	12 648	35.65	9.17	23	82
	G3 Male (=1)	12 648	0.51	0.50	0	1
	G3 Schooling (Daughter)	6219	11.36	3.66	1	20
	G3 Schooling (Son)	6429	11.32	3.83	0	20

Notes: All statistics are computed using the household sampling weights provided by the LSPS 2002. In total, we have 4529 individuals interviewed (G2) that provide information on their parents (G1) and all of their offspring (G3). G1 Schooling refers to the average years of education between the respondent' father and mother, who are the grandparents in our sample. All the rest of the "Schooling" variables refer to the average years of completed education for the corresponding group. The Higher Education binary indicators are equal to 1 if years of schooling are above 12 years and equal to 0 if not. The variable G2 Prim. Sch. in MR is equal to one if G2 attended primary school in the MR of Chile, and equal to zero otherwise.

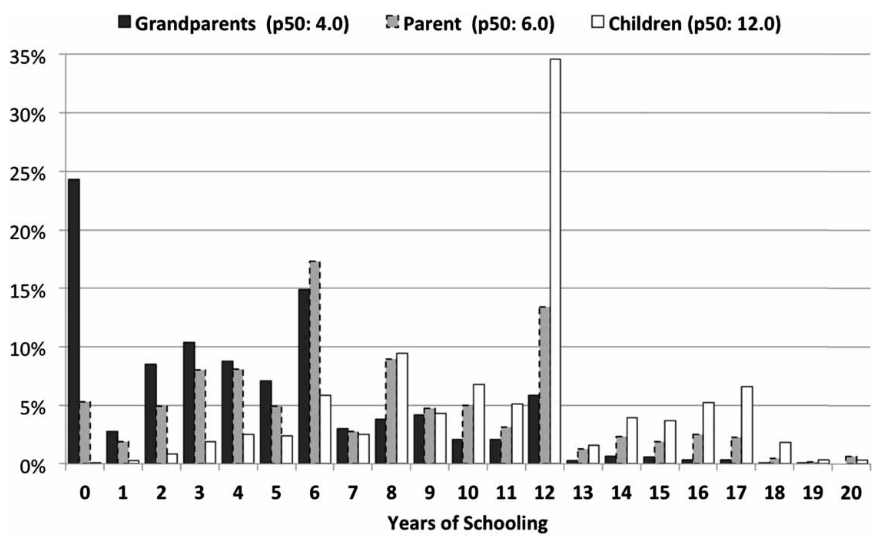

Figure 2. Distribution of schooling across generations.
Notes: This figure shows the distribution of years of schooling for the three generations we study. For G1 years of schooling, we use the average using education of both grandparents, or the one that is available when either the grandfather or grandmother information is missing.

the institutional arrangements described above, the schooling distribution shifts to the right with younger generations. It is worth noting the relatively high proportion—approximately 1 out of 4—of G1s that did not complete even 1 year of education. In the next generation, this proportion reduces to about 1 out of 20, while in the subsequent generation (G3) almost all individuals had at least some schooling.

Both grandparental and parental generations experience a spike at six years of schooling suggesting that the 1929 mandatory primary education law affected both. Meanwhile, G3 features its highest spike at 12 years of schooling. In this generation, around 58% of individuals completed at least secondary education. Even though these cohorts were not subject to any compulsory law mandating 12 years of education, secondary school coverage increased heavily since 1970.[13] One hypothesis that could explain this phenomenon is that the mandate for eight years of schooling in 1965 also had an effect on completing secondary school, since it lowered the time needed to get a high school diploma from six to four years.[14]

2.3. A Graphical Approach to Mobility Across Generations

Our first approach to mobility across generations is shown in Figures 3 and 4. In the first figure, we plot the average years of schooling of generation t in the y-axis against the years of schooling of generation $t-1$ in the x-axis. In the second figure, we plot the corresponding SD of schooling. The triangle dots correspond to the analysis of G1 and G2, while the circular dots represent the analysis of G3 and G2. The diagonal is a 45-degree line. These graphs are useful for at least two important reasons. First, they provide a notion on how mobility behaves at the bottom and the top of the schooling distribution. Second, the slopes depicted by the dots represent a graphical approximation of the regression coefficients between generations, which we present in the next section.

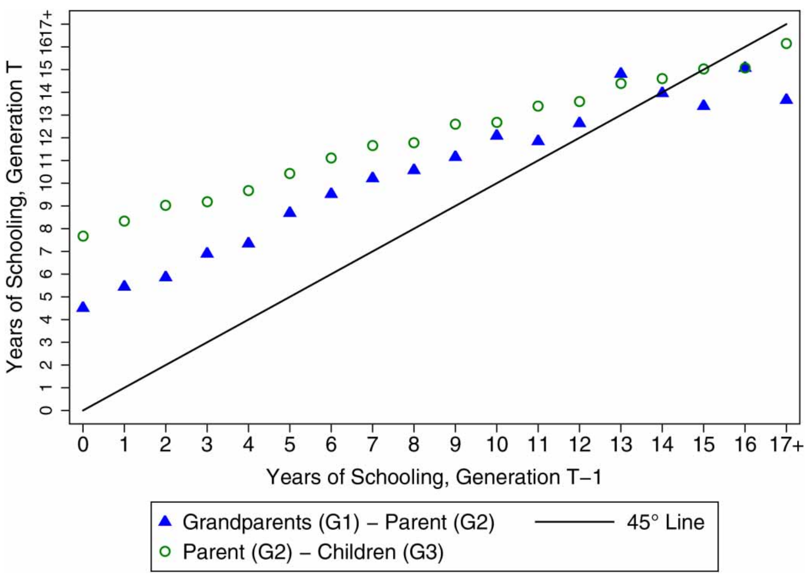

Figure 3. Absolute mobility across generations.
Notes: This figure shows the average years of schooling of generation t in the y-axis, against the years of schooling of generation $t-1$ in the x-axis. The triangle dots correspond to the analysis of G1 and G2, while the circular dots represent the analysis of G3 and G2. The diagonal is a 45-degree line.

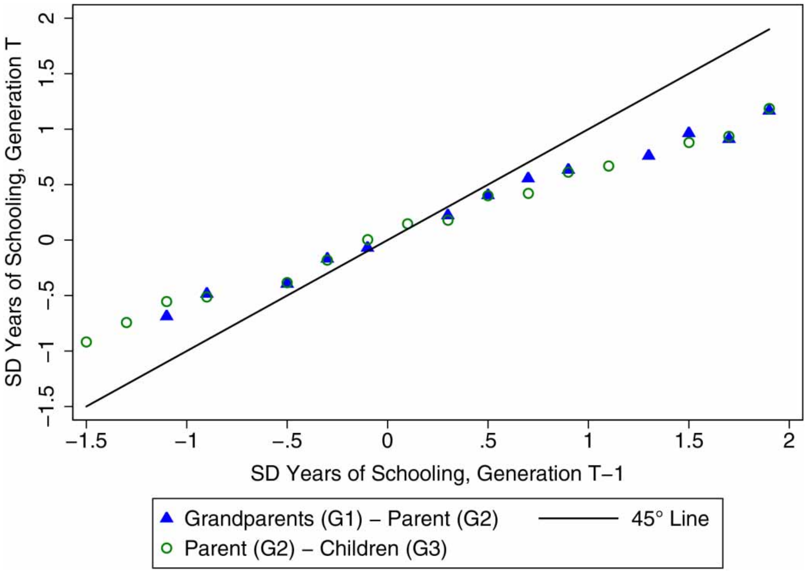

Figure 4. Relative mobility across generations.
Notes: This figure shows the average standardized years of schooling of generation t in the y-axis, against the years of schooling of generation $t-1$ in the x-axis. The triangle dots correspond to the analysis of G1 and G2, while the circular dots represent the analysis of G3 and G2. The diagonal is a 45-degree line.

Figures 3 and 4 give us a first view of how absolute and relative mobility evolve across generations, respectively.

For G1–G2, Figure 3 shows high mobility at the bottom of the schooling distribution of G1, since most of the triangular dots for the first 8 years of education in this generation (x-axis) are far above the diagonal in the next generation (y-axis). Individuals continue to have more years of education than their parents until 12 years of school. After that the triangular dots are not statistically distinguishable from the diagonal,[15] which implies that there is less mobility at the top of the schooling distribution. A similar result is shown in the transition of the next two generations, G2–G3. The figure shows that there is even higher mobility at the bottom than for G1–G2, because circular dots are further away from the 45-degree line before 8 years of schooling. The pattern described in Figure 4 is similar: higher mobility at the bottom (dots above the 45 degree line) and lower mobility at the top (dots below). However, while absolute mobility across two generations increases as we move forward in the generational spectrum in Figure 3, it remains basically unchanged in Figure 4 when we use measures of relative mobility. In the latter, both G1–G2 and G2–G3 depict the same pattern. This suggests that even though younger generations attain higher levels of education than their ancestors, their relative position in the schooling distribution does not change significantly.

2.4. Econometric Specifications

Our econometric specifications follow standard descriptive analyses of mobility between adjacent generations, based on the estimation of a reduced form equation derived from the microeconomic model in Becker and Tomes (1979, 1986). We first estimate a linear regression of years of education of generation (t) on years of education of an older generation $(t - s)$ in the same family, of the form,

$$S_{i,t} = \beta_0 + \beta_1 S_{i,t-s} + f(\text{age}_{it}, \text{age}_{it-s}) + \xi_{it}, \tag{1}$$

where $s \in \{1, 2\}$ and $f(\text{age}_{it}, \text{age}_{it-s})$ summarizes the fact that we include a quadratic function for the age of each generation in the regression. In this setting, the slope β_1 is a measure of immobility. It can be interpreted as a measure of absolute mobility, as it indicates how an additional year of education in generation $t - s$ changes education for generation t. If $S_{i,t}$ is defined relative to its distribution, then the coefficient β_1 represents a measure of relative mobility, indicating how the education attainment ranking changes from one generation to another.

