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Abstract

We show that the patterns of intergenerational earnings mobility in Denmark, Finland, and Norway, unlike those for the US and the UK, are highly nonlinear. The Nordic relationship between log earnings of sons and fathers is flat in the lower segments of the fathers' earnings distribution – sons growing up in the poorest households have the same adult earnings prospects as sons in moderately poor households – and is increasingly positive in middle and upper segments. This convex pattern contrasts sharply with our findings for the United States and the United Kingdom, where the relationship is much closer to being linear. As a result, cross-country comparisons of intergenerational earnings elasticities may be misleading with respect to transmission mechanisms in the central parts of the earnings distribution, and uninformative in the tails of the distribution.

JEL Classification: J3, J62

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It is now a stylised fact that intergenerational earnings mobility is higher in the Nordic welfare-state economies than in more market-oriented economies such as the US; see, e.g., Björklund and Jäntti (2000) and Solon (2002). To a large extent, this knowledge rests on between-country comparisons of either the elasticity of child income with respect to parental income (both measured during economically active ages), or of the correlation between parent and child (log) permanent incomes. Such comparisons are of course crude, and it is well known that elasticity estimates and correlation coefficients are sensitive to data definitions, the age at which parents' and offspring's incomes are measured, and the treatment of outliers; see, e.g., Corak (2006), Grawe (2005), Haider and Solon (2006), and Mazumder (2005).

Less attention has been paid to the fact that the appropriateness of elasticities and correlation coefficients as summary measures of intergenerational earnings mobility also depends on the functional form of the relationship between child and parent earnings being linear in logs. If the functional form of the intergenerational earnings relationship varies across countries, elasticities and correlation coefficients may not provide the appropriate foundation for cross-country comparisons. A linear model will involve specification biases that are likely to differ across countries and thereby affect the empirical assessment of international differences. Moreover, a comparison of countries is less informative if it misses how generational persistence differs across the earnings distribution. A plausible explanation for this lack of attention is that the relationship appears to be approximately linear in countries which have tended to dominate the empirical research on intergenerational earnings mobility, such as the UK and the US. As we discuss in Section 2 of this paper, there is an existing literature regarding linearity in intergenerational earnings mobility. This literature has focused on testing for a concave intergenerational relationship in log earnings – inspired by the Becker-Tomes (1986) hypothesis that poor families are credit constrained with respect to investments in offspring's education – with somewhat varying results. The issue of linearity

has not been given appropriate attention in the literature regarding mobility comparisons across countries.

Our paper focuses on the empirical analysis of the nature and extent of intergenerational earnings mobility in the Nordic countries of Denmark, Finland, and Norway, compared with the UK and the US, by means of comparable data particularly adapted for this purpose. Our data confirm the familiar patterns of intergenerational earnings persistence for these countries, including the stylised fact of lower elasticities between fathers' and sons' permanent earnings in the Nordic countries than in the US and the UK. It turns out, however, that the functional form of these intergenerational relationships varies widely across countries. While linear regressions fit the US – and even the UK – data reasonably well, the same regressions applied to the Nordic countries involve severe and serious specification error. The relationship between sons' and fathers' log earnings in the Nordic countries is not linear, but rather convex. Specifically, in the Nordic data the relationship starts out flat, implying that whether sons are born into very poor or moderately poor families has little impact on their own expected adult earnings.

There are a number of possible mechanisms that could explain this phenomenon. One is that the educational systems of the Nordic countries have succeeded in providing all citizens with sufficiently high basic skills so that, particularly in the bottom of the parents' earnings distribution, the adult earnings of sons are independent of their parents' economic resources. A second explanation holds that the wage setting institutions of the Nordic countries effectively have raised the left tail of the earnings distribution and, as a result, have eliminated the effect of family background for low wage earners. A third, and related, line of reasoning is that the absence of an extended left tail in the Nordic earnings distributions is the result of generous welfare systems and their effect on labour supply at low wages.

There is, however, a potentially much more mundane explanation for our findings, namely that the apparent 'tail-differences' across countries stem from differences in data measurement rather than genuine differences in economic realities. Transitory shocks to parental earnings and life-cycle bias in sons' earnings are familiar sources of measurement error bias in intergenerational studies, and cross-country differences in the importance of transitory variability of (low) earnings may well generate differences in the role of bias in international data. Another concern would arise if the register-based Nordic data sets contain fathers with underreported earnings. We make substantial efforts to discriminate between the substantive and the more spurious interpretations of our findings by examining a number of alternative indicators of parental wealth, and also by assessing the sensitivity of our results with respect to potentially questionable 'tail' observations. Our conclusion is that the Nordic convexity in intergenerational earnings persistence cannot be explained by measurement error.

The finding of widely different functional form relationships between the earnings of fathers and sons across countries does not necessarily render the conventional wisdom of higher intergenerational mobility in the Nordic countries invalid, but it certainly invites a rethink of the way differences across countries should be both investigated and interpreted.

1. Theoretical motivation

Discussion of nonlinearities in the relationship between the (log of) earnings of parent and child, like much of the economic and statistical analyses of intergenerational mobility, originates in the seminal treatment of Becker and Tomes (1979; 1986). In their human capital model of the 'rise and fall of families' Becker and Tomes (1986) crystallise the argument that the relationship is linear in the absence of obstacles to self-financing investments in children, but concave if poor families are more borrowing-constrained than rich families. In this

section, we illustrate how family investments may affect intergenerational earnings persistence in different ways.

Let e_t denote inherited human capital endowment ('ability') and let I_{t-1} denote income-related family investment in human capital. We can then write human capital as:

(1) $h_t = e_t + \theta \log I_{t-1}, \quad \theta \geq 0,$

In the case $\theta > 0$, equation (1) can be motivated within the Becker-Tomes framework as arising from the existence of borrowing constraints, with θ a parameter indicating the efficacy of investments in the child's human capital; see Solon (2004). We interpret the special case in which $\theta = 0$, as an educational system which is purely 'meritocratic' in the sense that human capital acquisition depends only on the child's underlying ability, independent of any income-related family investments. $\theta = 0$ coincides with the Becker-Tomes model with bequests and a perfect capital market. With perfect capital markets, even the poorest parents could borrow against their child's future earnings potential and hence make optimal investments.

Let the intergenerational transmission of the inherited endowment be given by:

(2) $e_t = \lambda e_{t-1} + v_t,$

where v_t is a stochastic error term. Suppose also that offspring (log) earnings are given by:

(3) $\log y_t = ph_t,$

where p is the rate of return on human capital. We focus now on the case with $\theta > 0$, and assume that parents seek to maximise a utility function of the form:

(4) $\mathrm{U}_{t-1} = \log C_{t-1} + \log y_t,$

through choice of investments, I_{t-1}, subject to a budget constraint given by:

(5) $\mathrm{y}_{t-1} = C_{t-1} + I_{t-1},$

where C_{t-1} is parental consumption and we are not allowing for parents to borrow against future expected offspring earnings. (If $\theta = 0$, optimal investment is, of course, zero). Substituting (1) and (3) in (4) and maximising subject to (5) yields a value for the optimal parental investment of:[1]

$$(6) \quad \mathrm{I}_{t-1} = \left[\frac{p\theta}{1+p\theta} \right] y_{t-1}.$$

Substituting (6), (1) and (2) in (3), yields the following relationship between offspring and parent earnings:

$$(7) \quad \log y_t = p\theta \log \left[\frac{p\theta}{1+p\theta} \right] + p\theta \log y_{t-1} + p(\lambda e_{t-1} + v_t).$$

The term $p\theta \log y_{t-1}$ in (7) represents the direct effect of parental investment on child earnings, while the term $p(\lambda e_{t-1} + v_1)$ is correlated with y_{t-1} through its association with e_{t-1}. The steady-state elasticity between child and parent earnings capturing both the direct effect of y_{t-1}, through $p\theta$, and the indirect effect, through λ, is written as (see also Solon, 2004):

$$(8) \quad \beta = \frac{\lambda + p\theta}{1+\lambda p\theta}$$

Note that in the special case of equal opportunities in which $\theta = 0$, it follows that $\beta = \lambda$ and hence the result of meritocracy is equivalent to the Becker-Tomes case of perfect capital markets. As Grawe and Mulligan (p. 47, 2002) observe, only child ability matters in this case. Parental earnings affect child earnings solely through λ; that is, through the auto-regression in inherited endowment. Otherwise, for $\theta > 0$, it follows that $\beta > \lambda \ \forall \ \lambda < 1$.

