

The intergenerational persistence of human capital: an empirical analysis of four generations*

by

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Abstract

Most previous studies of intergenerational transmission of human capital are restricted to two generations – parents and their children. In this study we use a Swedish data set which enables us link individual measures of lifetime earnings for three generations and data on educational attainments of four generations. We investigate to what extent estimates based on income data from two generations accurately predicts earnings persistence beyond two generations. We also do a similar analysis for intergenerational persistence in educational attainments. We find two-generation studies to severely under-predict intergenerational persistence in earnings and educational attainment over three generations.

Keywords: Intergenerational income mobility, Human capital transmission, Multigenerational income mobility

JEL-codes: D31; J62

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1 Introduction

Most families maintain close connections with the grandparent generation and honour the memories of great-grandparents. Most individuals would also admit to strong influences and transmission of different resources beyond their parent generation. Yet, economic analysis of intergenerational links is almost exclusively concerned with the relation between the parent and child generations. Dynamic macroeconomic models of human and physical capital investments, fertility and inequality, as well as models of cultural transmission, focus on the link between two consecutive generations (Diamond, 1965, Becker, Murphy and Tamura, 1990, Galore and Zeira, 1993, Bisin and Verdier, 2000, Mulligan, 1997, and Saez-Marti and Sjögren, 2008). Moreover, empirical studies on intergenerational income mobility, as surveyed in Solon (1999) and Black and Devereux (2010), are with few exceptions restricted to two generations.¹ The Becker-Tomes model – the by far most important model for intergenerational transmission of human capital – relates financial and other resources of the parent generation to the outcome of the child generation.

The fact that generations beyond the parent generation influence individual outcomes has important implications for how we view income inequality at a given point in time, as well as for how we interpret intergenerational transmission of human capital. Income inequality in a mobile society is commonly regarded as more justifiable since an individual's relative economic position is to a larger extent linked to the individual's own choices and economic performance, rather than inheritance from previous generations. A frequently cited example, as in Borjas (2009), is based on an initial income difference of 20 percent between two families. If there is an intergenerational correlation of 0.3, we expect only 30 percent of this difference, or 6 percentage points, to remain in the second generation. In the third generation, the difference is almost entirely eliminated, since only 1.8 percent is expected to remain. However, this example relies critically on the assumption that the intergenerational transmission process of human capital has a memory of only one period. If this is not the case, income convergence will take longer.

Extensions of the empirical analysis of intergenerational transmission of human capital beyond two consecutive generations relate to at least two additional strands in the literature on equality of opportunity and socio-economic mobility across generations. First, as pointed out in Solon (1999) or Björklund et al. (2010), the “explained” variation in models based on

¹ Examples of some studies that focus on estimating the relationship between outcomes (education or occupation) for grandparents and grandchildren are Behrman and Taubman (1985), Maurin (2002), Sacerdote (2004, 2005), Sauder (2006) and Warren and Hauser (1997).

siblings correlations is in general much higher than in models based on intergenerational correlations (around 0.3 compared to around 0.1). A plausible interpretation of this difference is that siblings share more characteristics than just parents. The potential influence of grandparents – and great-grandparents – is obviously one of these characteristics in addition to the influence of neighborhoods during adolescence, schools, and other environmental factors that siblings in most cases share, which may affect their economic position as adults. Second, extension of the analysis of intergenerational transmission beyond two generations relates to a recent literature which, following Roemer (1993), aims to measure the degree of equality of opportunity; see e.g. Aaberge et al.,(2010) or Björklund et al. (2012). Generations beyond the parental generation constitute an obvious “circumstance” that may influence the economic position of the child generation in addition to the investment decisions and endowments of the parent generation, as suggested in the Becker-Tomes model.

In this paper, we investigate whether there are independent effects of the grandparent and the great-grandparent generation in the intergenerational transmission of human capital. Is the AR(1) process used in most studies on intergenerational income mobility sufficient to describe the income process across generations and to predict the income distribution for future generations? To answer this question, we use an exceptional data set containing measures of lifetime earnings for three consecutive generations and data on educational attainments for four generations. The data set is based on a survey of all third graders in Sweden’s third largest city, Malmö, and its suburbs, in 1938. This index generation has subsequently been followed until retirement and information on parents, spouses, children and grandchildren have been added. The first generation was, on average, born in the late nineteenth century and the fourth generation typically completed their education in the early twenty-first century. Altogether there are 901 complete families, i.e., families where education data are available on at least one individual in each of four consecutive generations.

The empirical analysis is carried out in two steps. First, we estimate AR(1) models using OLS to investigate whether or not the analysis based on data from two consecutive generations can predict the correlations between the incomes of the child and grandparent generations for lifetime income and between the child and the great-grandparent generations for educational attainments. We explore heterogeneity in the intergenerational links in different parts of the income and educational distribution using transition matrices. We conclude that grandparents and even great-grandparents influence child earnings and education more than predicted by the correlation between two consecutive generations. In fact, the earnings correlation across three generations is more than 70 percent larger than