As discussed in Section 1, a multitude of processes may rationalize multigenerational mobility patterns. We follow Solon (2014) and trivially extend his "income mobility" model to a three generations "educational mobility" setup.[16] Utility-maximizing parents are concerned about the welfare of their children, and now the process describing how endowments are related over time is allowed to be AR(2). This opens the possibility of grandparent contribution beyond mediated contributions through parents. As we derive in Appendix 3, the model collapses to the following reduced form equation:

$$S_{i,t} = \beta_0 + \beta_1 S_{i,t-1} + \beta_2 S_{i,t-2} + f(\text{age}_{it}, \text{age}_{it-2}) + \xi_{it}, \tag{2}$$

which previous researchers have estimated for developed countries (for instance, Behrman and Taubman 1985, for the USA, or more recently, Lindahl et al. 2015, for Sweden). In specification (2), β_1 reflects the influence of parental education on children's education, conditioning on grandparental education. Likewise, our parameter of interest β_2 reflects the association between grandparents' and children's education, taking into account the parental factor. We are interested in testing the null hypothesis $H_0: \ \beta_2 = 0$. If rejected, it provides evidence of higher order levels of persistence in educational outcomes. In the next section, we present baseline results from the estimation of Equations (1) and (2). Then, we extend our analysis to study how mobility patterns have evolved over time, how they vary with geographical differences, and whether gender plays a role in the persistence of educational mobility over three generations.

3. Results

3.1. Basic Results

In this section, we present our basic estimates of intergenerational mobility using both absolute and relative measures. Table 2 exhibits the estimated transmission coefficients for years of education across the three generations under study. Estimates in columns (1)–(3) show the results from the bivariate regression (1), and column (4) shows the result from estimating Equation (2).

The association between educational outcomes for parents (G2) and their children (G3), as given in column (2) shows that there is a persistence of about 0.46 in absolute terms. In other words, one additional year of school for parents is related to about half of another year for their children. This is in the same order of magnitude as those found for Chile by Celhay, Sanhueza, and Zubizarreta (2010) and Núñez and Miranda (2011), and similar to the magnitudes reported by the World Bank in Ferreira et al. (2013). In relative terms, an increase in one SD in parental education—4.7 years of schooling in our sample—is associated with 2.2

Table 2. Schooling coefficients: baseline results

Dep. var. is schooling of:	(1)	(2)	(3)	(4)
	G2	G3	G3	G3
Schooling of G2		0.462***		0.400***
		(0.010)		(0.013)
		[0.575]		[0.499]
Schooling of G1	0.679***		0.388***	0.113***
	(0.016)		(0.015)	(0.015)
	[0.586]		[0.413]	[0.120]
Observations	4529	12 648	12 648	12 648
Adjusted R^2	0.423	0.369	0.234	0.378

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by ordinary least squares (OLS). Standardized coefficients are given within parentheses. G1: Mean schooling of the grandparent generation. G2: Schooling of the survey respondent. G3: Schooling of respondent's offspring. Column (1): Controls for a quadratic polynomial on age, sex of G2 and a binary indicator for whether G1 is alive. Each observation corresponds to a respondent in our sample. Column (2): Controls for a quadratic polynomial on age and sex of G3 and for whether G1 is alive. Column (3): Controls for a quadratic polynomial on age and sex of G2 and G3. Each observation corresponds to a child of the respondent. Column (4): Adds control for whether G1 is alive. Each term between brackets ([]) corresponds to the standardized coefficients.
*$p < .10$.
**$p < .05$.
***$p < .01$.

additional years of schooling in the next generation. This represents approximately 0.58 of a SD, as shown by the standardized coefficient in parentheses in column (2).

An interesting result, shown in column (1), is the high persistence in schooling between grandparents and parents. An additional year of education in the grandparent generation (G1) is related to 0.68 years of schooling in the next generation (G2). In relative terms, one additional SD in G1—equivalent to 4.1 more years of schooling—is associated with 3.2 additional years of schooling for G2 or 0.59 of a SD. These results indicate that absolute mobility increased Chile (0.68 to 0.46 years), while relative schooling mobility increased only moderately from G1–G2 (0.59 SD) to G2–G3 (0.58 SD). This is consistent with the slopes depicted in Figures 3 and 4.

These findings also show that if we compute mobility across three generations by the standard two-generation exponentiation procedure, we would be under-predicting intergenerational persistence in educational attainment over three generations for both absolute and relative measures. Suppose, as is the typical case, that we only had the association between educational outcomes for parents (G2) and their children (G3) as shown in column (2). According to the extrapolation by exponentiation method,[17] we would predict a fairly low coefficient for the association between G3 and G1, given by 0.462 = 0.21. However, the estimated coefficient 0.39 presented in column (3) is about twice as large. Note that although less severely, this also happens for the relative mobility measure.

Is this grandparental influence acting only through the parents' education? If so, we would expect the coefficient on grandparents' education to be zero when we estimate Equation (2). However, column (4) shows that, even after conditioning on parental education, the grandparent factor does not fade out, rejecting the null hypothesis $H_0 : \beta_2 = 0$. In other words, there is a persistent association between G1 and G2, despite the fact that there is one generation or an average of 50 years between the births of G1 and G3.

Lindahl et al. (2015) estimate similar specifications for Sweden, which provides a benchmark to interpret the coefficients for Chile described above. For cohorts that were born in similar years such as ours, their standardized estimated coefficients of Equation (2) are 0.267 for parents (0.499 in our specification) and 0.110 for grandparents (0.120 in our specification), respectively. Interestingly, even in a highly mobile country such as Sweden, the grandparental factor has an independent (from the parent) direct association when predicting grandchildren's years of education. Why do we get this prevalence of schooling over more than one generation? The next subsections of results explore possible avenues through which the transmission of human capital persists over more than one generation.

3.2. Changes Over Time: Institutional Channel

We extend the baseline equations to study how mobility among generations has changed over time, and then relate it to the trends in mobility and institutional changes Chile has experienced. First, we construct a variable for the birth cohort of G3. Table 3 shows the distribution of birth cohorts grouped into five-year periods.[18] To test for changes in educational mobility across time, we interact G2's education in Equation (1) and G1's education in Equation (2), with a binary indicator for each cohort group in Table 3. In addition, in the regressions of children's education on grandparents' education, we always condition on parents' years of education, unless stated otherwise.

The results are shown in Table 4. The first column shows the estimated parameters from Equation (1), relating parents' years of education (G2) to children's years of education (G3), controlling for cohort effects. The negative sign on the interaction coefficients and the fact that they are increasing in absolute value for younger cohorts are indicative of a consistent pattern of increasing mobility between generations G2 and G3 over time.[19] The second column shows the results for the same regression, but now for grandparents (G1) and children (G3), controlling for parental education and cohort effects. Similarly, the pattern over time displays an increasing trend in mobility between grandparents and their grandchildren.

A visual test of differential trends is shown in Figure 5, where we plot the coefficients from Table 4. Interestingly, we see a relatively steeper trend for cohorts born between 1950 and 1964 in both cases, after which the differences from one cohort to another are less obvious. This is more evident when we look at the relation between grandparents' and children's education.[20]

Table 3. Distribution of birth cohorts of the children generation.

Cohort group	Obs.	Percentage
1920–1944	244	1.90
1945–1949	391	3.20
1950–1954	817	6.70
1955–1959	1312	10.50
1960–1964	2064	16.30
1965–1969	2236	17.80
1970–1974	2728	21.40
1975–1979	2856	22.20
Total	12 648	100.00

Notes: This table shows the distribution of the offspring generation (G3) by five-year birth cohort groups. The first column shows the sample size in each birth cohort and the second column shows how birth cohorts of G3 are distributed in the sample.

Table 4. Cohort differences in intergenerational coefficients: G1–G3 and G2–G3

Dep. var. is schooling of:	(1) G3	(2) G3
Schooling of G1		0.320***
		(0.095)
Schooling of G2	0.685***	0.401***
	(0.053)	(0.013)
Schooling (G2) × Chrt: 1945–1949	0.005	
	(0.077)	
Schooling (G2) × Chrt: 1950–1954	−0.109	
	(0.070)	
Schooling (G2) × Chrt: 1955–1959	−0.180***	
	(0.059)	
Schooling (G2) × Chrt: 1960–1964	−0.228***	
	(0.056)	
Schooling (G2) × Chrt: 1965–1969	−0.242***	
	(0.056)	
Schooling (G2) × Chrt: 1970–1974	−0.252***	
	(0.055)	
Schooling (G2) × Chrt: 1975–1979	−0.278***	
	(0.054)	
Schooling (G1) × Chrt: 1945–1949		0.009
		(0.113)
Schooling (G1) × Chrt: 1950–1954		−0.080
		(0.094)
Schooling (G1) × Chrt: 1955–1959		−0.168*
		(0.099)
Schooling (G1) × Chrt: 1960–1964		−0.223**
		(0.095)
Schooling (G1) × Chrt: 1965–1969		−0.234**
		(0.096)
Schooling (G1) × Chrt: 1970–1974		−0.231**
		(0.095)
Schooling (G1) × Chrt: 1975–1979		−0.252***
		(0.095)
Adjusted R^2	0.375	0.382
Observations	12 648	12 648
F-test on interactions	287.00	8.678

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by OLS, where the dependent variable is years of schooling of G3. The base group for birth cohorts is 1920–1944, the omitted variable. All coefficients are in deviations from this group. We control for main effects in all regressions. Column (1): Controls for a quadratic polynomial on age and a binary indicator for sex of G2 and G3. Column (2): Adds control for whether G1 is alive. Main effects and additional controls are omitted from the table for presentation purposes.
*$p < .10$.
**$p < .05$.
***$p < .01$.