In much of the literature to date, discussion has focused on the distinction between perfect ($\beta = \lambda$) and imperfect ($\beta > \lambda$) capital markets. We can represent these two cases in Figure 1a.

- Figure 1 (panels 1a and 1b) around here -

An implication readily captured in Figure 1a is that of the Becker-Tomes conjecture of concavity in the relationship between child and parent earnings. Under the assumption that borrowing constraints are more likely to impact on poorer parents, it follows that a slope of $\beta > \lambda$ might apply for lower parental earnings while a slope of λ will be relevant for higher earning parents, creating a concave intergenerational earnings relationship: depicted by the bold outlining in Figure 1a.

While much of the literature has focused on testing for *concavity* in the child-parent earnings relationship, one could pose an alternative hypothesis of *convexity*, motivated as follows. Suppose that all families are borrowing-constrained, possibly because the optimal level of investment is higher for children with high ability; see, for example, Han and Mulligan (2001) and Grawe and Mulligan (2002). Then the default regression line will have a slope given by (8), where $\beta > \lambda$. Suppose now that educational policies and institutions are designed in such a way that, for lower levels of human capital formation, access to education services is characterized by equal opportunity. In this 'meritocratic' case, the slope of the intergenerational regression line is given by λ, but – unlike in the otherwise equivalent Becker-Tomes case – this flatter gradient applies to the *lower* rather than to the *higher* earning parents. In this scenario, the relationship between child and parent earnings is *convex* rather than *concave*. This is shown in Figure 1b.

Figure 1, then, portrays two special cases of nonlinearity. A number of variations on these themes suggest themselves. An S-shaped relationship, for example, could be interpreted as a combination of meritocratic aspects of human capital formation at the lower levels of education and the absence of credit constraints at the highest earning levels. Both the position of the discontinuities within the relation and its slope will be determined by institutional features both of the education system and of capital and labour markets. Redistributive educational policies which provide better-resourced public education in poorer communities

(see Hægeland *et al*. (2004) for evidence on this for Scandinavia) will, in our model, generate a lower value of θ for lower-earning parents, implying convexity of the sort represented in Figure 1b. In contrast, for example, in the UK there is a long tradition of private schooling and also a growing body of evidence on the effects of state school quality on local house prices (see Gibbons and Machin, 2003), indicating substantial parental investments in offspring's human capital. Convexity is less likely in this setting.

In this theoretical motivation, we have indicated some reasons for which there may be nonlinearities in the relationship between child and parent (log) earnings. In the following sections, we discuss our strategy for addressing empirically the nature and extent of intergenerational mobility across countries. In particular, we are concerned with examining whether the earnings relationship across generations is linear or nonlinear and how this might vary across countries. First, we provide a brief review of how the literature has addressed the issue of linearity.

2. Existing evidence

In his seminal article on intergenerational income mobility in the United States, Solon (1992), citing evidence from Atkinson *et al.* (1983) on the asymmetry of mobility in his early English study, includes the square of father's log earnings to allow for nonlinearity. Solon finds some evidence that the elasticity is increasing with father's earnings, but cannot statistically reject the hypothesis of linearity.

Most studies which have considered the issue of nonlinearity have done so in order to test the Becker-Tomes conjecture of a concave relationship between offspring's and parent's earnings. Mazumder (2005) finds evidence for the US consistent with the Becker-Tomes framework. Couch and Lillard (2004) provide similar empirical evidence indicating that the intergenerational father-son income elasticity is declining in father's income in the United States. They cannot confirm the same hypothesis for Germany. Mulligan (1999), using PSID

data, finds that OLS estimates of persistence are the same for both financially constrained and the unconstrained.

Corak and Heisz (1999) pay explicit attention to the issue of nonlinearities in larger data samples drawn from Canadian tax records, and conclude that mobility is greater in the lower end of the income distribution than in the upper end, contrary to the Becker-Tomes conjecture. Behrman and Taubman (1990) use PSID data and include a quadratic in the log of parental income, finding some evidence of nonlinearity; the intergenerational earnings elasticity seems to rise with parental income.

Grawe (2004), using Canadian data, reports that middle-earning families experience slower regression but, on the basis of quantile regression results, rejects a simple credit-constraint explanation. Grawe argues that the existence of credit constraints is neither a necessary nor a sufficient condition for there to be nonlinearities in intergenerational mobility: the relationship between child and parent earnings will depend, *inter alia*, on the nature of the earnings function. The implications for international comparisons of intergenerational earnings mobility are immediate: the nature of the functional form in the relationship between child and parental earnings is likely to vary across countries with the nature of earnings relationships as well as with differences in factors relating to financial markets, human capital acquisition and with public policy. Solon (2004) makes a similar argument in addressing sources of differences in cross-country estimates of the intergenerational earnings elasticity. Han and Mulligan (2001) develop a model of intergenerational mobility based on parental investment choices. Their simulations suggest that cross-country differences in mobility are more likely to reflect differences in (the heterogeneity of) inherited ability rather than differences in optimal family investment choices or policies across countries. This is because in their model even the complete elimination of borrowing constraints has little numerical effect on the degree of persistence in their simulations.

The next sections of the paper describe our empirical analysis which, we believe, represents the first study of functional form in the context of a cross-country analysis of intergenerational mobility, based on intergenerational samples – standardised as closely as possible – for 5 different countries: the UK, the US and the Nordic countries of Denmark, Finland and Norway.

3. Data

We exploit intergenerational earnings data from five countries; Denmark, Finland, Norway, United Kingdom, and the United States. While the data from the UK and the US are based on household surveys, the Nordic data are collected from administrative registers. In the present paper, we focus on sons because international comparisons of daughters' incomes entail certain complications as patterns of female labour force participation vary across countries. The guiding principle behind our adaptation of data from the different countries is to exploit the flexibility and richness of register data to 'mimic' the data generating processes behind the two survey-based datasets. The UK National Child Development Study (NCDS) acts as a baseline to which the other data sets are adapted. The NCDS sampled all children born during the week of March 3rd- 9th, 1958, and is the data source exploited in the work of Dearden *et al*. (1997) and Blanden (2005), *inter alia*. The most recent sweeps are those from 1991 and 1999, providing information on the offspring's gross earnings at ages 33 and 41. Furthermore, from the 1974 sweep we obtain information on fathers' earnings at a time when the sampled children were about 16 years of age.