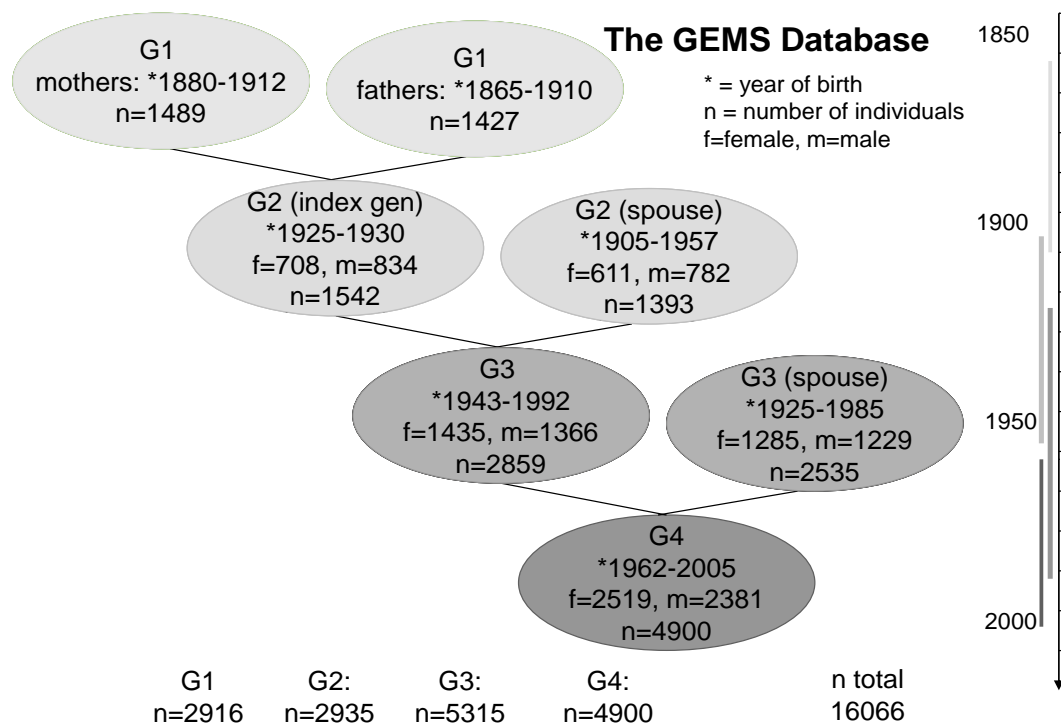
predicted by the consecutive two-generation earnings correlations and the correlation in educational attainments across four generations is almost three times larger than predicted from the three consecutive generation correlations.

The paper proceeds as follows. In Section 2 we introduce the data set, discuss the construction of variables and provide some descriptive statistics of the variables used in this study. In Section 3 we present descriptive estimations from associating outcomes of children with those of parents, grandparents (income and education) and great-grandparents (education). Section 4 concludes.

2 Data and descriptive statistics

Figure 1 shows a schematic overview of the data set consisting of information on individuals from four generations of the same family. The data set originally stems from the so called Malmö Study, a survey initiated in 1938 by a team of Swedish educational researchers.² All pupils attending third grade (normally at age 10) in any school in the Malmö metropolitan area (n=1,542) were part of the original survey and constitute the index generation, which is the second generation included in the data set. The original purpose was to analyze the correlation between social surroundings and cognitive ability. Hence, a host of family background information was collected, including parental earnings for several years and father's education. Over the years, the Malmö Study has been extended with information from both several rounds of follow-up surveys and register data. The last collection of data using questionnaires to the children initially sampled was conducted 55 years after the first survey, i.e., in 1993.³ By that time, most of the individuals had reached retirement age.

Figure 1: Schematic overview of the GEMS database.



² The material was originally collected by Siver Hallgren and developed by Torsten Husén.

³ In 1993, 38% of the third and fourth generations still lived in Malmö, an additional 31% lived elsewhere in the county of Skåne, which is where Malmö is situated, 8% lived in the county of Stockholm, and the rest were quite evenly spread out in the rest of Sweden.

We have extended the data in several ways. We have added parish-register information on date of birth and death of the parents of the index generation. These parents constitute the first generation and were born between 1865 and 1912. We have also added register information on the second generation's children and grandchildren, as well as information on the spouses of the index generation, i.e., the second parent of these children and of the grandchildren. The resulting data set consists of information on four generations of the same families. The average birth year of the first generation (G1) is 1898. The second generation (G2), i.e. the index generation, is on average born in 1928; the third generation (G3), the children of the index generation, in 1956; and, finally, the fourth generation (G4), the grandchildren of the index generation, in 1985.

In the Appendix we provide a short historical overview on Malmö and Sweden, focusing on the evolvement of institutions of likely importance to intergenerational mobility and the welfare state in Sweden during the relevant time period.

2.1 Data on educational attainment

The measure of educational attainments for the first generation was constructed by educational scientists and based on occupational classification of fathers from a survey in 1938. For the second to fourth generations, we have obtained data on educational attainments from the national education register. We mainly use data from 1985 for the second generation and from 2009 for the third and fourth generations. We transform the educational level measure for all generations into years of schooling based on the required number of years that has to be completed for each level.⁴ In order to avoid the problem that some children in the youngest generation may still have been in school at the time of data collection, we restrict the analysis of years of education to individuals who were at least 25 years of age in 2009, hence excluding those born after 1984.

So as to further increase the sample size for the analysis of education transmission, we construct a measure of whether or not an individual has completed an academic track in high school. This is a strong predictor of whether or not the individual continues on to higher

⁴ With detailed information on completed level of education, we construct years of schooling as follows: 7 for (old) primary school, 9 for (new) compulsory schooling, 9.5 for (old) post-primary school (*realskola*), 11 for short high school, 12 for long high school, 14 for short university, 15.5 for long university, and 19 for a PhD. For those few individuals in the second generation where registry information for 1985 is missing, we use survey information from 1964. The education information from 1964 is in 6 levels, and probably of lower quality than for 1985 or 2009. The conversion is done by imputing years of schooling by regressing the years of schooling variable in 1985 on indicators for 1964 using all individuals for whom educational information is available in both years. For individuals in the third generation with missing education data, we instead draw on registry information from 2005 and 1985.

education. We are then able to include children born until 1990. This increases the sample by about 35 percent.