One explanation for such change may be attributed to institutional rearrangements. In 1965, Chile implemented a compulsory schooling law that established mandatory attendance to primary school that, at the time, corresponded to eight years of schooling.[21] Oreopoulos and Page (2006), for the UK, and Nybom and Stuhler (2014), for Sweden, show that

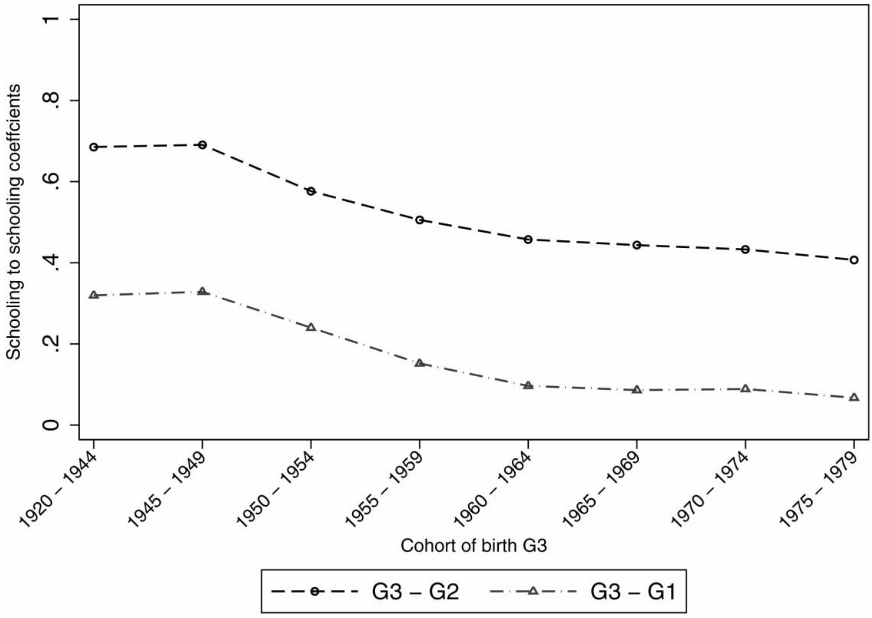

Figure 5. Trends in intergenerational schooling coefficients.
Note: This figure shows in the *y*-axis the coefficients between a regression of G3 years of schooling against G2 years of schooling (in circles), and against G1 years of schooling (in triangles), for each birth cohort in Table 3.

compulsory laws have a significant effect on the distribution of schooling for the affected generation. In particular, one may expect compulsory laws to increase the mean and shrink the variance of schooling for the affected cohort, as compared to the precedent cohort not affected by the law.

We show that this is the case for Chile using data from the 2002 Census. Figure 6 plots the mean and SD of years of education for each of the G2 cohorts in our sample. The figure illustrates that for birth cohorts that were potentially affected by the compulsory law, that is, those born after 1950, the mean shifts—slightly, and the SD decreases dramatically until 1961. This period coincides with the time of the acceleration in the downward trend shown in Figure 5, suggesting that the correlation of G3 education with G2 or G1 education decreases as compulsory laws reduce the dispersion of children's educational attainment. Hence, the data support that compulsory educational laws represent a driving mechanism for upward mobility.

3.3. Is it Location? Geographical Differences

Recent studies for other countries have shown that intergenerational mobility varies substantially across geographical areas.[22] For instance, Chetty et al. ("Is the United States Still a Land of Opportunity?" 2014, "Where is the Land of Opportunity?" 2014) find that, in the USA, more racially and income segregated areas as well as higher income inequality areas have lower levels of mobility, and that the quality of local school supply in the K-12 system is positively correlated with mobility. Regarding Chile, there is important geographical variation in terms of school quality, local labor markets, culture, economic activity, and income inequality (Agostini and Brown 2007). In the northern regions, the main economic activities are commerce and mining, while the economy in

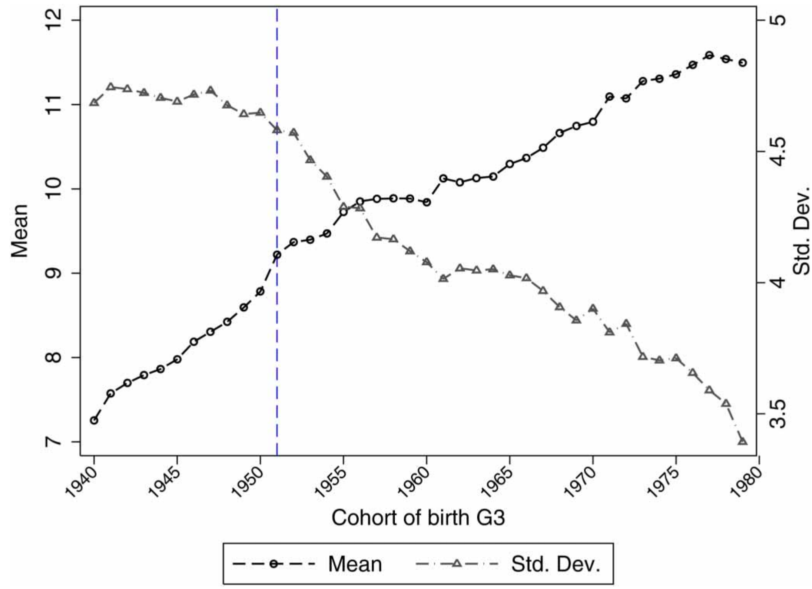

Figure 6. Mean and SD of years of schooling by cohort of birth of G3.
Notes: This figure shows in the left *y*-axis the average years of schooling and in the right *y*-axis the SD of years of schooling for cohorts born between 1940 and 1980. Numbers are computed using the Census of year 2002.

southern regions is concentrated in agriculture. In addition, households in northern regions have higher than national average household income, while the south has more impoverished households.[23] These facts motivate us to study how intergenerational educational mobility differs across the country.

Historically, Chile has been geographically divided into 13 different regions,[24] with the MR being the most populated followed by the 8th and 5th Regions. These three regions represent about 62% of the country's population, and their main cities are considered as the three great urban centers of Chile. Our data allow us to study changes in intergenerational mobility by grandparents' place of origin. Ideally, one would have the birthplace to test for differences by origin. Given that the survey we use lacks this information, we approximate grandparents' place of origin by the region in which G2 attended primary school. One important question remains: how much did regions differ when G2 was growing up? To address this issue, we do the following. The median birth cohort of parents is 1940. Hence, using the Chilean Census of 1960, we can study regional differences in different outcomes by the time the median G2 was 20 years old. In particular, for each region, we compute the percentage of people who attended less than primary school, the percentage of households without sewage and piped water, and the concentration of industries as reported by employed respondents in the Census. These are shown in Table A3. All in all, the patterns of regional differences explained above are similar to the ones in 1960.

In the following, we test for whether the coefficients found in Table 2 between G1 and G2, and the ones between G1 and G3, differ by the place where G2 attended primary school. We concentrate on differences from all regions with respect to the MR, that is, the capital. We hypothesize that the MR may have presented better economic opportunities at the time, and hence this comparison would help to test whether intergenerational patterns vary with local characteristics.

In particular, we construct a binary indicator for each region according to G2's primary school and interact each of these indicators with G1's education level. We regress the years of schooling of G2 against that of G1, its interaction with the regional indicators, main effects, and all of the controls included in our baseline results. The coefficient of each interaction shows the differences in the education correlations for those in G2 who attended primary school in these regions as opposed to the MR. We perform the same analysis using G3 schooling as the dependent variable.

The results are shown in Table 5. Each coefficient is in deviation from the MR, the omitted category.[25] The first column shows the differences across regions in schooling mobility between grandparents and parents (G1–G2). In the MR, an additional year of grandparents' education is associated with 0.63 additional years of schooling for the parents. The interactions show that the relation between grandparents' and parent's education is lower for 7 out of the remaining 12 regions. In particular, it shows significantly higher mobility in Regions 5 and 3 and lower mobility in Region 4 with respect to the MR. The cross-regional differences are jointly significant.

Grandparents may invest in their children thinking about the welfare of the grandchildren generation, among many other reasons. However, their direct influence in the success of grandchildren can be offset or complemented by parent's actions. We run Equation (2) to test for whether there are significant cross-regional differences in mobility between grandparents (G1) and their grandchildren (G3), using the region in where the parent (G2) went to primary school. Column (2) in Table 5 shows the results of estimating Equation (2) with the regional interactions. There still is significant geographical heterogeneity; however, there is a less consistent cross-regional pattern as the one shown previously.

The results in Table 5 mirror those in Figure 3 where we document higher educational mobility at the bottom of the schooling distribution. In fact, previous studies for Chile find that there is high mobility at the bottom and low mobility at the top of the distribution for different economic outcomes (see Torche 2005). Thus, we would expect to see higher mobility in regions outside the MR since those regions would have been the most disadvantaged for G1. The fading effect in upward mobility outside the MR, when we study mobility from G1 to G3, may be due to the fact that G2 sorted into different regions of the country, so locational differences for their offspring do not follow the same pattern.