Included in the UK analysis sample are sons who are employed (full time or part time) with at least one valid earnings observation in 1991 or 1999. Because the age of the father was recorded only in the initial sweep (in 1958), the sample is limited to those living with their biological father in 1974. In addition to father's earnings, we consider family income which is computed as the sum of father's and mother's net pay, plus income from other

sources.[2] The income measures are converted to annual income and inflated from the interview month (which ranges from January 1973 to February 1975) to 2000 currency. Excluded from the sample are those whose father or mother report being employed at the time of the 1974 sweep but failed to provide pay information. Also excluded are families where neither the father nor the mother provides any pay information at all. Finally, we exclude 28 observations from the father's earnings sample, and 22 observations from the family income sample, where reported income appears to be an extreme outlier.[3]

Our US data are based on the National Longitudinal Survey of Youth (NLSY79). In order to obtain a sample of reasonable size, while maintaining comparability with the UK data, we include the birth cohorts between 1957 and 1964 in the US sample. Parental income refers to family income from all sources in 1978 and 1979, when the children were between 13 and 21 years old. Sample inclusion requires that we can link children and fathers, either because the respondent or a (younger) biological sibling lived in the same residence as the father at the time when we observe parental income. The children's earnings refer to annual wage or salary income in 1995 and 2001.[4]

For Norway, we have drawn the complete 1958 birth cohort from population registers, matched with biological fathers' earnings records from 1971 and 1976. Earnings records for both father and son generations are drawn from the pension register, and include incomes from all labour-related sources such as wage and salary income, self-employment earnings (net of interest payments), unemployment benefits, and long-term sickness benefits. Sons' earnings are measured in 1992 and 1999. For Denmark, we also use the 1958 birth cohort, with biological fathers' earnings measured in 1980 and 1981 and sons' earnings measured in 1998 and 2000.[5] The earnings information emanates from tax registers covering total earnings from all employers paid to each worker during the year. These data are considered to be of high quality as they are used by tax authorities to assess each employee's earnings. As the wage

records also constitute deductible labour costs for employers, firms have a strong incentive to provide accurate and timely information to tax authorities. During the period studied, there was no change in the construction of the earnings variable.

For Finland, we use the 1956-1960 birth cohorts included in the quinquennial census panel covering the 1970-2000 period. As with the US sample, we use multiple birth cohorts out of sample size concerns. Fathers' earnings are observed in 1970 and 1975 and sons' earnings are observed in 1998 and 2001. The main source for the earnings data is tax records, which across the relevant years had quite similar definitions of earnings, including all wages and salaries and both farm and non-farm self-employment income as defined for purposes of taxation. We use 1998 and 2001 for sons' earnings as the very high unemployment rates in the early to mid-1990s in Finland cause unnecessarily noisy earnings in earlier years.

All earnings measures used in this paper are adjusted for general wage growth and are measured in terms of international US dollars in year 2000 prices. We convert national currencies using the PPP exchange rates in World Development Indicators 2003 and use national CPI price indices to convert nominal amounts into the year 2000 prices.[6] Note that in our baseline analyses, all income measures are based on two observation years, with the exception of parents in the UK for whom only a single year of earnings data are available. But, as becomes clear in the next sections, we also provide a number of modifications of the data for pair-wise comparisons, with alternative definitions of both parental and offspring income; e.g., by using more than two observation years to identify 'permanent income,' and alternating between using father's earnings only and family income as our measure of the households' economic resources.

4. The functional form between fathers' and sons' permanent earnings

The standard way of addressing the issue of the intergenerational transfer of earnings is to set up a linear log earnings regression equation, with some measure of the permanent earnings of

the sons on the left-hand side, and the permanent income of the father (or the family) along with age controls on the right-hand side. In this section, we first show the results of such linear regressions for each of the five countries, based on the baseline datasets described in the previous section. To evaluate the model specifications, we first plot the computed regression lines together with a direct representation of the data points. In order to make the data points interpretable, we have divided each data set into percentiles of the distribution of parental earnings; i.e., each data point gives the mean log earnings of sons and parents for each percentile of the parental earnings distribution. Figures 2 and 3 provide the results for the US and the UK, respectively. The slopes of the regression lines (i.e., estimates of the intergenerational earnings elasticity based on the 100 grouped data points) are 0.55 in the US plot and 0.44 in the UK plot. Both regression lines seem to fit well with the 100 data points, lending support to the linear representation of these functional relationships.

- Figures 2 and 3 around here -

Figures 4-6 provide similar plots for the Danish, Finnish, and Norwegian data. The slopes of the regression lines clearly indicate higher earnings mobility in these countries than in the UK and the US. The slopes are 0.12 for Denmark, 0.16 for Norway, and 0.19 for Finland. These estimates are in line with those of prior studies, such as Bratberg *et al*. (2005) for Norway and Österbacka (2001) for Finland. The main message coming out of these graphs, however, is that of functional form misspecification. The source of nonlinearity is that the sons' earnings profiles are flat at the bottom of the fathers' earnings distribution. Although there are certain differences across countries (and different degrees of noise in the scatter plots reflecting differences in sample size), it seems to be the case for all three countries that there is little relationship between the earnings of fathers and sons for the lowest 15-20 percentiles of the fathers' earnings distribution. In other words, a child from the 1st percentile of the fathers' earnings distributions faces roughly the same adult earnings prospects as a

child from the 20th percentile. At higher percentiles, the appropriate regression lines are clearly much steeper than those indicated by the estimated elasticities based on the linear model. Hence, the low intergenerational elasticities typically reported for the Nordic countries are not representative for the majority of the population. In particular, they understate the degree of earnings persistence in central and upper parts of the parental earnings distribution.

- Figures 4-6 around here -

Given that the linear regressions do not always appear to fit the data well, we now turn to more flexible regression specifications. Our main strategy is to make the functional forms more flexible by adding higher-order polynomial terms to the five regression equations, to the extent that these are supported by the data. We then select the preferred specification for each country based on minimum root mean squared error (or, equivalently, maximum adjusted R^2). By this model selection criterion, nonlinear models are preferred for all countries: second-order polynomials for Finland, the UK, and the US, a third-order polynomial for Norway, and fourth-order for Denmark. For each estimated equation, we report three son-father earnings elasticities, evaluated at the 10th, 50th, and 90th percentiles of fathers' earnings. Key results are reported in Table 1.

- Table 1 around here -

The results in Table 1 show that, in all of the countries considered, the intergenerational earnings elasticity is higher in the middle than at the bottom of the earnings distribution. For the Nordic countries, the difference is highly significant both in a statistical and a substantive sense. (For the UK and the US, there are some, but not robust, indications of a convex functional form.). A striking illustration of the specification bias in the Nordic data is that elasticity estimates from the linear model fall 27 (Finland), 45 (Norway), and 50 percent (Denmark) below those from the linear model and evaluated at the median of father's earnings. In other words, the extremely high Nordic mobility suggested by the linear model

understates the impact of parental earnings on the adult economic outcomes of children in these countries. For the UK and the US, estimates from the linear specification are in line with those from the nonlinear model. As such, comparisons of intergenerational persistence based on the linear model overstate differences across countries. For example, the comparison of persistence in the US and the Nordic countries overstates the difference by 12 (Finland),[7] 26 (Denmark), and 31 percent (Norway) when based on the linear as opposed to the nonlinear model evaluated at median earnings. A final pattern to emerge from the table is that differences between the Nordic countries on the one hand and the UK and the US on the other are much smaller in the middle and the top of the income distribution than at the bottom. Notwithstanding these results, intergenerational earnings mobility remains significantly higher in the Nordic countries than in the US (according to the elasticity measures) throughout the income distribution.