2.2 Measures of lifetime earnings

Detailed earnings information allows us to construct measures of lifetime earnings for men in the first three generations. The fourth generation is not included in the analysis of earnings transmission since a large fraction of these individuals are too young to allow the construction of meaningful measures of lifetime earnings. Although the amount of earnings information differs across generations, available data from local and national tax registers cover the most important years of working life for all generations.

As regards the first generation, born on average in 1896, we have annual income information from local tax registers for the years 1929, 1933, 1937, 1938 and 1942. This implies that income is typically observed between ages 33 and 46. The income measure is the sum of capital and labor income.

The second generation, most of whom were born in 1928 (the original Malmö population) or around 1928 (the other parent of the Malmö children), is covered from age 20 by at least 15 observations of annual earnings. The first observations of labor earnings stem from 1948.⁵ From then on, there is information on earnings every third-fifth year until 1984. After 1984, we have annual observations of earnings.

As for the third generation, typically born in the mid-1950s, earnings data start in 1968. Like the second generation, information on earnings was collected every third-fifth year until 1984, after which there are annual observations.

We compute our earnings measure in two steps. First, using all earnings data available,⁶ we regress log-earnings on a cubic in birth year as well as year dummies, i.e.,⁷

$$\log(\text{earnings})_{it} = \alpha + \gamma_1 \text{birthyear}_i + \gamma_2 \text{birthyear}_i^2 + \gamma_3 \text{birthyear}_i^3 + \text{year}_t + \varepsilon_{it}. \quad (1)$$

⁵ Prior to 1968, information on earnings is from local tax registers. As of 1968, the earnings data are from national registers. For individuals in the second generation who were not part of the original sample, i.e. the other parent of the third generation individuals, we have earnings information from 1948 if they cohabited with the Malmö-parent and from 1968 if they did not.

⁶ We include all years for which we observe positive earnings, but exclude the observations when the individual was very young: 19 years of age for the first generation, 23 for the second and 27 for the third.

⁷ This is the approach taken in e.g. Haider and Solon (2006) and Böhlmark and Lindquist (2006). Life-cycle bias should hence not be an issue here, as we have access to reasonable lifetime income measures for both parents and children. See also Lee and Solon (2009).

Second, we obtain the residual for each individual-year cell it , and then compute the mean residual for each individual, i.e., the stable part of individual earnings, which is used as a measure of lifetime earnings.

2.3 Descriptive statistics

We have information on educational attainments for 901 complete families, i.e., with data available on at least one individual in each generation, for four consecutive generations.⁸ For earnings, there are 730 families with earnings information available for one male member of the family in three consecutive generations. The main reason for attrition of families is that the individual has no children. There are, however, some individuals with missing information on earnings and/or education. Since earnings data are less informative for women in the earlier years, we restrict the analysis of earnings associations to sons, fathers and grandfathers. Note that for roughly half of the earnings sample, the male family member in the second generation (the father) is not the biological son of the male member of the family in the first generation (the grandfather), but is instead the son-in-law. This almost doubles the earnings sample.⁹

Table 1 reports descriptive statistics by generation and gender for the samples used in this study. We show statistics corresponding to the individuals in our estimation sample for education (four generations separated by gender) and earnings (three generations of men). The first column shows means and standard deviations for the fathers of the children in the index generation (generation 2). These 905 fathers were on average born in 1896 and had 7.3 years of schooling. The next two columns show descriptive statistics for those in the index generation (first interviewed in 1938 and typically born in 1928) as well as mothers and fathers of the children in the third generation. For this second generation, typically born in 1928, there are 470 men who acquired 10.2 years of schooling and 435 women who acquired 9.5 years, on average.¹⁰

The earnings figures for men in the second and third generations pertain to sons and grandsons of the first generation of men as well as the male spouse of the daughters and granddaughters belonging to the index and the next generations. Hence, the dispersion in the

⁸ We have 901 complete families with four generations when we include fourth generation children born until 1990. For this sample, the education measure used for the fourth generation is academic high-school track. In order to obtain a meaningful measure of years of education for the fourth generation, we restrict the analysis to children born before 1986, resulting in 673 complete families.

⁹ As a check, we also estimated transmission coefficients for education using these sample restrictions. The estimates are then very similar to those using only individuals who are biologically related across the four generations (which are the estimates reported in Table 2).

¹⁰ On average, earnings increased from about SEK 86,000 (calculated in 1933) for the men in the first generation to SEK 311,000 (in 2000) for the men in the third generation, all expressed in 2010 prices.

year-of-birth variable is much higher for the men in the index generation. The last two columns show descriptive statistics for the descendants of the three earlier generations who are old enough to be included in the regressions: 27 years in 2008 for earnings regressions; 25 years in 2009 for education estimations; and, finally, 19 years for the academic high-school track regressions. The average residual of log earnings, with means and standard deviations reported in the third row, summarizes the earnings measure actually used in estimations.¹¹

¹¹ These numbers are based on averages across years and are negative because those with fewer years of earnings data have lower earnings.