The relation between intergenerational mobility and income inequality has started to be addressed in the literature, mainly due to the work by Corak (2013). He reports a high correlation between intergenerational elasticities of income and income inequality measured by the Gini coefficient using data from 13 developed countries. In addition, Chetty et al. ("Where is the Land of Opportunity?" 2014) construct measures of intergenerational elasticities in income and income inequality for all commuting zones in the USA to study geographical patterns of intergenerational mobility, finding a strong negative correlation between income inequality and upward mobility. We carry out a similar analysis here, applied to intergenerational educational mobility. Figure 7 exhibits, in the y-axis, the correlation between the region-specific mobility coefficients from Table 5 plotted against regional Gini coefficients, in the x-axis.[26] The first panel shows the relation between the Gini coefficient and the schooling coefficients for schooling of grandparents and parents (G1–G2), and between schooling of grandparents and years of schooling of their grandchildren (G1–G3). The second panel shows a similar analysis using the probability of attending higher education as the outcome for children.[27] Both panels show a positive relation between downward mobility (a higher coefficient) and inequality across regions in Chile.[28] This is more evident when we use the probability of attending higher education as the dependent variable.[29]

Table 5. Regional variations

Dep. var. is schooling of:	(1) G2	(2) G3
Schooling of G1	0.629***	0.105***
	(0.026)	(0.015)
Schooling (G1) × Region 1	−0.124	−0.217***
	(0.097)	(0.063)
Schooling (G1) × Region 2	−0.018	0.019
	(0.104)	(0.044)
Schooling (G1) × Region 3	−0.134	−0.007
	(0.082)	(0.053)
Schooling (G1) × Region 4	0.120*	−0.059*
	(0.062)	(0.033)
Schooling (G1) × Region 5	−0.074	−0.028
	(0.047)	(0.026)
Schooling (G1) × Region 6	−0.003	0.097***
	(0.070)	(0.034)
Schooling (G1) × Region 7	0.020	−0.041
	(0.071)	(0.029)
Schooling (G1) × Region 8	−0.051	0.057**
	(0.046)	(0.023)
Schooling (G1) × Region 9	−0.027	0.057**
	(0.072)	(0.029)
Schooling (G1) × Region 10	0.064	0.044
	(0.064)	(0.032)
Schooling (G1) × Region 11	0.146	0.327*
	(0.226)	(0.181)
Schooling (G1) × Region 12	0.184	−0.038
	(0.148)	(0.070)
Schooling (G1) × Region 13	−0.109	0.102***
	(0.174)	(0.033)
Adjusted R^2	0.475	0.383
Observations	4529	12 648
F-test of interactions	120.17	17.21

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by OLS where the dependent variable is years of schooling of G2 and years of schooling of G3, respectively. The base group for the regional interactions is the MR, the omitted variable. All coefficients are in deviations from this region. We control for main effects in all regressions. Column (1): Controls for a quadratic polynomial on age and a binary indicator for sex of G2 and G3. Column (2): Adds control for whether G1 is alive. Main effects and additional controls are omitted from the table for presentation purposes.
*$p < .10$.
**$p < .05$.
***$p < .01$.

We believe that these results are important in shedding light on how geographical differences matter for upward educational mobility. Differences in education may be driving cross-regional differences in inequality that could be explained by local institutions, characteristics of residents, local labor markets, or other factors. Tracking outcomes at local geographical levels is a first step to study, for instance, the importance of the design of decentralized policies in highly centralized countries, as is the case in most of Latin America.

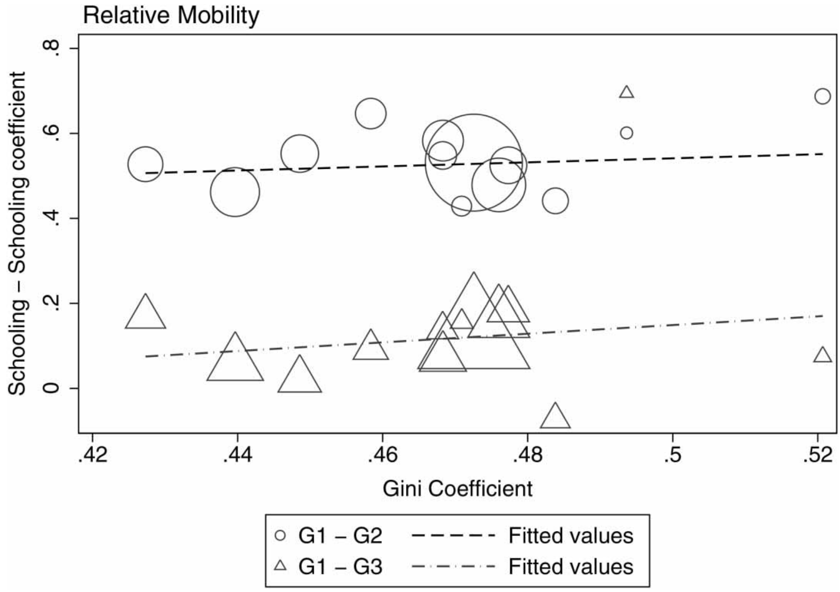

Figure 7. Correlation between Gini coefficient and intergenerational schooling coefficients for regions in Chile (Gatsby Curve).

Notes: The left panel plots in the *y*-axis the coefficients between a regression of G2 years of education against G1 years of education (in circles) and a regression between G3 years of schooling against G1 years of schooling (in triangles), for each region of the country against the median Gini coefficient, in the *x*-axis, of the region as shown in Agostini and Brown (2007). The right panel plots the similar figures but using the coefficients of a regression of G2 rate of higher education attendance against G1 years of education (in circles) and a regression between G3 rate of higher education attendance and G1 years of education (in triangles).

3.4. Does Sex Matter? Gender Differentials

Gender roles are related to social norms and cultural attitudes (Farré and Vella 2013; Moen, Erickson, and Dempster-McClain 1997), which may play a role in explaining schooling persistence. Children learn gender roles from their parents, and it may be the case that children mimic other family members such as grandparents. Two-generational mobility studies have found that parents and children of the same gender have stronger ties when measured by the intergenerational educational transmission compared to cross-gender relationships (Fernández, Folgi, and Olivetti 2004; Olivetti and Paserman 2013). In this section, we present novel evidence of the role of gender in explaining educational mobility across three generations.

The nature of our data allows us to study patrilineal and matrilineal lineages (Chan and Boliver 2013; Hertel and Groh-Samberg 2014), that is, lineages composed by paternal grandfathers, fathers, and sons, and maternal grandmothers, mothers, and daughters, respectively. Figure 8 describes such lineages. For instance, if the survey respondent was the father (mother) of the household, we have information on paternal (maternal) grandparents and children.[30] Therefore, we can take a finer step than in previous analyses and estimate gender-specific intergenerational coefficients.[31]

Tables 6 and 7 present the results for the patrilineal and matrilineal estimations, respectively. Columns (1) and (2) from Table 6 exhibit coefficients using the son's years of education as the dependent variable and father's and grandfather's education as explanatory variables. The first result is that an additional year of grandfather's education is significantly

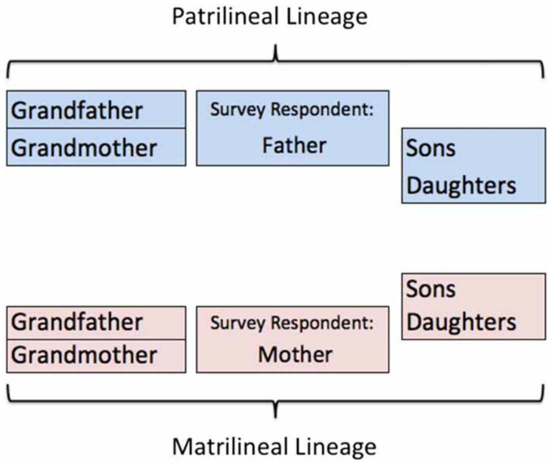

Figure 8. Gender structure of the data.

Table 6. Patrilineal schooling coefficients

Dep. var. is schooling of:	(1) Son	(2) Son	(3) Daughter	(4) Daughter
Father	0.436***	0.416***	0.402***	0.362***
	(0.020)	(0.022)	(0.020)	(0.021)
Paternal grandfather	0.09***	0.059**	0.085***	0.013
	(0.022)	(0.025)	(0.021)	(0.026)
Paternal grandmother		0.077**		0.159***
		(0.031)		(0.032)
Adjusted R^2	0.408	0.410	0.392	0.403
Observations	2577	2577	2414	2414

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by OLS and control for age and age squared of sons/daughters and fathers. From the 4529 respondents, 2395 are men 2134 are women. Following the patrilineal lineage, the male respondents report to have an offspring of 7029, divided in 3647 sons and 3382 daughters. The number of sons with complete information on their grandmother's and grandfather's schooling, parent education, and age is of 2577. The same number for the daughters is 2414.
*$p < .10$.
**$p < .05$.
***$p < .01$.

associated with 0.090 school years for the grandson after we take paternal education into account. When we include grandmother's education in column (2), the paternal grandfather's coefficient remains significant, but the grandparental effect appears to be divided in similar magnitudes between the two. The relation of grandmother's and grandfather's education to the grandson's education is statistically indistinguishable from each other.

Column (3) shows a similar result for granddaughters. An additional year of schooling for grandfathers is associated with 0.085 years of education for granddaughters. However, once we control for grandmother's education, the results show that the grandparental influence is due to only grandmothers. An additional year of grandmother's schooling is associated with 0.159 additional years of schooling for granddaughters, while the effect of grandfathers is not distinguishable from zero. This suggests that while both patrilineal

Table 7. Matrilineal schooling coefficients

Dep. var. is schooling of:	(1) Daughter	(2) Daughter	(3) Son	(4) Son
Mother	0.426***	0.413***	0.422***	0.395***
	(0.023)	(0.024)	(0.028)	(0.029)
Maternal grandmother	0.079***	0.053**	0.105***	0.042
	(0.028)	(0.026)	(0.031)	(0.036)
Maternal grandfather		0.047		0.102***
		(0.030)		(0.030)
Adjusted R^2	0.414	0.416	0.393	0.400
Observations	2033	2033	2033	2033

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by OLS and control for age and age squared of sons/daughters and parents. From the 4529 respondents, 2395 are men 2134 are women. Regarding the matrilineal lineage, the 2134 women report having 5698 children older than 23 years of age. Of them, 2827 are sons and 2871 are daughters. The number of them with complete information is 2333 for sons and daughters.
$^{*}p < .10$.
$^{**}p < .05$.
$^{***}p < .01$.

grandparents matter for the grandsons' education, granddaughters' years of schooling are mostly related to their grandmother's education.