5. Is the evidence for the Nordic countries the result of measurement error?

Estimates of intergenerational earnings mobility in the Nordic countries are typically based on administrative register data. And, because of the requirement that both fathers and sons need be observed at economically active ages, it will often be the case that fathers' earnings are measured in the 1970s or early 1980s. During that time period, the Nordic countries had strongly progressive tax schedules that also embodied a number of options for legal (as well as illegal) 'income manipulation' for the purpose of tax avoidance. Hence, an important concern is that some of the fathers who are classified as 'poor' in intergenerational income studies are in fact very rich, and that this might be the true reason why their children perform so well. An alternative explanation is that some parents had very volatile annual earnings, so that the use of only two years worth of data for identification of parental earnings renders the 'poor parents group' a mixture of actual poor parents and parents who are not really poor, but happened to have low earnings in these particular years only. Solon (1992) - see also

Mazumder (2005) - demonstrates that, because of persistent transitory fluctuations of earnings, using a single year of parental earnings leads to serious downward bias in US elasticity estimates. In both cases of under-reported earnings and of transitory fluctuations, the stylised fact of high intergenerational mobility in the Nordic countries may be an illusion, created by data measurement error. Further, samples based on administrative registers on the one hand and survey data on the other invariably entail differences in sample design and measurement of key variables that may influence results. In this section, we address whether such issues drive our conclusions.

Family income. One source of cross-country data differences is that of the definition of earnings. While the son's earnings in all five countries refer to the wage and salary income from work during the calendar year, data on father's earnings are unfortunately not available in the US, for which we use log family income from all sources. Further, use of father's earnings presents a potential data problem if they do not fully capture the economic resources of the family, particularly for low-income fathers. It is commonly held that mobility measures based on family income ('all sources') show more intergenerational persistence than estimates from earnings (Chadwick and Solon, 2002). Studies from the US, e.g., Solon (1992) and Peters (1992), typically report estimates using the same income measure for both generations and it is plausible that non-labour income, for example from financial capital or property, is transmitted mechanically from one generation to the next contributing to high persistence of family income. The evidence on the impact of family income relative to father's earnings on individual offspring earnings is less clear cut, however. For example, Mazumder (2005) reports higher persistence using family income, but this result turns out to be driven mainly by sample selectivity, as a comparison based on the same individuals discloses only a minor difference between the two approaches.

For these reasons, we re-estimate the linear and nonlinear models for four of the countries, replacing fathers' earnings with family income (alternatively, the sum of earnings of both parents when income from other sources is not available). Results appear in Table 2. As the table shows, replacing father's earnings with family income increases the intergenerational elasticity estimates by a small amount in two of the countries (Denmark and Finland), but reduces the estimate in the other two (Norway and the UK). Importantly, the nonlinearity results from Table 1 prevail: even when we use family earnings as the measure of parental resources, intergenerational persistence follows a highly convex pattern in the Nordic countries, while in the UK there are no indications of nonlinearity. For Finland, we have data on both parental earnings and income from other sources, including self-employment and transfers such as disability and maternity-leave allowances. Using the broader income measure reduces the degree of convexity somewhat, but the empirical evidence still points to a highly nonlinear functional form. The results in Table 2 therefore show that the patterns of nonlinearity in the Nordic countries and linearity in the UK and the US are unlikely to result from differences in definition of parental income.

- Table 2 around here -

Transitory shocks or lifecycle bias. A second concern is that measurement of permanent earnings based on only two observations imparts measurement error, and this may be particularly severe in the left tail of the earnings distribution. We take advantage of the long panels of earnings records available for both generations in the Norwegian data, and re-estimate the equations using ten years of earnings for fathers and eleven years for sons (see results in Table 3, column 1). If anything, this experiment increases the degree of nonlinearity in the earnings relation. While the elasticity estimate in the lower tail is similar to that based on only two observations, the estimate in the upper tail is ten percent higher than that in Table 1. Curiously, the elasticity estimate from the linear model *declines* compared to that based on

only two years of fathers' earnings. At first glance, this finding runs counter to the standard argument that more years provide a better measure of permanent earnings. The reason for the Norwegian pattern turns out to be that, when we average fathers' earnings over several years, the sample will include fathers who are excluded in single years because of zero earnings. This group of fathers tends to have low earnings in years with positive earnings. Thus, their inclusion in the sample exacerbates the specification error of the linear model. When we restrict the sample to fathers with non-zero earnings in all years, we find, along the lines of Mazumder (2005), indication of attenuation bias in single-year based estimates.

- Table 3 around here -

Sample selection bias; fathers. A third concern is that cross-country differences with respect to patterns of nonlinearity might result from differences in sample design. Recall that, for two of the Nordic countries (Denmark and Norway), fathers and sons are matched through birth records. Thus, in cases where sons are separated from their biological father, our use of father's earnings may not accurately reflect the son's economic circumstance during childhood and adolescence. In contrast, the UK and US samples, for whom we do not find nonlinearity, are based on household surveys and our linkage of fathers and sons is conditional of them living in the same household. This raises the question whether the Nordic pattern is driven by our matching low-income fathers to sons when they actually live apart. To investigate this issue, we restrict the Danish and Norwegian samples to families where we observe the mother and father living together, which raises the likelihood that the son also lives with the father. Results based on the restricted samples are listed in Table 3, for Norway in columns 2 and 3, and for Denmark in columns 4 and 5. These sensitivity checks fail to uncover results that differ in any meaningful sense from those of the prior tables, and in each case considered there is evidence of significant convexity. Finally, the baseline results from Finland, where matching of father and son is conditional on the two living in the same

household in the 1970 or 1975 censuses, provide further evidence that the nonlinear relation uncovered for the Nordic countries is not the consequence of sample design.[8]

Sample selection bias; sons. Because only strictly positive earnings are used in the regression analysis of log earnings, there is another problematic selection issue involved in the calculation of intergenerational earnings elasticities. If the probability that sons report zero earnings is inversely related to parental income, this might bias the estimated income elasticities at low parental income levels downwards and can, perhaps, explain the observed nonlinear patterns. The relatively generous Nordic welfare systems might be expected to exacerbate any such selection effect, as labour market withdrawal is more attractive than in the US. As shown in Table 4, which reports results from probit regressions of sample exclusion on log parental earnings, it is indeed the case that sample exclusion in the Nordic samples declines with parental resources. However, it turns out that the negative relationship between parental income and the likelihood that the son has zero earnings is even stronger in the UK and in the US. Hence, the selection problem caused by zero earnings among sons is an unlikely candidate to explain the observed differences of the Nordic countries from the UK and the US.

- Table 4 around here -

Under-reported earnings. If some of the fathers in the lowest earnings percentiles in the data were in fact highly paid, we would expect them to have accumulated greater economic wealth later in life than is typically associated with very low earnings. In the Nordic data samples, we have access to gross taxable wealth about 20 years after we observe earnings, and in the upper panel of Figure 7 we plot the relationship between economic wealth in 1994 and the percentile-position in the earnings distribution of the baseline years. As the measure of gross wealth includes property value (although recorded below market value), wealth is more difficult to conceal than income. The plot does not suggest that fathers in the

bottom of the earnings distribution may have had large unreported economic resources. Particularly in the Norwegian sample, the relationship between earnings and subsequent wealth 20 years hence is steep in the lower tail of the earnings distribution.

- Figure 7 around here -

Taxable wealth in 1994 is, of course, only recorded for fathers who were still alive in 1994. And, as illustrated in the lower panel of Figure 7, only 30 (Finland) and 40 percent (Denmark and Norway) of fathers in the lowest earnings percentile were still alive by the mid to late 1990s. In comparison, around 80 percent of the fathers in the upper earnings percentiles were still alive. Given the existing scientific evidence on social gradients in health status and mortality rates, we interpret the plot as additional evidence that the observed earnings distribution in the 1970s indeed represents the true economic resources of Nordic fathers quite well.