Table 1: Descriptive statistics

| Variable | Generation 1 (great-grandparents) | | Generation 2 (grandparents) | | Generation 3 (parents) | | Generation 4 (children) | |
|------------------------------------|--------------------------------------|----------------------------------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|----------------------------------|--|
| | Great-grandfather (1) | Grandmother (3) | Grandfather (4) | Mother (5) | Father (6) | Daughter (7) | Son (8) | |
| Years of schooling | 7.30 (1.60) [5.14] | 9.53 (2.67) [7.19] | 10.15 (2.96) [7.20] | 12.05 (2.47) [7.20] | 12.11 (2.59) [7.20] | 12.95 (1.98) [7.20] | 12.42 (2.13) [7.20] | |
| Academic high-school track | | | | | | 0.55 (0.50) [0.1] | 0.44 (0.50) [0.1] | |
| Average residual log earnings | -0.047 (0.529) [-1.74,2.76] | | -0.018 (0.637) [-2.71,2.26] | | -0.121 (0.763) [-4.11,1.90] | | | |
| Year of birth (Education) | 1896.12 (7.20) [1859,1910] | 1927.91 (0.40) [1925,1930] | 1927.87 (0.40) [1926,1929] | 1954.67 (4.90) [1944,1970] | 1954.53 (4.46) [1943,1969] | 1981.45 (6.30) [1962,1990] | 1981.49 (6.35) [1962,1990] | |
| Year of birth (Earnings) | 1895.70 (7.48) [1865,1910] | | 1926.73 (3.27) [1888,1947] | | 1956.69 (5.54) [1943,1981] | | | |
| Number of observations (Education) | 905 | 435 | 470 | 831 | 722 | 1,451 | 1,548 | |
| Number of observations (Earnings) | 803 | | 1,174 | | 1,174 | | | |

Notes: The first figure in each cell is the mean of the variable. The figure in parenthesis is the standard deviation and the figures in square brackets are minimum and maximum values, respectively. The education statistics are calculated for the observations used in Table 2 (column 1) and Table 3 (columns 1-2) and the earnings statistics are calculated for the observations used in Table 5. The statistics for year of schooling for generation 4 are calculated for those born before 1985 (887 daughters and 936 sons)

3 Results: Intergenerational persistence in educational attainments and earnings

3.1 Intergenerational persistence in educational attainments

The first set of results, the estimated transmission coefficients for education across the four generations under study, are shown in Table 2. All estimates are results from the bivariate regression model

$$y_t = a + by_{t-j} + u_t, \quad (2)$$

where $j \geq 1$, y_t is the outcome of the child and y_{t-j} is outcome of the parent ($j=1$), grandparent ($j=2$) or great-grandparent ($j=3$). Since many members of the last generation had not yet completed their education at the date of data collection, we use completion of an academic track in secondary school as a proxy for educational aspiration. The last row in Table 2 reports linear probability model estimates of the relation between the probability of having completed an academic high-school track and earlier generations' educational attainments measured in years of education. The estimates (standard errors) are outcomes from regressions using unstandardized variables. We report standardized estimates in brackets.

Table 2 reveals two interesting results. First, there is a statistically significant estimate for the association between great-grandfather's educational attainment and that of great-grandchildren. This result shows that there is a persistent correlation despite the fact that there are two generations, or on average 75 years, between the births of these generations. Second, the association between educational outcomes of the great-grandparent generation and the child generation, as well as between the great-grandparent generation and the parent generation is stronger than what would be expected if we were to predict these correlations based on the correlation between the adjacent generations involved.

The second result is easily obtained by multiplying the diagonal elements in Table 2. For example, multiplying the coefficient estimate between the first and second generations, 0.607, by that between the second and third, 0.281, yields a prediction for the association between the first and third generations of 0.171. By applying the delta method we obtain approximate

bounds for the standard error of this prediction of between 0.023 and 0.033.¹² These approximate bounds enable us to formally test and reject that the prediction obtained is equal to the coefficient between the first and the third generation, which was estimated to be 0.375.

Table 2: Matrix of estimated transmission coefficients across generations: Education

| | Years of Schooling – great grandparent (1) | Years of Schooling – grandparent (2) | Years of Schooling – parent (3) |
|----------------------------------|--|--|--|
| Years of Schooling – grandparent | 0.607*** (0.065) [0.334] N=905 | | |
| Years of Schooling – parent | 0.375*** (0.043) [0.229] N=1553 | 0.281*** (0.024) [0.312] N=1553 | |
| Years of Schooling – child | 0.145*** (0.046) [0.123] N=1823 | 0.131*** (0.023) [0.202] N=1823 | 0.296*** (0.021) [0.412] N=1823 |
| Academic HS track (=1) – child | 0.032*** (0.007) [0.104] N=2999 | 0.028*** (0.004) [0.163] N=2999 | 0.066*** (0.004) [0.343] N=2999 |

Notes: Each reported estimate is from a separate regression of the education of members of one generation on the education of members of an older generation. All regressions control for a quadratic in the birth year of the member of both generations. The reported standard errors (in parentheses) are clustered on families. Standardized estimates are reported in brackets.

Table 3 reports the results from estimations of the intergenerational transmission coefficients separately by gender of offspring and ancestor. The most striking feature of these estimates is that the intergenerational correlation in educational attainments seems to be independent of the gender of both ancestor and offspring. For example, the correlation between the first and third generations is almost the same for males and females in the third generation.

¹²The approximation of the variance for the product of β_1 and β_2 , where β_1 is the estimate between generation one and two and β_2 is the estimate between generation two and three, is $\beta_2^2 \sigma_{\beta_1}^2 + \beta_1^2 \sigma_{\beta_2}^2 + 2\beta_1\beta_2\sigma_{\beta_1\beta_2}$. Since we are not able to estimate the covariance term $\sigma_{\beta_1\beta_2}$, we instead use the estimates of σ_{β_1} , σ_{β_2} and the fact that the maximum correlation coefficient value is 1 to obtain an upper bound for $\sigma_{\beta_1\beta_2}$. The lower bound $\sigma_{\beta_1\beta_2}$ is set to 0.