An analogous analysis is carried out for matrilineal lineages in Table 7. Column (1) shows that an additional year of grandmother's education is associated with 0.079 years of granddaughter's education after we condition for the mother's education. This effect holds after we include the grandfather's education, which appears to be non-significant. Columns (3) and (4) replicate these analyses for sons. While there is a significant coefficient for grandmother's schooling on grandsons' education, it vanishes when we control for grandfathers.

These results suggest that grandsons benefit from both grandparents within the patrilineal lineage, while the maternal grandfather has the strongest influence for the matrilineal lineage. Meanwhile, the association between grandmother and granddaughters is significant for both lineages, but its magnitude is markedly higher within the patrilineal lineage.[32] That is, women born to low-educated grandmothers and high-educated grandfathers have lower education than granddaughters born to higher educated grandmothers and lower educated grandfathers. This evidence supports the notion that having more educated same-sex ancestors matters more for women and suggests that gender-related social roles may be passed along generations within families.

4. Concluding Remarks and Discussion

This paper contributes to a recent and increasing literature studying intergenerational mobility across multiple generations. It is one of the first to address long-run educational mobility for a developing country, complementing the new wave of American and European studies that go beyond two generations to understand the evolution of inequality. In particular, we present novel evidence on educational mobility patterns across three generations in Chile. We study intergenerational transmission of schooling by estimating standard reduced form equations for two and three generations. We first find that there is higher mobility at the bottom and lower mobility at the top of the schooling distribution of the precedent generation for both absolute and relative mobility measures. This holds for transitions from grandparents to parents and parents to children. We also find that absolute mobility increased across generations, that is, that individuals have consistently achieved higher levels of education compared to their ancestors. This can be a reflection of the rise in economic growth and mandatory schooling reforms experienced by Chile. Meanwhile, relative educational mobility has remained stable, which suggests that the schooling attainment ranking has not changed significantly from one generation to another.

An important result from this paper is the finding of persistence in education between grandparents and grandchildren even after conditioning for parental education. This result illustrates that, even in a context of high immobility, the transmission between grandparents and grandchildren is under-predicted by the standard simple extrapolation of a two-generational regression coefficient. This finding is consistent with the evidence found for developed countries (Lindahl et al. 2015).

We then extend this analysis aiming to get a better understanding on the different mechanisms through which human capital (im)mobility persists; in particular, we examine the relationship among educational mobility patterns and institutional changes, geographical differences, and gender differentials. Evidence shows that upward mobility in education has increased with younger cohorts, and that such changes may be attributable to compulsory schooling laws (as found by Oreopoulos and Page 2006 and Nybom and Stuhler 2014 for developed countries). Our results also suggest that there is important heterogeneity in mobility across regions in Chile, and that regional inequality and mobility are negatively correlated, consistent with what has been recently found for the USA, by Chetty et al. (“Is the United States Still a Land of Opportunity?” 2014, “Where is the Land of Opportunity?” 2014) and by Corak (2013) in a cross-country comparison. This result sheds light on the importance of parents’ place of origin in upward mobility. Finally, a gender lineage analysis indicates that while grandsons benefit from the education of both grandparents, grandmothers influence strongly granddaughters’ education levels. This suggests that gender-related models may be transmitted within the family even across generations, which is similar to recent findings by Olivetti, Paserman, and Salisbury (2014) for the USA.

A vast new literature is being developed to study correlations between multiple generations in different outcomes such as education, income, social class, and occupation. Our results contribute to this literature by presenting the first evidence for a Latin American country. We understand that surveys like the one we use in this paper are being implemented in other nations from the region. This will surely boost Latin American research on the topic in the near future. Our findings indicate that beyond nuclear family, family members like grandparents matter for educational mobility. Therefore, studying how grandparents influence their grandchildren can benefit the understanding of long-run mobility. Challenges for future work are clearly directed in understanding the role of grandparents and to pin down the causal channels of persistence. Still, the evidence so far indicates that family background effects can be longer lasting than previously believed, affecting the endowments and idiosyncratic capabilities of children. This needs to be taken into account by policies aimed at improving human development and reducing inequality.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. For instance, see the special issue on Inequality Across Multiple Generations (March 2014), based on a recent conference organized by the Panel Study of Income Dynamics in Michigan.
2. Some examples are Chan and Boliver (2013) on class mobility and Long and Ferrie (2013) on occupational mobility, for the UK; Olivetti, Paserman, and Salisbury (2014) on earnings mobility for the USA; Hertel and Groh-Samberg (2014) comparing class mobility between the USA and Germany; Clark (2014), who uses surnames to study social mobility among a group of eight countries, and Lindahl et al. (2014, 2015) and Havari and Savegnago (2013) on educational mobility for Sweden, and for a group of European countries, respectively.
3. There is extensive previous research documenting intergenerational mobility on educational attainment across different countries, contexts, and periods. Good examples are Bowles (1972), de Broucker and Underwood (1998), and Jæger (2007).
4. As a benchmark consider Hertz et al. (2007), which is a 50-year trends study across 42 countries that showed that 1 SD difference in parental education corresponded to a global average educational difference of 0.4 SDs in the subsequent generation.
5. Quoting Solon (2014), "… manifestations of family genetic traits can 'skip a generation' (which) is another way of opening up the possibility of a positive coefficient for grandparents' status."
6. The following waves use the same individuals with data updated in 2004, 2006, and 2009. We use data from 2002 since we would not gain any additional information from other waves and lose a substantial number of observations due to sample attrition. On a related note, the sampling frame may underrepresent lower income households, working women, and workers with informal jobs. However, as we detail in Appendix 2, our sample does not differ greatly in terms of average schooling attainment when compared to a nationally representative sample.
7. This is a standard procedure in the literature as carried out by Behrman, Gaviria, and Székely (2001) and Hertz et al. (2007). Moreover, evidence for Chile shows that schooling accumulation after 23 years old is very low (Núñez and Miranda 2011). This restriction excludes 10 955 individuals whose children could still be completing their schooling. See Appendix 2 for the full detail regarding the imposed sample restrictions.
8. This is an approximate year of birth for the grandparents' generation. The precise information is not available in the survey for all of G1 individuals.
9. Our sample is one in which the survival rate of the second generation is equal to 1 by construction—alive respondents—with a fraction of grandparents dead at the moment of the interview. Hence, the data do not allow us to study the influence of grandparents on grandchildren in the absence of parents. Similarly, the survival rate for those in the third generation is also equal to 1, because we are keeping respondents with at least one son/daughter over 23 years old.
10. As a check, we use the 1960 Chilean Census to compare the overall schooling distribution for individuals born in the same birth cohorts as the G1 sample. We find that our sample is very similar to the one in the Census 1960.
11. G1 schooling corresponds to the mean schooling of both grandfather and grandmother. If there is a missing value, we only consider the schooling of the non-missing ancestor. In all regression analyses, we control for a missing value indicator.
12. The MR contains the capital of the country, Santiago. By the time of the survey, 40% of the population lived in the MR.
13. That law was implemented much later around 2003 (Congreso Nacional de Chile 2003).
14. Probably, the returns from those additional four years of schooling were much higher than dropping out of school and entering the labor market. The assumption here is that labor market demand and supply forces were playing an important role on students' decision to continue and complete 12 years of schooling.
15. This is mainly due to the fact that we have very few grandparents with education above 12 years of schooling so that the estimates of the education mean for those years are much less precise.
16. The microeconomic model extended for three generations is derived in Appendix 3.
17. Consider $S_{it} = \beta_0 + \beta_1 S_{i,t-1} + \xi_{it}$. If we assume the exact same process for the past generation, then $S_{it-1} = \beta_0 + \beta_1 S_{i,t-2} + \xi_{it-1}$. Replacing the second in the latter, we get $S_{it} = \alpha_0 + \alpha_1 S_{i,t-2} + \varepsilon_{it}$, where $\alpha_0 = \beta_0 + \beta_1$, $\alpha_1 = \beta_1^2$ and $\varepsilon_{it} = \beta_1 \xi_{it-1} + \xi_{it}$.
18. We pool observations born between 1920 and 1944 due to sample size restrictions and use this cohort as our base group.
19. The F-test for the joint significance of the interaction terms is at the bottom of the table.
20. An analog analysis using relative measures of mobility finds the same results (see Figure A1).
21. In this same period, to attend the increase in demand as a result of the compulsory schooling law, there was an important expansion of government spending in school infrastructure, teacher training, and food provision in schools, among others. See Gobierno de Chile (1962) and Schiefelbein (1976) for references and anecdotal evidence.