Common sample restrictions. Even though the above analysis suggests that the low-income fathers in the Nordic samples were indeed poor, it remains a concern that their recorded earnings may understate their true economic resources. And, as was apparent from Figures 2-6, the very poorest percentile groups of fathers in the Nordic samples are recorded with much lower earnings than their counterparts in the UK and the US, and their inclusion in the regression sample has a strong influence on the specification bias of the linear model. In the final sensitivity check, we examine the consequences of imposing a common sample restriction on the data, and drop from the regression samples fathers (or families) with earnings below $3,000. The results are reported in Table 5. The elasticities, both in the linear and nonlinear specifications, are higher than without the low-income sample restriction. For example, the Danish elasticity is now 0.169 as opposed to 0.121 in the linear case and 0.254 compared to 0.241 in the linear case evaluated at the median of father's earnings. However,

the nonlinear functional form is still supported by the data for the Nordic countries and the elasticities are lower than in the US (and the UK) throughout the earnings distribution.

6. Educational attainment and parental earnings

From the investigations in the previous section, we conclude that the nonlinear pattern uncovered in the Nordic countries, with relatively favourable adult earnings among sons from the poorest households, reflects genuine economic realities and can not be explained by data deficiencies such as measurement error. What, then, are the mechanisms? Because skills and educational attainment are closely linked to family background, including parental earnings, nonlinear returns to schooling could be an explanation. However, prior empirical studies do not suggest low marginal returns for the first years of post-compulsory education, see, e.g., Hægeland et al. (1999).

A nonlinear association between human capital and parental earnings provides an alternative, and more promising, hypothesis. As discussed in our theoretical motivation, Nordic educational policies are highly redistributive in that they provide better-resourced public schools in poor communities as well as targeted individual teaching to children with limited learning capacities. The explicit motive behind redistributive educational policies is to offset what would otherwise be an educational disadvantage for children of poorer parents. To the extent that these policies are targeted at establishing common minimum standards of educational attainment, we might expect to observe an 'education floor' in the Nordic countries. In Figure 8, we plot the associations between parental earnings and years of schooling in Denmark, Finland, Norway and the US. The patterns are very similar to what we have seen for earnings in all of the four countries. While variation in economic resources of the family seems to have minimal influence on attainment in the first earnings quantile in the Nordic countries, it does affect schooling more in the US. The nonlinear relationship between

economic resources of the family and the offspring's human capital presents an avenue to explore further in order to understand the drivers behind the nonlinear patterns of earnings persistence in the Nordic countries. We leave this to further work.

- Figure 8 around here -

7. Concluding remarks

We have shown that the patterns of intergenerational earnings mobility in the Nordic countries are highly nonlinear, and that the regression lines linking sons' and fathers' log earnings are flat in the bottom segments of the fathers' earnings distribution. The adult earnings prospects of sons born into the very lowest percentiles of the fathers' earnings distribution are remarkably similar to those of the sons born into the 15^{th}-20^{th} percentiles in each of the Nordic countries included in our analysis (Denmark, Finland, and Norway). This pattern contrasts with the results for the US and the UK, where the relationships between the sons' and fathers' earnings are much closer to being linear throughout the income distribution.

We have shown that intergenerational earnings mobility is higher in the Nordic countries than in the US, for all parts of the parental earnings distribution, while mobility in the UK lies between the two. However, the nonlinearity we have identified means that the differences between the Nordic countries and both the US and the UK are much larger at the bottom of the parental earnings distribution than at the top. As a result, cross-country comparisons of intergenerational earnings elasticities from linear models are misleading. The linear model also represents a serious misspecification in the Nordic countries and comparisons based on such estimates tend to overstate the high earnings mobility in these countries. The finding also implies that the prospects for moving out of poverty in the US and the UK are poorer than in the Nordic countries.

We have made careful attempts to check the robustness of our results against possible data problems and conclude that the nonlinear pattern uncovered in the Nordic countries is

genuine and not a result of, for example, measurement error. We have also provided preliminary evidence that our findings might be related to institutional differences in educational systems. Nordic policy makers have traditionally made large efforts to ensure equal educational standards for all citizens, regardless of geographical location (Raaum *et al*., 2003; 2006) and family economic resources. One potential explanation for our findings is thus that, consistent with our theoretical discussion, Nordic educational policies have been successful in creating a kind of qualifications floor, to which most citizens can aspire, regardless of parental resources.

Endnotes

[1] We assume that returns to human capital investments, $p\theta$, are sufficiently large to provide an inner solution.

[2] NCDS reports income by source "father's earnings," "mother's earnings" and "other income," each component within weekly or monthly intervals. We assign a value to each interval applying the algorithm of Blanden (2005), who uses the within-band mean value for each income component obtained from comparable families in the 1974 Family Expenditure Survey. Sensitivity checks, using data from the other countries of this study, in which we mimic the income brackets of the UK data, yield results that are very similar to those reported below based on non-bracketed data.

[3] Sample exclusion is based on a regression of log(father's earnings) or log(family income) on home ownership, father's and mother's occupations, educational attainments, and ages, plus interaction terms. We drop observations when the absolute value of the residual exceeds three times the root mean squared error of the regression. In the father sample, 25 observations are dropped because of extremely low values, and three because of extremely high values. In the family income sample, the algorithm dropped 19 observation with extremely low, and 3 with extremely high, values. Further details are available from the authors upon request.

[4] Because the NLSY79 contains supplementary samples of Hispanic, black, and poor households, we apply the sampling weights from the initial survey. Results are very similar, albeit less precise, if we restrict the analysis to the representative subsample of the survey.

[5] As in the UK data, we drop some apparent extreme outliers from the Danish sample. Sample inclusion is based on a regression of log(father's earnings) on father's age and educational attainment, log(wealth in 1994), and a dummy variable for missing wealth data. The procedure drops 559 observations with residuals that in absolute value exceeds three times the regression's root mean squared error, all with extremely low earnings. Further details are available upon request.

[6] We use one PPP for each of the parents' (DK 1980, FI and NO 1975, UK 1974, US 1978) and sons' earnings (NO and UK 1999, elsewhere 2000).

[7] I.e., (0.542-0.189)/(0.575-0.259); see Table 1.

[8] On the other hand, the data samples do not allow us to rule out that convexity may be present even in the US and the UK, and that our failure to find nonlinearity is due to stronger sample selection effects in these countries than in the Nordic countries or to systematic non-reporting of earnings among poor households in survey data.