Table 3: Matrix of estimated transmission coefficients across generations: Years of education

| | Great-grandfather | Grandmother | Grandfather | Mother | Father |
|----------------------------------|--|---|---|---|---|
| Years of Schooling – grandmother | 0.565*** (0.076) [0.311] N=435 | | | | |
| Years of Schooling – grandfather | 0.661*** (0.118) [0.364] N=470 | | | | |
| Years of Schooling – mother | 0.344*** (0.049) [0.210] N=831 | 0.287*** (0.047) [0.319] N=415 | 0.273*** (0.039) [0.303] N=416 | | |
| Years of Schooling – father | 0.409*** (0.060) [0.250] N=722 | 0.322*** (0.057) [0.357] N=335 | 0.249*** (0.048) [0.277] N=387 | | |
| Years of Schooling – daughter | 0.159*** (0.062) [0.135] N=887 | 0.135*** (0.043) [0.208] N=461 | 0.117*** (0.040) [0.181] N=426 | 0.305*** (0.039) [0.425] N=556 | 0.228*** (0.041) [0.318] N=331 |
| Years of Schooling – son | 0.133** (0.052) [0.113] N=936 | 0.118*** (0.041) [0.183] N=483 | 0.146*** (0.042) [0.226] N=453 | 0.306*** (0.042) [0.426] N=521 | 0.328*** (0.035) [0.458] N=886 |
| Academic HS track – daughter | 0.035*** (0.009) [0.112] N=1451 | 0.022*** (0.008) [0.129] N=713 | 0.030*** (0.007) [0.172] N=738 | 0.069*** (0.007) [0.358] N=815 | 0.055*** (0.008) [0.289] N=636 |
| Academic HS track – son | 0.029*** (0.010) [0.093] N=1548 | 0.030*** (0.008) [0.176] N=747 | 0.028*** (0.007) [0.160] N=801 | 0.066*** (0.007) [0.343] N=829 | 0.071*** (0.006) [0.368] N=719 |

Notes: Each reported estimate is from a separate regression of the education of members of one generation on the education of members of an older generation. All regressions control for a quadratic in the birth year of the member of both generations. The reported standard errors (in parentheses) are clustered on families. Standardized estimates are reported in brackets.

Changes in education distributions, changes in the meaning of a particular number of years of education over time and possible non-linearities in the transmission process are not fully captured in the linearly estimated transmission coefficients. We therefore compute intergenerational transmission probabilities across education categories and corresponding odds ratios. The results are reported in Table 4a-4d. For each generation we define four levels of education, from compulsory to university education.

Transition probabilities and odds ratios confirm the main result from Table 2, namely that there is substantial persistence across generations in the education level attained. In particular, Table 4c shows that there is a higher probability that an individual has university education if the ancestor, three generations before had education above the compulsory level at the time. In addition, these transition probabilities indicate a presence of non-linearities: there is higher persistence in the upper end of the education distribution. Those with more than compulsory education in the first generation are on average between 49 and 67 percent more likely, compared to random assignment, to have university educated great-grandchildren, whereas those with only compulsory schooling are only 3 percent more likely than random assignment to have great grandchildren with compulsory schooling.

Table 4a: Education of children (generation 2) conditional on education of parents (generation 1), transition probabilities and odds ratios

| Education of parents (generation 1) | | Education of children (generation 2) | | | | All |
|--------------------------------------|-------------------|--------------------------------------|---------------------------------------|-------------|------------|-----------|
| | | Compulsory | Post compulsory : short or vocational | High school | University | Pi. Obsi. |
| Compulsory | P_{1j} | 0.50 | 0.32 | 0.14 | 0.04 | 0.85 |
| | $P_{1j}/P_{.j}$ | 1.12 | 1.01 | 0.86 | 0.54 | 765 |
| Post compulsory: Some vocational | P_{2j} | 0.23 | 0.31 | 0.31 | 0.16 | 0.08 |
| | $P_{2j}/P_{.j}$ | 0.50 | 0.99 | 1.85 | 2.19 | 75 |
| Post compulsory: Academic (short) | P_{3j} | 0.08 | 0.32 | 0.30 | 0.30 | 0.04 |
| | $P_{3j}/P_{.j}$ | 0.18 | 1.04 | 1.79 | 4.08 | 37 |
| High school/ University | P_{4j} | 0.11 | 0.18 | 0.25 | 0.46 | 0.03 |
| | $P_{4j}/P_{.j}$ | 0.24 | 0.58 | 1.51 | 6.37 | 28 |
| All | $P_{.j}$ | 0.45 | 0.31 | 0.17 | 0.07 | |
| | Obs. _j | 408 | 281 | 150 | 66 | 905 |

Notes: Education generation 1: compulsory max 8 years, post-compulsory: vocational 9 years, post-compulsory: academic (*Realskola*) 10 years, high school or university: min 12 years

Education generation 2: compulsory max 9 years, post-compulsory: short academic or vocational high-school track (*Realskola* or short high-school track) 10-11 years, academic high-school track 12-14 years, university: min 15 years.