22. See Corak (2013) for a cross-country variation.
23. See Contreras (2001) for an analysis of the evolution of poverty by Regions between 1990 and 1996. See Gobierno de Chile (2013) for Regional differences in poverty rates and average household income in year 2012.
24. Since 2007, the number increased to 15.
25. We group all observations using the former divisions, which consisted of 13 regions in total.
26. The different size of the regions is considered by the diameter of each circle or triangle. The biggest is the MR.
27. We run our regressions using the probability of having more than 12 years of schooling as the dependent variable. Higher education is an interesting variable to study since access to higher education is more related to family background given its higher costs, while earlier education may be more inclusive and may grow mechanically with local school supply expansion and compulsory schooling laws.
28. As a reminder, higher coefficients in the regressions are interpreted as lower mobility. Hence, the graphs are showing a positive relation between downward mobility and inequality.
29. We performed the same analysis using relative measures of mobility and the same results were found (see Figure A2).
30. From the 4529 respondents, 2395 are men and 2134 are women. Following the patrilineal lineage, the male respondents have 7029 children, 3647 sons and 3382 daughters. The number of sons with complete information on both their grandmother's and grandfather's schooling, parental education, and age is 2577. There are 2414 daughters with the same data. Regarding matrilineal lineage, the 2134 women report having 5698 children older than 23 years of age. Of them, 2827 are sons and 2871 are daughters. The number of them with complete information is 2333 for both sons and daughters—by chance the same number.
31. By restricting the sample to specific genders in G1, G2, and G3, our sample size diminishes markedly. Regrettably, this prevents us from performing lineages analysis by cohorts given the low number of observations available for the combination gender-generations-cohorts.
32. Results are similar when considering the relative measure of mobility as shown in Tables A3 and A4.
33. As pointed out by Stuhler (2012), Lindahl et al. (2014) and others, there are other ways to extend the underlying Becker–Tomes model.
34. Another point to rise is that the structural parameters from the model (as in the original Becker–Tomes model) are identified since we have three equations and five unknowns (δ, γ_0, γ_1, λ_1, λ_2). Fixing, say, δ and γ_0, we could "identify" the rest of the more relevant parameters γ_1, λ_1, and λ_2.

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Appendix 1.

Table A1. full models and IPW corrections

Dep. var. is schooling of:	(1) G2	(2) G3	(3) G3	(4) G3	(5) G2 (IPW)	(6) G3 (IPW)	(7) G3 (IPW)	(8) G3 (IPW)
Schooling of G2		0.462***		0.400***		0.464***		0.404***
		(0.010)		(0.013)		(0.010)		(0.013)
Schooling of G1	0.679***		0.388***	0.113***	0.670***		0.390***	0.113***
	(0.016)		(0.015)	(0.015)	(0.016)		(0.014)	(0.014)
Age of G2	−0.078	0.244***		0.237***	−0.005	0.250***		0.241***
	(0.052)	(0.045)		(0.044)	(0.049)	(0.044)		(0.043)
Age of G2 square	−0.000	−0.002***		−0.002***	−0.001	−0.002***		−0.002***
	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)
Sex of G2 (Male = 1)	0.434***	−0.353***	−0.039	−0.297***	0.346***	−0.369***	−0.118	−0.323***
	(0.119)	(0.094)	(0.109)	(0.093)	(0.119)	(0.092)	(0.106)	(0.091)
G1 still lives (=1)	0.326**		0.058	0.029	0.361**		0.026	−0.022
	(0.147)		(0.115)	(0.101)	(0.148)		(0.113)	(0.102)
Age of G3		0.026	0.075**	0.025		0.038	0.082**	0.035
		(0.033)	(0.032)	(0.032)		(0.032)	(0.033)	(0.031)
Age of G3 square		−0.001***	−0.002***	−0.001***		−0.001***	−0.002***	−0.001***
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Sex of G3 (Male = 1)		−0.138**	−0.061	−0.127**		−0.129**	−0.053	−0.118**
		(0.056)	(0.061)	(0.055)		(0.056)	(0.062)	(0.055)
Constant	9.354***	0.473	9.941***	0.673	7.165***	0.114	9.845***	0.483
	(1.602)	(1.265)	(0.608)	(1.244)	(1.517)	(1.186)	(0.606)	(1.190)
Observations	4529	12 648	12 648	12 648	4529	12 648	12 648	12 648
Adjusted R^2	0.423	0.369	0.234	0.378	0.409	0.372	0.233	0.381

Notes: Robust standard errors in parentheses clustered at the family level. G1: Mean schooling of the grandparent generation. G2: Schooling of the survey respondent. G3: Schooling of respondent's offspring. Column (1): OLS of G2 Schooling on G1 Schooling, and controls for a quadratic polynomial on age and a binary indicator of sex of G2 and a binary indicator for whether any grandparent is still alive. Each observation corresponds to a respondent in our sample. Column (2): OLS of G3 Schooling on G2 Schooling, and controls for a quadratic polynomial on age and a binary indicator of sex of G2 and a quadratic polynomial of age and a binary indicator of sex of G3. Each observation corresponds to a child of the respondent. Column (3): OLS of G3 Schooling on G2 and G1 Schooling, and controls for a quadratic polynomial on age and a binary indicator of sex of G2, a quadratic polynomial of age and a binary indicator of sex of G3, and a binary indicator for whether any grandparent is still alive.

*$p < .10$.

**$p < .05$.

***$p < .01$.

Table A2. Regional variations: full tables

Dep. var. is:	(1) Sch. G2	(2) H.Ed. G2	(3) Sch. G3	(4) H.Ed. G3
Schooling of G1	0.629***	0.032***	0.105***	0.011***
	(0.026)	(0.002)	(0.015)	(0.002)
Schooling (G1) × Region 1	−0.124	0.000	−0.217***	−0.005
	(0.097)	(0.010)	(0.063)	(0.007)
Schooling (G1) × Region 2	−0.018	−0.007	0.019	0.002
	(0.104)	(0.007)	(0.044)	(0.006)
Schooling (G1) × Region 3	−0.134	0.018	−0.007	−0.001
	(0.082)	(0.020)	(0.053)	(0.006)
Schooling (G1) × Region 4	0.120*	0.001	−0.059*	−0.004
	(0.062)	(0.006)	(0.033)	(0.004)
Schooling (G1) × Region 5	−0.074	−0.004	−0.028	−0.006*
	(0.047)	(0.004)	(0.026)	(0.003)
Schooling (G1) × Region 6	−0.003	−0.004	0.097***	0.003
	(0.070)	(0.007)	(0.034)	(0.004)
Schooling (G1) × Region 7	0.020	−0.002	−0.041	−0.004
	(0.071)	(0.006)	(0.029)	(0.004)
Schooling (G1) × Region 8	−0.051	−0.009**	0.057**	−0.002
	(0.046)	(0.004)	(0.023)	(0.003)
Schooling (G1) × Region 9	−0.027	−0.006	0.057**	0.000
	(0.072)	(0.005)	(0.029)	(0.004)
Schooling (G1) × Region 10	0.064	0.000	0.044	−0.006
	(0.064)	(0.006)	(0.032)	(0.004)
Schooling (G1) × Region 11	0.146	0.009	0.327*	0.022
	(0.226)	(0.019)	(0.181)	(0.022)
Schooling (G1) × Region 12	0.184	0.035	−0.038	0.017
	(0.148)	(0.025)	(0.070)	(0.017)
Schooling (G1) × Region 13	−0.109	−0.014	0.102***	0.002
	(0.174)	(0.009)	(0.033)	(0.005)
Age of G2	−0.133***	0.012**	0.229***	0.024***
	(0.050)	(0.006)	(0.029)	(0.004)
Age of G2 square	0.001	−0.000**	−0.001***	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Sex of G2 (Male = 1)	0.447***	0.002	−0.284***	−0.040***
	(0.115)	(0.011)	(0.058)	(0.007)
Region 1	1.275	−0.005	1.397***	0.028
	(0.792)	(0.088)	(0.368)	(0.049)
Region 2	0.703	0.063	0.403	0.046
	(0.612)	(0.054)	(0.328)	(0.046)
Region 3	0.218	−0.315*	0.257	0.015
	(0.538)	(0.187)	(0.383)	(0.045)
Region 4	−0.942***	−0.019	0.669***	0.076***
	(0.313)	(0.044)	(0.182)	(0.024)
Region 5	−0.067	−0.015	0.334**	0.052**
	(0.276)	(0.035)	(0.169)	(0.021)
Region 6	−0.672**	0.007	0.030	0.026
	(0.327)	(0.044)	(0.170)	(0.022)
Region 7	−0.627**	0.008	−0.042	0.003
	(0.303)	(0.035)	(0.154)	(0.021)
Region 8	−0.458*	0.027	−0.220	0.032*
	(0.259)	(0.033)	(0.137)	(0.017)
Region 9	−0.267	0.047	−0.082	0.000
	(0.306)	(0.034)	(0.157)	(0.021)
Region 10	−1.268***	−0.033	−0.601***	0.036

(*Continued*)

Table A2. Continued.

Dep. var. is:	(1) Sch. G2	(2) H.Ed. G2	(3) Sch. G3	(4) H.Ed. G3
	(0.270)	(0.039)	(0.174)	(0.022)
Region 11	−0.648	−0.129	−1.308	−0.007
	(1.029)	(0.079)	(0.800)	(0.088)
Region 12	0.059	−0.332	0.826	0.011
	(1.021)	(0.233)	(0.616)	(0.097)
Region 13	−4.788***	0.026	−0.380**	0.044*
	(0.334)	(0.056)	(0.151)	(0.024)
G1 still lives (=1)	0.312**	0.023*	0.039	0.017**
	(0.142)	(0.012)	(0.067)	(0.009)
Age of G3			0.025	−0.013***
			(0.025)	(0.003)
Age of G3 square			−0.001***	0.000**
			(0.000)	(0.000)
Sex of G3 (Male = 1)			−0.122**	−0.001
			(0.055)	(0.007)
Schooling of G2			0.391***	0.038***
			(0.008)	(0.001)
Constant	11.348***		0.931	
	(1.540)		(0.775)	
Adjusted R^2	0.475	0.232	0.383	0.276
Observations	4529	4529	12 648	12 648

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by OLS. Column (1) uses years of schooling of G2 as the dependent variable, column (2) uses a binary variable for whether G2 attended higher education or not, column (3) uses years of schooling of G3 as the dependent variable, and column (4) uses a binary variable for whether G3 attended higher education or not. Columns (2) and (4) report marginal effects of a probit model. The R^2 for these two columns corresponds to the pseudo-R^2 from the probit models.