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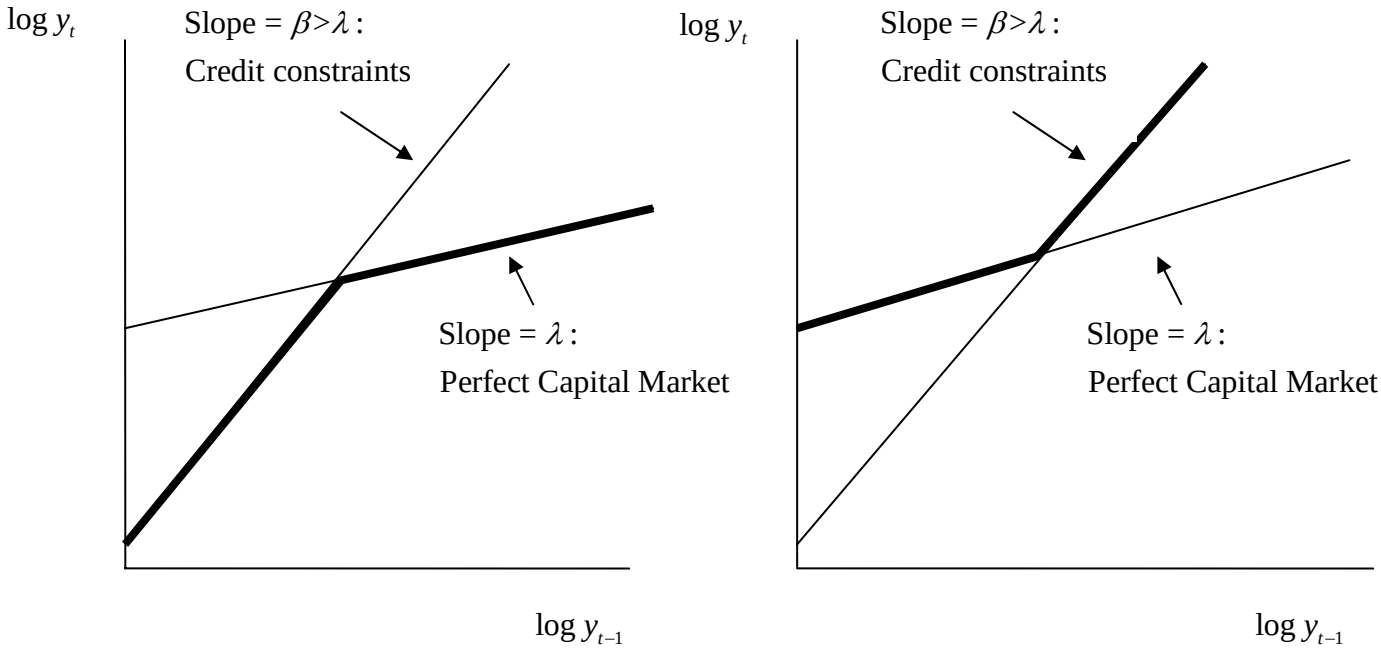

Panel (a)
The Becker-Tomes Conjecture (Concavity)

Panel (b)
An Alternative Conjecture (Convexity)

Fig. 1. Two alternative conjectures on nonlinearity

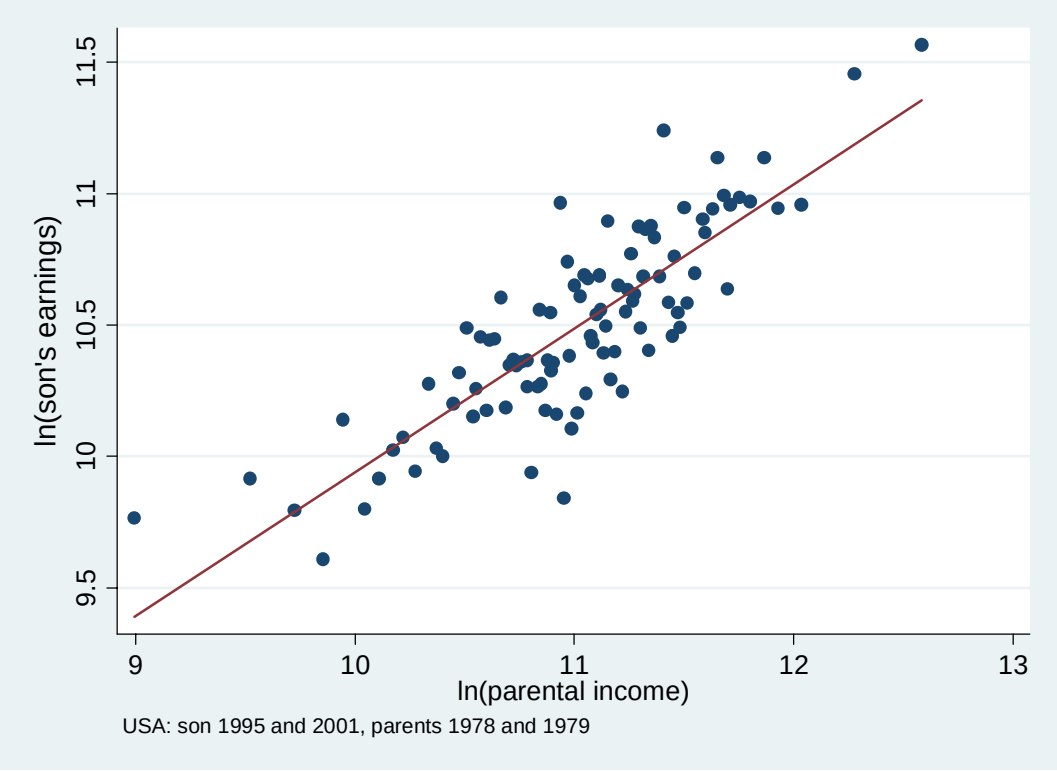

Fig. 2. Log earnings of sons and parental income in the United States. Regression line [slope = 0.547(0.035)] and mean log earnings of sons and parents for each percentile of the parental income distribution.

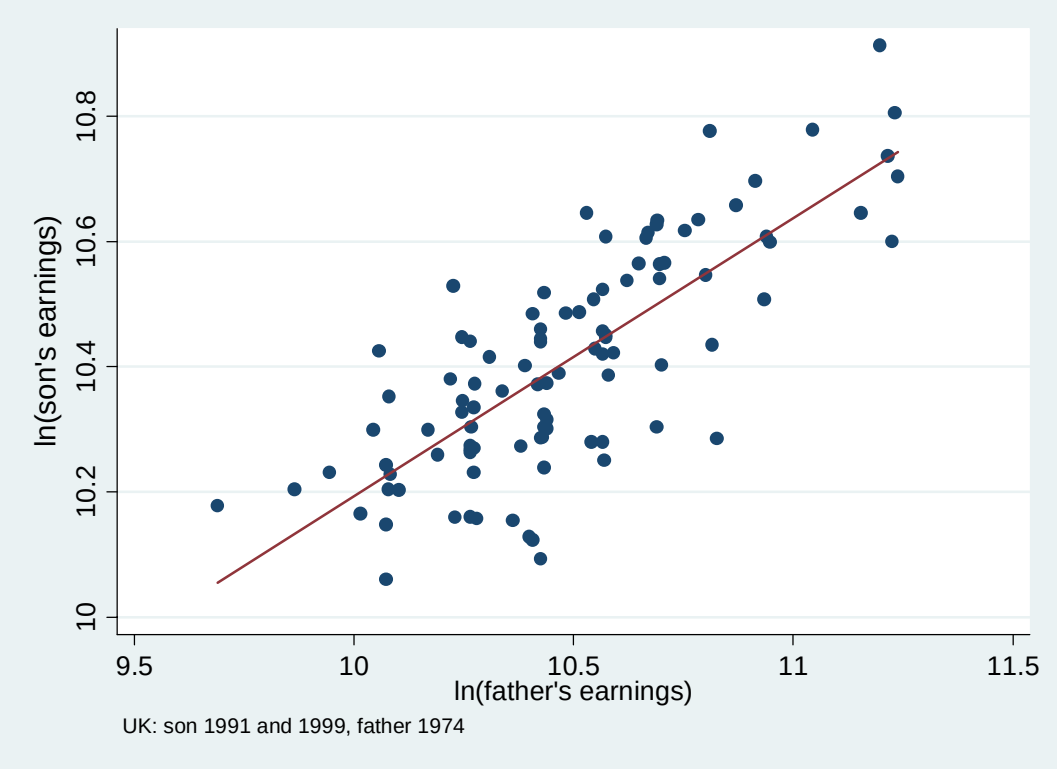

Fig. 3. Log earnings of sons and fathers in the United Kingdom. Regression line [slope=0.444(0.036)] and mean log earnings of sons and fathers for each percentile of the father's earnings distribution.