Table 4b: Education of grandchildren (generation 3) conditional on education of grandparents (generation 1), transition probabilities and odds ratios

| Education of grandparents (generation 1) | | Education of grandchildren (generation 3) | | | | All |
|--|---------------------------------|---|---------------------------------------|-------------|------------|---------------------------------|
| | | Compulsory | Post compulsory : short or vocational | High school | University | P _i Obs _i |
| Compulsory | P _{1j} | 0.20 | 0.40 | 0.26 | 0.15 | 0.85 |
| | P _{1j} /P _j | 1.08 | 1.09 | 0.98 | 0.79 | 1317 |
| Post compulsory: Some vocational | P _{2j} | 0.13 | 0.23 | 0.30 | 0.34 | 0.08 |
| | P _{2j} /P _j | 0.69 | 0.64 | 1.11 | 1.84 | 128 |
| Post compulsory: Academic (short) | P _{3j} | 0.10 | 0.15 | 0.33 | 0.42 | 0.04 |
| | P _{3j} /P _j | 0.55 | 0.41 | 1.24 | 2.23 | 60 |
| High school/ University | P _{4j} | 0.02 | 0.13 | 0.29 | 0.56 | 0.03 |
| | P _{4j} /P _j | 0.12 | 0.34 | 1.09 | 3.01 | 48 |
| All | P _j | 0.18 | 0.37 | 0.27 | 0.19 | |
| | Obs _j | 280 | 567 | 416 | 290 | 1553 |

Notes: Education generation 1: compulsory max 8 years, post-compulsory: vocational 9 years, post-compulsory: theoretical (*Realskola*) 10 years, high school or university: min 12 years.

Education generation 3: compulsory max 9 years, post-compulsory: short academic or vocational high-school track (*Realskola* or short high-school) 10-11 years, academic high-school track, 12-14 years, university: min 15 years.

Table 4c: Education of great-grandchildren (generation 4) conditional on education of great-grandparents (generation 1), transition probabilities and odds ratios. (families with 4th generation born before 1985)

| Education of great-grandparents (generation 1) | | Education of great-grandchildren (generation 4) | | | | All |
|--|---------------------------------|---|--|-------------|------------|---------------------------------|
| | | Compulsory | Post compulsory : short or vocational. | High school | University | P _i Obs _i |
| Compulsory | P _{1j} | 0.10 | 0.16 | 0.50 | 0.24 | 0.89 |
| | P _{1j} /P _j | 1.03 | 1.05 | 1.01 | 0.93 | 1620 |
| Post compulsory: Some vocational | P _{2j} | 0.09 | 0.07 | 0.46 | 0.38 | 0.07 |
| | P _{2j} /P _j | 0.93 | 0.43 | 0.94 | 1.49 | 121 |
| Post compulsory: Academic (short) | P _{3j} | 0.04 | 0.13 | 0.40 | 0.43 | 0.03 |
| | P _{3j} /P _j | 0.43 | 0.82 | 0.82 | 1.67 | 47 |
| High school/ University | P _{4j} | 0.06 | 0.11 | 0.43 | 0.40 | 0.02 |
| | P _{4j} /P _j | 0.58 | 0.74 | 0.87 | 1.57 | 35 |
| All | P _j | 0.10 | 0.16 | 0.49 | 0.25 | |
| | Obs _j | 179 | 283 | 897 | 464 | 1823 |

Notes: Education generation 1: compulsory max 8 years, post-compulsory: vocational 9 years, post-compulsory: academic (*Realskola*) 10 years, high school or university: min 12 years.

Education generation 4: compulsory max 9 years, post-compulsory: short academic or vocational high-school track (*Realskola* or short high-school) 10-11 years, Academic high-school track 12-14 years, university: min 15 years.

Table 4d: Education of great-grandchildren (generation 4) conditional on education of great-grandparents (generation 1), transition probabilities and odds ratios. (families with 4th generation born before 1990)

| Education of great-grandparents (generation 1) | Education of great-grandchildren (generation 4) | | | All |
|--|---|--|----------------------------|-----------------------------|
| | | Compulsory or vocational high-school track | Academic high-school track | P_i , Obs _i |
| Compulsory | P_{1j} | 0.53 | 0.47 | 0.86 |
| | P_{1j}/P_j | 1.04 | 0.95 | 2567 |
| Post compulsory: Some vocational | P_{2j} | 0.40 | 0.60 | 0.08 |
| | P_{2j}/P_j | 0.79 | 1.22 | 238 |
| Post compulsory: Theoretical (short) | P_{3j} | 0.38 | 0.62 | 0.04 |
| | P_{3j}/P_j | 0.75 | 1.26 | 111 |
| High school/ University | P_{4j} | 0.29 | 0.71 | 0.03 |
| | P_{4j}/P_j | 0.57 | 1.44 | 83 |
| All | P_j | 0.51 | 0.49 | |
| | Obs _j | 1521 | 1478 | 2999 |
| | | 0.53 | 0.47 | 0.86 |

Notes: Education generation 1: compulsory max 8 years, post-compulsory: vocational 9 years, post-compulsory: theoretical (*Realskola*) 10 years, high school or university: min 12 years

Education generation 4: Compulsory or vocational high-school track, academic track measured at earliest age 19

3.2 Intergenerational persistence in earnings

Table 5 shows the estimates of intergenerational earnings mobility between the first and second generations, the second and third generations as well as between the first and third generations, respectively. Although Swedish society has undergone extensive and important changes in different dimensions between the most active period of the first generation born around 1900 and the third generation mostly born in the 1950s and 1960s, the elasticities in earnings between consecutive generations seem to be quite stable: 0.356 between the first and second generations and 0.303 between the second and third. The latter elasticity is only slightly larger compared to estimates in previous studies for Sweden for children born in similar years (see e.g. Björklund, Lindahl and Plug, 2006).

The results in Table 5 allow us to predict the earnings mobility between the first and third generations from the two two-generation mobility measures. This gives us a prediction of 0.108, which is substantially lower than the estimate of 0.184 obtained from data. Again applying the bounding exercise for the delta method (as explained in footnote 12) gives an estimate of the standard error ranging from 0.020 to 0.027. A *t*-test of equality between the predicted and the estimated three-generation mobility

measure gives a t -statistic between 1.47 and 1.58, i.e., indicating a marginally significant difference.