*$p < .10$.

**$p < .05$.

***$p < .01$.

Table A3. Differences by region in census 1960

	Region of Chile												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	RM
Demographics													
% Less than primary Sch.	62.0%	60.1%	64.9%	79.2%	65.4%	79.7%	83.6%	77.7%	80.9%	82.8%	84.6%	64.8%	61.1%
% Not connected sewage	47.6%	41.5%	60.7%	72.3%	37.0%	75.3%	72.4%	69.2%	84.2%	82.1%	88.9%	47.8%	33.4%
% No piped water	43.5%	28.5%	54.2%	65.9%	29.7%	68.8%	63.3%	54.0%	72.4%	76.1%	66.3%	35.4%	18.7%
Industries													
Agriculture and others	12.6%	2.3%	20.1%	41.6%	22.7%	54.6%	58.5%	38.1%	55.7%	51.0%	41.6%	16.9%	9.3%
Mining	8.2%	35.8%	24.2%	6.1%	1.2%	5.8%	0.3%	5.7%	0.4%	0.2%	0.7%	8.6%	0.4%
Manufacturing	15.7%	10.1%	7.9%	9.7%	17.7%	7.8%	8.2%	15.5%	8.2%	11.6%	14.8%	13.8%	26.0%
Electricity, gas, and water	0.6%	0.9%	0.3%	0.5%	0.7%	0.7%	0.9%	0.6%	0.3%	0.7%	3.5%	0.3%	1.3%
Construction	8.4%	9.5%	12.0%	6.2%	7.4%	5.4%	5.0%	7.3%	4.4%	6.4%	2.8%	8.3%	8.6%
Wholesale and retail trade	13.4%	9.3%	7.6%	9.8%	11.4%	8.5%	6.9%	8.2%	6.9%	6.5%	7.8%	9.2%	14.9%
Hotels and restaurants	2.1%	2.0%	1.4%	1.7%	2.5%	1.3%	1.2%	1.3%	0.9%	0.7%	2.1%	3.4%	2.6%
Transportation and comm.	10.3%	10.6%	10.3%	6.1%	8.2%	2.7%	2.7%	4.6%	3.7%	5.2%	4.9%	5.2%	5.6%
Financial services	0.6%	0.7%	0.3%	0.5%	1.2%	0.6%	0.5%	0.5%	0.4%	0.9%	1.4%	0.3%	2.0%
Public administration	18.3%	5.1%	2.7%	2.2%	9.4%	2.0%	2.8%	4.5%	4.9%	3.1%	9.2%	21.2%	5.9%
Real estate	0.0%	0.2%	0.3%	0.5%	0.3%	0.1%	0.2%	0.3%	0.2%	0.2%	0.0%	0.0%	0.6%
Education	2.3%	4.2%	3.5%	3.6%	3.5%	1.9%	2.1%	2.5%	2.5%	2.1%	1.4%	2.0%	3.3%
Health and social work	1.0%	2.0%	0.8%	0.9%	2.6%	1.3%	2.0%	1.3%	1.1%	1.3%	0.7%	1.7%	3.6%
Other services	2.7%	2.8%	4.1%	2.4%	3.2%	1.8%	2.2%	2.1%	1.7%	2.1%	2.1%	2.9%	4.3%
Private household services	4.0%	4.5%	4.6%	8.2%	8.0%	5.6%	6.9%	7.5%	8.7%	8.1%	7.0%	6.3%	11.8%

Notes: All statistics are computed from the Chilean Census 1960 sample provided in IPUMS-International. The percentage of people with less than primary school is computed among those born between 1939 and 1941, which corresponds, to the median cohort of the parental generation in our sample. The percentage of households not connected to sewage system and the percentage of households not connected to pied water are computed at the household level using household weights provided by the Census. The percentage of people within industries is computed among all those observations that are employed. The industry codes correspond to International Industry Codes.

Table A4. Patrilineal schooling standardized coefficients

Dep. var. is schooling of:	(1) Son	(2) Son	(3) Daughter	(4) Daughter
Father	0.530***	0.505***	0.489***	0.440***
	(0.024)	(0.026)	(0.024)	(0.026)
Paternal grandfather	0.106***	0.070**	0.101***	0.015
	(0.026)	(0.030)	(0.025)	(0.031)
Paternal grandmother		0.076**		0.158***
		(0.031)		(0.032)
Adjusted R^2	0.408	0.410	0.392	0.403
Observations	2577	2577	2414	2414

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by OLS and control for age and age squared of sons/daughters and fathers. From the 4529 respondents, 2395 are men 2134 are women. Following the patrilineal lineage, the male respondents report to have an offspring of 7029, divided in 3647 sons and 3382 daughters. The number of sons with complete information on their grandmother's and grandfather's schooling, parent education, and age is of 2577. The same number for the daughters is 2414.
*$p < .10$.
**$p < .05$.
***$p < .01$.

Table A5. Matrilineal schooling standardized coefficients

Dep. var. is schooling of:	(1) Daughter	(2) Daughter	(3) Son	(4) Son
Mother	0.486***	0.470***	0.481***	0.450***
	(0.026)	(0.028)	(0.032)	(0.033)
Maternal grandmother	0.079***	0.063**	0.104***	0.042
	(0.028)	(0.031)	(0.031)	(0.036)
Maternal grandfather		0.046		0.121***
		(0.029)		(0.036)
Adjusted R^2	0.414	0.416	0.393	0.400
Observations	2033	2033	2033	2033

Notes: Robust standard errors in parentheses clustered at the family level. All regressions are estimated by OLS and control for age and age squared of sons/daughters and parents. From the 4529 respondents, 2395 are men 2134 are women. Regarding the matrilineal lineage, the 2134 women report having 5698 children older than 23 years of age. Of them, 2827 are sons and 2871 are daughters. The number of them with complete information is 2333 for sons and daughters.
*$p < .10$.
**$p < .05$.
***$p < .01$.

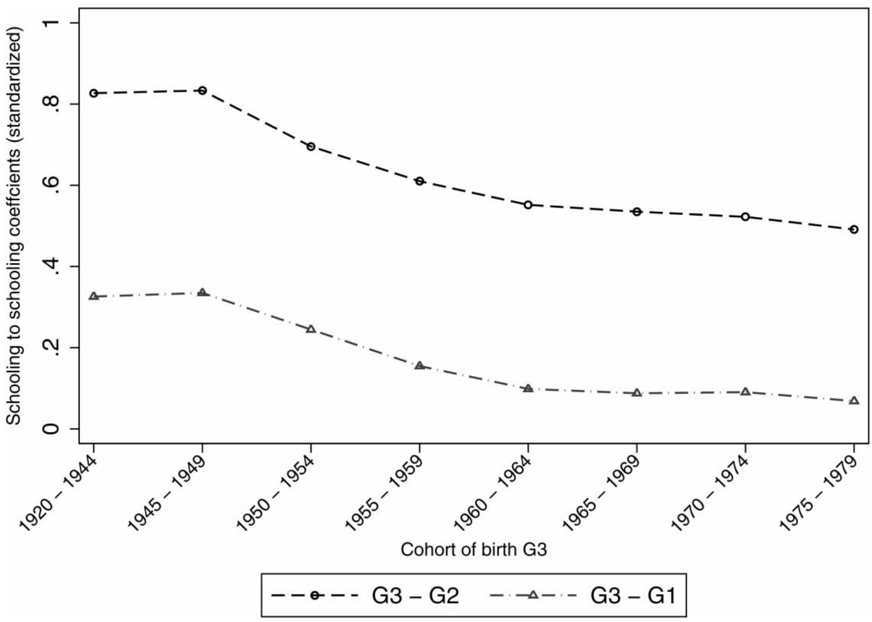

Figure A1. Trends in intergenerational standardized schooling coefficients.
Notes: This figure shows in the *y*-axis the coefficients between a regression of G3 standardized years of schooling against G2 standardized years of schooling (in circles), and against G1 standardized years of schooling (in triangles), for each birth cohort in Table 3.

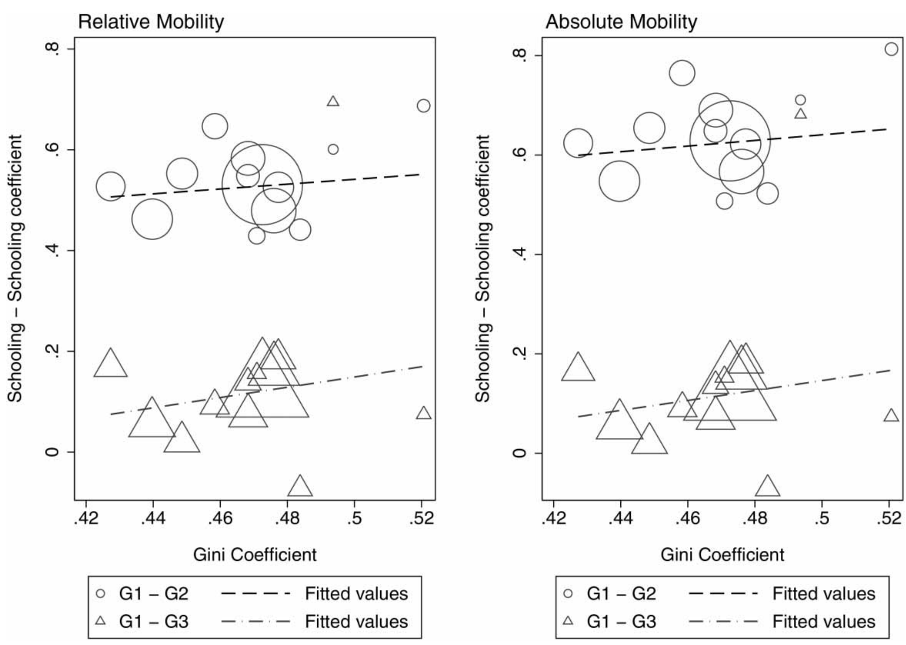

Figure A2. Correlation between Gini coefficient and Intergenerational standardized schooling coefficients for regions in Chile (Gatsby Curve).
Notes: The left panel plots in the *y*-axis the coefficients between a regression of G2 standardized years of schooling against G1 standardized years of schooling (in circles) and a regression between G3 standardized years of schooling against G1 standardized years of schooling (in triangles), for each region of the country against the median Gini coefficient, in the *x*-axis, of the region as shown in Agostini and Brown (2007). The right panel plots the similar figures but using the coefficients of a regression using years of schooling without standardization.