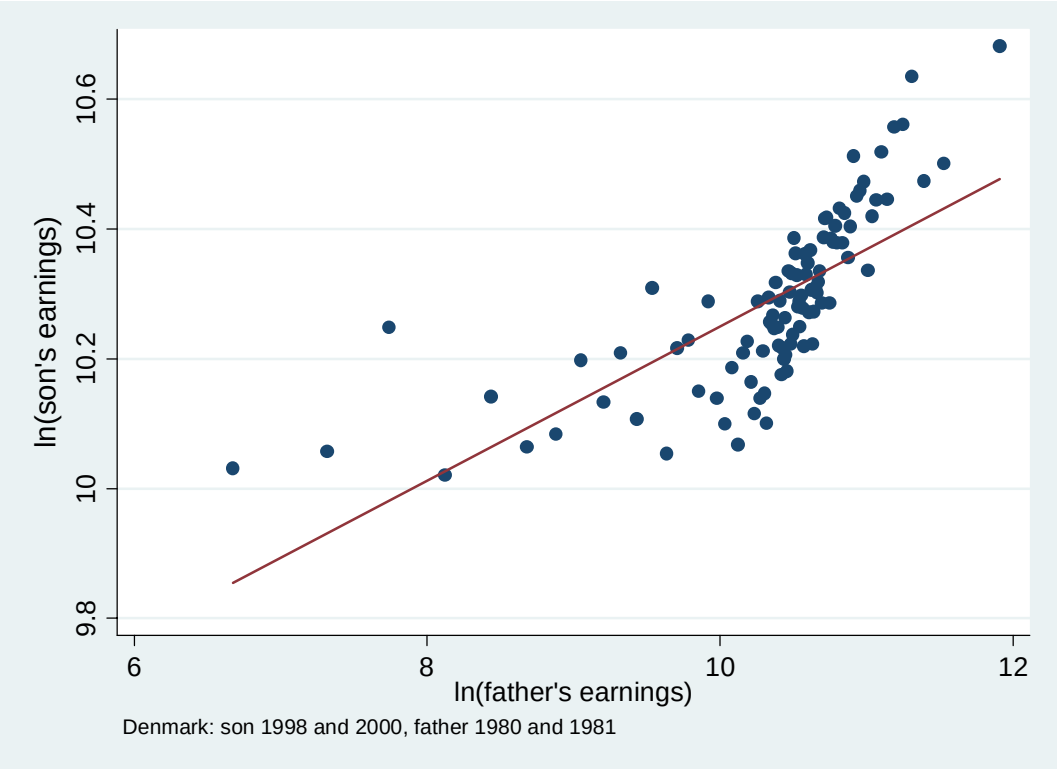

Fig. 4. Log earnings of sons and fathers in Denmark. Regression line [slope=0.119(0.011)] and mean log earnings of sons and fathers for each percentile of father's earnings distribution.

Fig. 5. Log earnings of sons and fathers in Finland. Regression line [slope=0.190(0.015)] and mean log earnings of sons and fathers for each percentile of father's earnings distribution.

Fig. 6. Log earnings of sons and fathers in Norway. Regression line [slope=0.159(0.012)] and mean log earnings of sons and fathers for each percentile of father's earnings distribution.

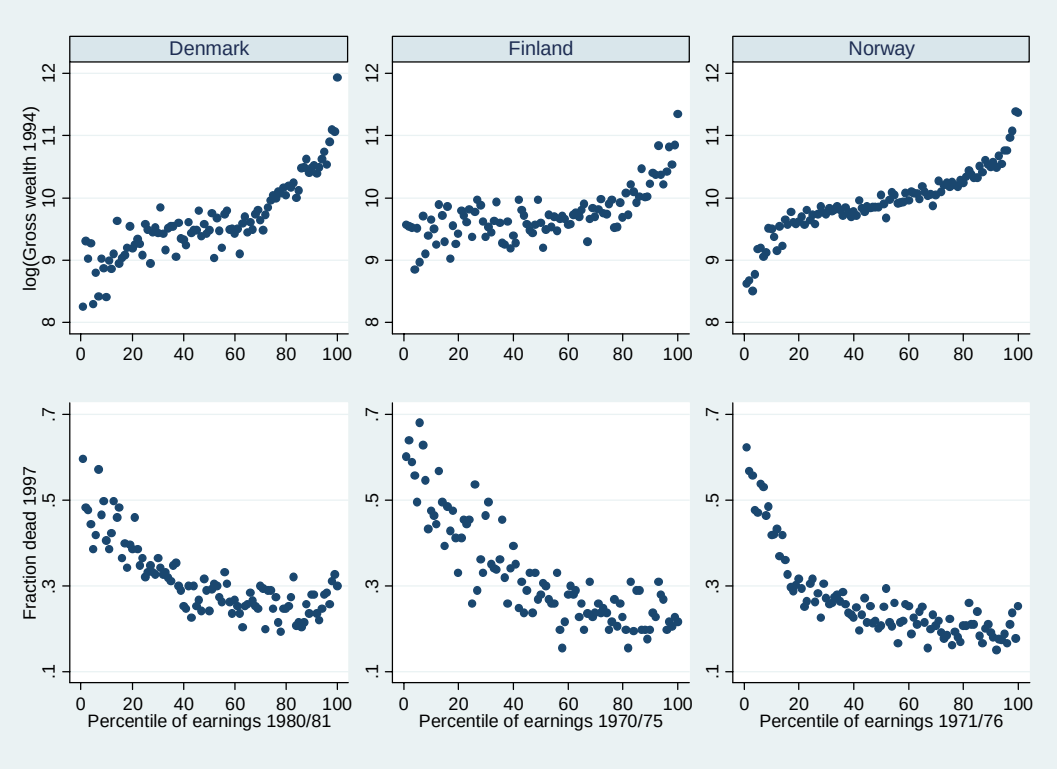

Fig. 7. Log wealth in 1994 and mortality by 1997 of fathers in Nordic samples, by percentile of earnings distribution.

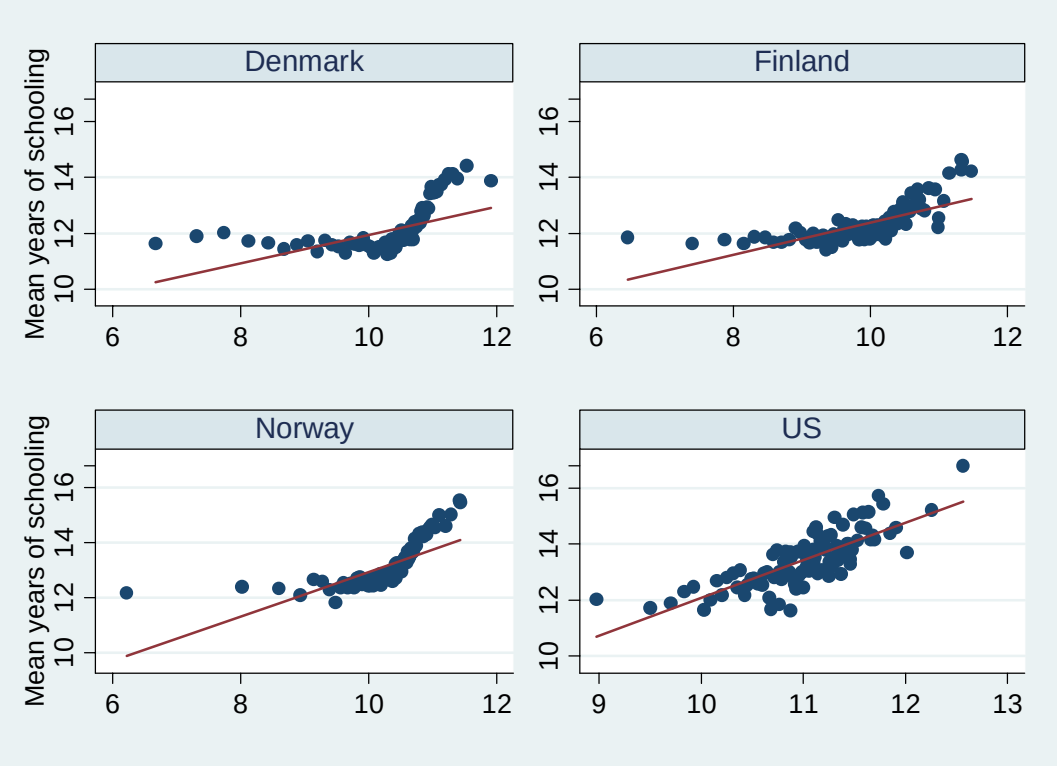

Fig. 8. Sons' educational attainment and parental earnings. Regression line [slopes are 0.505(0.079) in Denmark, 0.574(0.057) in Finland, 0.778(0.079) in Norway, and 1.346(.105) in the US] and mean years of schooling vs. mean log parental earnings for each percentile of earnings distribution (father's earnings in Nordic countries and parental income in the US).