Table 5: Matrix of estimated transition coefficients across generations: log earnings of male offspring regressed on log earnings of male ancestor

| Offspring | Grandparent Generation 2 | Ancestor | Parent Generation 3 |
|--|--|----------|--|
| Log(Earnings) – parent Generation 3 | 0.356*** (0.040) [0.307] N=803 | | |
| Log(Earnings) – child Generation 4 | 0.184*** (0.044) [0.141] N=1174 | | 0.303*** (0.043) [0.268] N=1174 |

Notes: Each reported estimate is from a separate regression of the son's residual log earnings on residual log earnings of the ancestor. The earnings measures are average residual log-earnings from a regression of log earnings on a cubic in birth year and year dummies (see section 2). The reported standard errors (in parentheses) are clustered on families. Standardized estimates are reported in brackets.

As in the case of education, it is interesting to explore a presence of non-linearities in the transmission of earnings across generations. We examine this by means of transition matrices. Table 6 shows transition matrices for income quintiles across generations. The first panel reports the transition probabilities between the first and second generations; the second panel the corresponding figures for the second and third generations; finally, the third panel shows the transitions between the first and third generations.

There is one result of particular interest revealed in Table 6. The persistence across two consecutive generations is higher at the higher end of the income distribution. The highest persistence in all of three panels is found for the fifth quintile, i.e. the top 20 percent of the earnings distribution. As many as 34 percent of the grandchildren of those in the fifth quintile remain at the very top of the income distribution. Interestingly, the persistence in this cell is almost as high when we compare grandfathers and grandsons (first and third generations) as when the grandsons are instead compared to their fathers (second and third generations).

Table 6: Transition matrices: offspring earnings quintile conditional on ancestor's earnings quintile.

| Earnings quintile of ancestor | | Earnings quintile of offspring | | | | |
|-------------------------------|------|--------------------------------|------|------|------|--|
| | | Fathers – Generation 3 | | | | |
| Grandfathers Generation 2 | Q1 | Q2 | Q3 | Q4 | Q5 | |
| Q1 | 0.30 | 0.29 | 0.21 | 0.11 | 0.10 | |
| Q2 | 0.25 | 0.20 | 0.20 | 0.23 | 0.11 | |
| Q3 | 0.16 | 0.20 | 0.26 | 0.22 | 0.17 | |
| Q4 | 0.16 | 0.18 | 0.21 | 0.27 | 0.18 | |
| Q5 | 0.14 | 0.14 | 0.11 | 0.18 | 0.44 | |
| | | Sons- Generation 4 | | | | |
| Fathers Generation 3 | Q1 | Q2 | Q3 | Q4 | Q5 | |
| Q1 | 0.31 | 0.26 | 0.17 | 0.18 | 0.09 | |
| Q2 | 0.20 | 0.24 | 0.19 | 0.20 | 0.18 | |
| Q3 | 0.21 | 0.18 | 0.28 | 0.18 | 0.15 | |
| Q4 | 0.15 | 0.18 | 0.22 | 0.22 | 0.23 | |
| Q5 | 0.14 | 0.15 | 0.14 | 0.23 | 0.35 | |
| | | Sons Generation 4 | | | | |
| Grandfathers Generation 2 | Q1 | Q2 | Q3 | Q4 | Q5 | |
| Q1 | 0.19 | 0.23 | 0.21 | 0.24 | 0.14 | |
| Q2 | 0.23 | 0.22 | 0.23 | 0.17 | 0.14 | |
| Q3 | 0.25 | 0.19 | 0.20 | 0.20 | 0.16 | |
| Q4 | 0.17 | 0.20 | 0.21 | 0.20 | 0.22 | |
| Q5 | 0.16 | 0.16 | 0.16 | 0.18 | 0.34 | |

Notes: Fathers and sons; 774 families

If we briefly summarize the results from our descriptive estimations, they point toward a surprisingly strong association between grandparental education/earnings and education/earnings of grandchildren, and between great-grandparental education and education of great-grandchildren. Hence, regression toward the mean takes longer time in Sweden than suggested by the comparatively low estimates of intergenerational persistence found for two consecutive generations. In addition, transition matrices reveal that there is higher persistence at the upper end of the education and income distributions. We also find that simply taking the square of the intergenerational elasticity does not give an accurate picture of what we find using children and grandparents, suggesting that the basic assumption that intergenerational transmission follows an AR(1) process does not hold.

4 Conclusions

We have explored intergenerational transmission of economic status across adjacent and distant generations over the span of a century. Our data enable us to link great-grandparents born at the end of the nineteenth century to great-grandchildren who finished their education in the early twenty-first century. We estimate intergenerational correlations in educational attainments between these generations and income correlations between the first generation and their grandchildren.

We find striking persistence in economic outcomes across generations. There is significant correlation between the educational attainments of the first generation and their great-grandchildren. Persistence is also striking for the intergenerational earnings correlation. Individuals in the highest earnings quintile are more than twice as likely to have grandchildren in the highest income quintile as the rest of the population. From the estimates of the intergenerational correlations in both educational attainments and earnings we can reject the validity of simple extrapolations from correlations between adjacent generations to more distant generations as suggested in elementary text books on labor economics, such as Borjas (2009). Our findings imply that the persistence of inequality across generations is stronger than we would expect from the numerous studies on mobility in earnings and educational attainments based on only two generations. We therefore conclude that intergenerational mean reversion takes longer time than we previously knew.

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Appendix: Institutional background

The four generations studied in this paper span a century during which Swedish society was transformed from early industrialization to present day welfare society. While subsidized childcare, generous child allowances, free schooling through high school, generous grants and loans for higher education, social security, unemployment benefits, free health care and pensions constitute today's welfare system, Malmö in the beginning of the 20th century had some, but not all of these institutions in place, when the parents of the initially sampled index generation grew up.