Appendix 2. Data sample restrictions

Data set sample restrictions: for the purpose of our analysis, we restrict the sample in different ways. The original sample consists of 17 246 individuals. We exclude those that are dead at the moment of the interview (937), and have no children that are 23 years old at the moment of the interview (10 955). This leaves 5354 “usable” primary sample members. In addition we have problems of missing data on the first generation (765), missing data on education (11), and age inconsistencies between generations 2 and 3. We drop 71 observations for which the difference in age between generations 2 and 3 is less than 14 years old. We attempt to control for the missing data problem or show robustness of our results by adjusting sampling weights by Inverse Probability Weighting (see Wooldridge 2007). Briefly, we run a probit model of a binary indicator that equals 1 if the information is missing and 0 otherwise on region of residence age and gender. We adjust the initial sampling weights by the predicted probability of this model. We report results with and without this adjustment in Table A1, which show little differences and provide us more confidence on the robustness of our findings.

An additional note on the data set is given by Bravo, Mukhopadhyay, and Todd (2010). As they describe, the sampling frame of the 2002 survey consists of individuals enrolled in the social security system for at least 1 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 next survey, 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. In their paper, Bravo, Mukhopadhyay, and Todd (2010) supplemented the 2002 survey with 2004 information. Regrettably, we cannot do the same for our purposes, given that the 2004 wave did not collect information on all of the respondent’s offspring education. Therefore, we stick with the 2002 information only.

On a concluding mark, the representativeness of our sample is of those affiliated to the pension system in year 2002 and with at least 1 child of 23 years old or more. To check how the lack of national representativeness was affecting the robustness of our results, we computed the schooling attainments for the 2004 LSPS sample. We found the fraction of individuals with higher education to be lower in the nationally representative sample, but differences were not huge (12% compared to 15% in our sample). In addition, we found the average years of schooling to be eight years of education, as in our 2002 sample.

Appendix 3. The extended economic model of intergenerational mobility

Existing theoretical models of intergenerational transmission of socioeconomic status have strong implications for the association of outcomes across multiple generations of a family. These models, however, do not encompass many plausible avenues for transmission across multiple generations. Solon (2014) extends existing models to encompass some of these avenues and draws out empirical implications for the multigenerational persistence of socioeconomic status.

We present theoretical intergenerational mobility model of schooling, which adds the possibility of grandparental contribution to the child education (building on Solon (2014), and Behrman and Taubman 1985, both in the spirit of Becker and Tomes 1979). The following four equations describe the basics of the model. Parents are budget constrainted, so they divide their income into consumption and investment in their child human capital (Equation (3)); there is a technology that transforms that investment into human capital (schooling) for the child (Equation (4)); an AR(2) process (hence, allowing grandparental contribution[33] beyond the contribution mediated through the parent) describes how endowments are related over time (Equation (5)); and human capital (schooling) translates into earnings in the labor market according to Equation (6).

$$y_{i,t-1} = C_{i,t-1} + I_{i,t-1}, \tag{3}$$

$$S_{i,t} = \theta \log(I_{i,t-1}) + e_{it}, \tag{4}$$

$$e_{it} = \delta + \lambda_1 e_{i,t-1} + \lambda_2 e_{i,t-2} + v_{it}, \tag{5}$$

$$\log(y_{i,t}) = \mu + pS_{i,t}. \tag{6}$$

Parents have an altruistic utility function depending on their own consumption, $C_{i,t-1}$ and their children's (expected life time) earnings. This variable, in turn, depends on the investment made by parents, $I_{i,t-1}$. Parents maximize utility over consumption and investment, subject to the budget constraint (Equation (3)).

$$\max_{C_{i,t-1},\ I_{i,t-1}} (1-\alpha)\log(C_{i,t-1}) + \alpha\log(y_{i,t}) \quad \text{s.t. (3)}.$$

Also, note that consider lagging Equation (6)

$$\log(y_{i,t-1}) = \mu + pS_{i,t-1}.$$

Therefore,

$$C_{i,t-1} = \exp(\mu + pS_{i,t-1}) - I_{i,t-1}.$$

Additionally, consider replacing Equation (4) in Equation (6),

$$\log(y_{i,t}) = \mu + p(\theta\log(I_{i,t-1}) + e_{it})$$

and denote $\gamma_1 = p\theta$ the elasticity of the child's income with respect to investment in the child's human capital,

$$\log(y_{i,t}) = \mu + \gamma_1\log(I_{i,t-1}) + pe_{it}.$$

So if parents are aware of Equations (4)–(6), the objective function can be re-written in terms of $I_{i,t-1}$ as

$$\max_{I_{i,t-1}}(1-\alpha)\log(\exp(\mu + pS_{i,t-1}) - I_{i,t-1}) + \alpha(\mu + \gamma_1\log(I_{i,t-1}) + pe_{it}) \quad \text{s.t. (3)}$$

with first order conditions given by

$$\frac{1-\alpha}{\exp(\mu + pS_{i,t-1}) - I_{i,t-1}} = \frac{\alpha\gamma_1}{I_{i,t-1}}.$$

Hence, the optimal investment in human capital is given by

$$I^*_{i,t-1} = \frac{\alpha\gamma_1}{\alpha(\gamma_1 - 1) + 1}\exp(\mu + pS_{i,t-1}).$$

Therefore, replacing in Equation (4), we get an equation relating the child's schooling with the parental schooling,

$$S_{i,t} = \theta\log(I^*_{i,t-1}) + e_{it},$$

$$S_{i,t} = \underbrace{\theta\left[\log\left(\frac{\alpha\gamma_1}{\alpha(\gamma_1+1) - 1}\right) + \mu\right]}_{=\gamma_0} + \gamma_1 S_{i,t-1} + e_{it},$$

$$S_{i,t} = \gamma_0 + \gamma_1 S_{i,t-1} + e_{it}.$$

Still, we need to incorporate the human capital endowment process information, e_{it}. Since we are allowing for grandparental contribution—beyond the parental one—we are going to get a reduced form that links the child's education with the grandparent schooling.

Let us lag the equation from last line in one and two periods, and pre-multiply them by λ_1 and λ_2, respectively,

$$S_{i,t} = \gamma_0 + \gamma_1 S_{i,t-1} + e_{it},$$

$$\lambda_1 S_{i,t-1} = \lambda_1 \gamma_0 + \lambda_1 \gamma_1 S_{i,t-2} + \lambda_1 e_{it-1},$$

$$\lambda_2 S_{i,t-2} = \lambda_2 \gamma_0 + \lambda_2 \gamma_1 S_{i,t-3} + \lambda_2 e_{it-2}.$$

Replacing these last two equations in Equation (5),

$$e_{it} = \delta + \lambda_1 S_{i,t-1} - \lambda_1 \gamma_0 - \lambda_1 \gamma_1 S_{i,t-2} + \lambda_2 S_{i,t-2} - \lambda_2 \gamma_0 - \lambda_2 \gamma_1 S_{i,t-3} + v_{it}.$$

Replacing the expression for e_{it} in the equation we just lagged, we get

$$S_{i,t} = \gamma_0 + \gamma_1 S_{i,t-1} + \delta + \lambda_1 S_{i,t-1} - \lambda_1 \gamma_0 - \lambda_1 \gamma_1 S_{i,t-2} + \lambda_2 S_{i,t-2} - \lambda_2 \gamma_0 - \lambda_2 \gamma_1 S_{i,t-3} + v_{it}.$$

Rearranging,

$$S_{i,t} = \underbrace{\delta + \gamma_0(1 - \lambda_1 - \lambda_2)}_{=\beta_0} + \underbrace{(\gamma_1 + \lambda_1)}_{=\beta_1} S_{i,t-1} + \underbrace{(\lambda_2 - \lambda_1 \gamma_1)}_{=\beta_2} S_{i,t-2} + \underbrace{v_{it} - \lambda_2 \gamma_1 S_{i,t-3}}_{=\xi_{it}}.$$

So, our reduced form equation looks like

$$S_{i,t} = \beta_0 + \beta_1 S_{i,t-1} + \beta_2 S_{i,t-2} + \xi_{it}. \tag{7}$$

Note that the coefficient for grandparental schooling may be positive because of the incorporation of a grandparental contribution to the child's genetic/cultural inheritance. In particular, the grandparental coefficient is positive if our structural parameters satisfy $\lambda_2 - \lambda_1 \gamma_1 > 0$. This would imply that grandparental contributions to genetic or cultural inheritance are important enough to more than compensate a parental "bad draw" endowment effect (Solon 2014).[34]