Table 1. Intergenerational earnings persistence – elasticity estimates

	Denmark	***Finland***	***Norway***	***UK***	***US***
Linear model					
Elasticity	0.121	0.189	0.156	0.450	0.542
	(0.008)	(0.011)	(0.007)	(0.032)	(0.032)
RESET test, p-value	0.000	0.000	0.000	0.042	0.193
Nonlinear model					
At 10th percentile	0.063	0.138	0.168	0.346	0.489
	(0.015)	(0.014)	(0.009)	(0.073)	(0.039)
At 50th percentile	0.241	0.259	0.281	0.424	0.575
	(0.017)	(0.014)	(0.010)	(0.036)	(0.035)
At 90th percentile	0.312	0.339	0.368	0.531	0.646
	(0.022)	(0.022)	(0.017)	(0.060)	(0.055)
p-value nonlinear vs. linear model	0.000	0.000	0.000	0.114	0.019
Observations	18 706	9 706	26 628	2 384	1 999

Note: Standard errors are reported in parentheses. Nonlinear results are based on second (Finland, UK, and US), third (Norway), and fourth (Denmark) order polynomial specification of ln(father's earnings) (family income in the US). Selection of polynomial order is based on root mean square error. Regressions control for father's age and its square.

Table 2. Elasticity of son's earnings with respect to family income

	Denmark	***Finland***		***Norway***	***UK***
	(1)	(2)	(3)	(4)	(5)
Linear model					
Elasticity	0.155	0.216	0.231	0.138	0.359
	(0.009)	(0.012)	(0.012)	(0.006)	(0.033)
RESET test, p-value	0.000	0.000	0.000	0.000	0.556
Nonlinear model					
At 10th percentile	0.153	0.149	0.173	0.154	0.322
	(0.016)	(0.015)	(0.016)	(0.009)	(0.046)
At 50th percentile	0.271	0.288	0.266	0.269	0.367
	(0.017)	(0.015)	(0.014)	(0.010)	(0.033)
At 90th percentile	0.336	0.366	0.324	0.358	0.412
	(0.025)	(0.023)	(0.022)	(0.017)	(0.055)
p-value nonlinear vs. linear model	0.000	0.000	0.000	0.000	0.247
Comment	Sum of mother's and father's earnings	Sum of mother's and father's earnings	Family income from all taxable sources	Sum of mother's and father's earnings	Family income from all sources
Observations	18 706	9 856	9 937	27 364	2 337

Note: Standard errors are reported in parentheses. Nonlinear results are based on second (Finland and UK), third (Norway), and fourth (Denmark) order polynomial specification of ln(family income). Regressions control for father's age and its square.

Table 3. Sensitivity analyses

	Norway			***Denmark***	
	(1)	(2)	(3)	(4)	(5)
Linear model					
Elasticity	0.139	0.160	0.140	0.124	0.157
	(0.006)	(0.007)	(0.007)	(0.008)	(0.009)
RESET test, p-value	0.000	0.000	0.000	0.000	0.000
Nonlinear model					
At 10th percentile	0.178	0.166	0.154	0.062	0.153
	(0.008)	(0.010)	(0.009)	(0.015)	(0.017)
At 50th percentile	0.314	0.285	0.276	0.254	0.279
	(0.011)	(0.011)	(0.010)	(0.018)	(0.018)
At 90th percentile	0.405	0.379	0.369	0.340	0.369
	(0.016)	(0.017)	(0.017)	(0.023)	(0.026)
p-value nonlinear vs. linear model	0.000	0.000	0.000	0.000	0.000
Observations	27 108	24 536	25 228	16 373	16 373
Comment	Father's earnings 1971-1980, son's earnings 1992-2002	Father's earnings; father and mother do not live apart 1993	Family earnings; father and mother do not live apart 1993	Father's earnings; father and mother live together 1981	Family earnings; father and mother live together 1981

Note: Standard errors are reported in parentheses. Nonlinear results are based on third (Norway) and fourth (Denmark) order polynomial specification of ln(parents' earnings). Regressions control for father's age and its square.

Table 4. Probability that son is excluded from earnings sample because of zero earnings; probit regressions

	Denmark	*Finland*	*Norway*	*UK*	*US*
ln(father's earnings)	-.0145 (.0023)	-.0174 (.0029)	-.0067 (.0011)	-.0459 (.0120)	-.0301 (.0077)
Observations	20 648	10 431	27 295	2 487	2 134
Mean exclusion rate	.0928	.0695	.0244	.0515	.0633

Note: Gross samples consist of all sons with at least one valid earnings observation. "Sample exclusion" means that the son is recorded with zero earnings (Denmark, Finland, and Norway), reports being unemployed or otherwise economically inactive (UK), or reports zero earnings (US). In the UK sample, self-employed persons are omitted from the gross sample (because self-employment income is not reported in the survey). Among those excluded, 100 (Denmark), 97 (Finland), 84 (Norway), 31 (UK), and 61 (US) percent have zero earnings both observation years. Coefficients reflect change in probability (dp/dx). Standard errors are reported in parentheses. Regressions control for father's age and its square.

Table 5. Elasticity estimates using common sample restriction

	Denmark		*Finland*		*Norway*		*US*
Earnings of:	Father	Family	Father	Family	Father	Family	Family
Linear model							
Elasticity	0.169 (0.011)	0.202 (0.011)	0.247 (0.015)	0.260 (0.013)	0.240 (0.009)	0.224 (0.009)	0.555 (0.035)
RESET test, p-value	0.000	0.000	0.021	0.010	0.000	0.000	0.126
Nonlinear model							
At 10th percentile	0.083 (0.024)	0.159 (0.023)	0.184 (0.025)	0.186 (0.024)	0.187 (0.016)	0.171 (0.016)	0.486 (0.050)
At 50th percentile	0.254 (0.019)	0.278 (0.020)	0.262 (0.015)	0.290 (0.016)	0.294 (0.013)	0.274 (0.012)	0.576 (0.035)
At 90th percentile	0.332 (0.027)	0.341 (0.027)	0.321 (0.029)	0.352 (0.029)	0.360 (0.021)	0.352 (0.023)	0.651 (0.062)
p-value nonlinear vs. linear model	0.000	0.000	0.048	0.000	0.000	0.000	0.068
Observations	18 121	18 411	9 417	9 673	26 245	26 978	1 995

Note: Standard errors are reported in parentheses. All samples are limited to those with parental earnings of at least $3,000. Nonlinear results are based on second (Finland and US), third (Norway), and fourth (Denmark) order polynomial specification of ln(parental earnings). Regressions control for father's age and its square.