Malmö is located in the southern part of Sweden. It was and is by population size Sweden's third city. At the beginning of the 20th century Malmö grew at a rapid pace and tripled its population from 61,000 to 192,000 between 1900 and 1950, compared to today's 300,000. Much of the population growth was a result of rapid urbanization. Malmö was early on one of the most industrialized cities in Sweden. When the original data collection of the Malmö study was initiated, in 1938, three large employers dominated.¹³ After 1960, an increasing fraction was employed within the public sector and by 1980, 20% of the men and 50% of the women held public sector jobs.

In the early 20th century, Swedish compulsory schooling was only six years, but a seventh year was introduced already in 1914 in Malmö. Yet, many children kept leaving school after six years. Seven years of schooling only become the norm around 1920 when a municipal grant was introduced to compensate poor families for the lost earnings during the seventh year of school. This grant existed until 1936 when compulsory schooling was extended to seven years throughout Sweden. In the late 1930's almost a third of all Malmö children continued beyond compulsory schooling. School enrolment was hence higher than in the rest of Sweden. Malmö was also the first large municipality to extend compulsory schooling to nine years in 1962. Arguably, basic educational infrastructure was well developed and accessible already to the index-generation studied here.

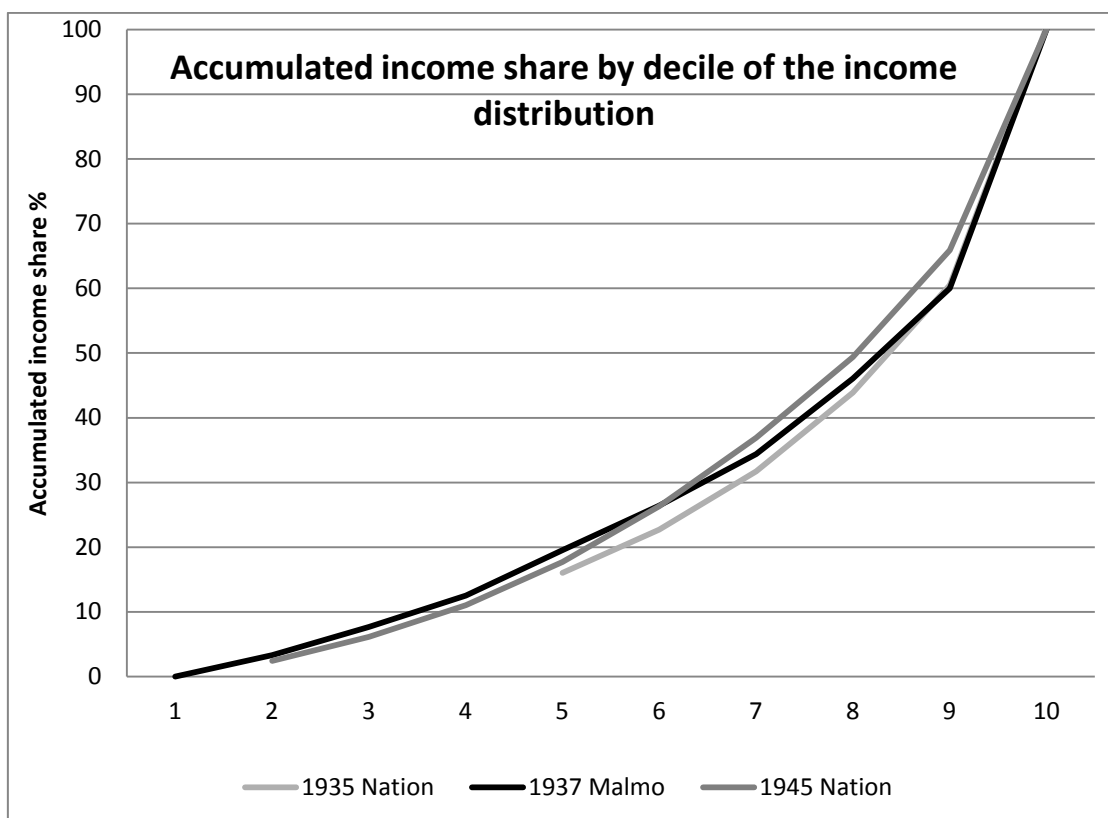
Since the 1920's, loans to help finance higher education were in principle available to the tiny fraction of young people qualified to studying at universities. In the late 1950's student loans were also made available for studies at the high school level. The

¹³ *Kockums*, a shipbuilding company and mechanical workshop, with 2,300 employees; *Skånska Cement*, a construction company, with almost 2,000 employees; and *Malmö strumpfabrik*, a stocking factory, with more than 1,000 employees.

present day generous grant and loans program for university students was introduced in 1964. Since then, credit constraints are arguably unlikely to play a role for higher education choices.

Although our sample is not a random sample from the Swedish population, Malmö was (and is) a fairly representative city in Sweden. This can be seen if we compare the earnings distribution for our first generation from Malmö (using our sample) with the earnings distribution for the entire country. To do this we use estimates of the earnings distribution obtained by Bentzel (1952), who used tax registers to construct measures of the Swedish income distribution. Figure 2 compares the earnings distribution of the first generation in our data in 1937 with those obtained by Bentzel for the years 1935 and 1945. It is interesting to note that the income distribution among the Malmö families does not deviate drastically from the national income distribution.

Figure 2: A comparison of earnings distribution for the first generation in the Malmö data for 1937 with those obtained by Bentzel (1952) for Sweden in 1935 and 1945.



Source: Own computation based on Malmö data and Bentzel (1952).