Catalogue no. 11F0019MIE — No. 207
ISSN: 1205-9153
ISBN: 0-662-34673-4

Research Paper

Analytical Studies Branch research paper series

Life cycle bias in the estimation of intergenerational earnings persistence

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August 2003

Thanks to Casey Mulligan, Sherwin Rosen, Jenny Wahl, Scott Drewianka, and two anonymous referees for helpful comments on this work. All errors are the sole responsibility of the author.

Aussi disponible en français

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ABSTRACT

The estimation of intergenerational earnings mobility is rife with measurement problems since the researcher does not observe permanent, lifetime earnings. Nearly all studies correct for mean variation in earnings due to age differences among respondents. And recent works employ average earnings or instrumental variables methods to address the effects of classical measurement error resulting from transitory earnings shocks and mis-reporting. However, empirical studies of intergenerational mobility have paid no attention to changes in earnings variance across the life cycle suggested by economic models of human capital investment. Using information from the Intergenerational Income Data from Canada, and the National Longitudinal Survey and Panel Study of Income Dynamics from the United States, this study finds a strong association between age at observation and estimated earnings persistence. Part of this age-dependence is related to a general increase in transitory earnings variance during the collection of data. But an independent effect of life cycle investment is also identified. These findings are then applied to the variation among intergenerational earnings persistence studies. Among studies with similar methodologies, one-third of the variance in published estimates of earnings persistence is attributable to cross-study differences in the age of responding fathers. Finally, these results call into question tests for the importance of credit constraints based on measures of earnings at different points in the life cycle.

Keywords: Intergenerational mobility and human capital formation.

JEL: J62, J24

I. *INTRODUCTION*

From a study of intergenerational earnings persistence estimates (the elasticity of son's earnings with respect to father's earnings) it would be reasonable to conclude that earnings regress toward the mean. But the rate of this regression is unclear; wide variation in estimates impedes precise estimation even within a country or data set. Of course, methodological differences can cause disparities in estimates. Couch and Lillard (1998) highlight the importance of alternative treatments of unemployed periods. And Solon (1992) and Zimmerman (1992) demonstrate the need for measurement-error correction since transitory earnings and reporting errors presumably affect the data. Correction for measurement error does in part explain the historical increase in persistence estimates. But, as Table 1 documents, substantial variation remains even among studies following the sample selection rules and measurement error correction proposed by Solon (1992) (averaging at least three years of earnings data or employing instrumental variables (IV)).[1] It is unreasonable to expect perfect conformity across studies, but differences of more than 200% warrant closer examination to see if we can understand these differences.

This paper offers an explanation for the remaining disagreement between studies: changing variance in earnings across the life cycle. Two important sources of earnings variance growth have been identified by economists. Multiple studies document increasing transitory earnings variance in the past several decades. Within a given data set, the later the time period, the older the age of both father and son and the more transitory earnings variance. Solon's (1989) observation concerning attenuation bias suggests decreasing persistence estimates as the father's age at observation increases (but no change as son's age) *ceteris paribus*. But there is a second factor at play that affects these predictions. Life cycle models of human capital investment (see Ben-Porath, 1967 or Mincer, 1974) predict an increase in non-transitory earnings variance over the life cycle. And so it is unclear whether estimated earnings persistence should rise or fall with father's age since the signal-to-noise ratio depends on which variance grows more. Across the son's life cycle, earnings persistence estimates should follow a U-shape similar to the U-shape in earnings variance found in the Ben-Porath model.

This paper studies the degree to which these two explanations account for variation in earnings persistence estimates across the life cycle. The next section reviews existing theory concerning the relationship between earnings persistence estimates and the ages of both the parent and child at the point of observation. The magnitude of the two effects is then estimated using data from the Canadian Intergenerational Income Data (IID) and the American Panel Study of Income Dynamics (PSID) and National Longitudinal Survey (NLS). The results indicate that both a general increase in transitory earnings variance and a 'life cycle bias' exist. Combined, these effects are much larger than those attributed in Solon (1992) to attenuation bias. In the fourth section, looking across studies it is found that approximately one-third of the variation in estimates is accounted for by the age of the father at the point of earnings observation. Finally, a

[1] Zimmerman (1992) is not included in this table because he restricts the sample to fathers and sons who are employed full-time where full-time is defined as 30 hours per week and 30 weeks per year. Given the results in Couch and Lillard (1998) and the warning in Solon (1992) that sample homogeneity exacerbates the bias caused by measurement error, this study is omitted. Altonji and Dunn (1991) study the same data as Zimmerman without imposing the additional full-time restriction. Their result is included in place of Zimmerman's.

positive use of the results is demonstrated with an application to testing for the presence of intergenerational credit constraints.

II. THE PROBLEM OF LIFE CYCLE BIAS

There are (at least) two reasons why we should expect estimates of intergenerational persistence to vary with the ages at which fathers and sons earnings are measured. First, as pointed out in Solon (1989, 1992, 1999), noise in measured earnings (whether due to mistaken reporting or transitory earnings components) produces an attenuation bias that reduces persistence estimates. A substantial literature (Gottschalk and Moffitt, 1994; Buchinsky and Hunt, 1999; Gittleman and Joyce, 1996; Haider, 2001; Baker and Solon, 1999) documents a general increase in inequality in both permanent and transitory components in Canada and the U.S. Growth in transitory earnings variance could lead to a larger attenuation bias (and lower persistence estimates) in later periods; as fathers age, estimates of earnings persistence might diminish.[2]

A second, less studied, reason for age-dependence in earnings persistence estimates is found in the theory of human capital accumulation. Ben-Porath (1967) models life cycle earnings as the outcome of a dynamic investment process. Workers who seek to maximize net lifetime earnings allocate their human capital *k* between one of two activities: production and learning. In addition, workers purchase investment goods *i* at price *P* per unit. Ben-Porath notes that the model is greatly simplified when a Cobb-Douglas form is assumed in the learning technology. In this case, the investment problem faced by the worker is

$$\begin{aligned} &\max_{s(.),i(.)} \int_0^T [R(1-s(t))k(t) - Pi(t)]e^{-rt}\,dt \\ &s.t.\quad k'(t) = \beta(s(t)k(t))^{\gamma_1} i(t)^{\gamma_2} \end{aligned} \tag{1}$$

where *r* is the discount rate, *T* is the length of the worker's career, *R* is the rental rate of capital, and *s* is the fraction of human capital devoted to the learning process. The parameter β represents worker ability which complements learning investments. Given this complementarity, workers with higher ability invest more and so experience greater earnings growth and, ultimately, higher earnings levels.

Of course, the optimal investment policy involves large up-front learning investments in both goods and time which gradually diminish over the life cycle as the end of the career draws near. This investment process produces a pattern of increasing earnings variance across the life cycle (or, more accurately, a U-shaped pattern, as Mincer (1974) observed.) Figure 1 illustrates this pattern using a calibrated version of the model drawn from Neal and Rosen (2000).[3] As workers age, the variance in the permanent component of annual earnings rises. To differentiate this

[2] Whether the attenuation bias increases or decreases with father's age depends on the trend in signal relative to noise. Since both permanent and transitory earnings components increased in Canada and the U.S., we cannot say for certain that the attenuation bias increased over time. In Canada, Baker and Solon (1999) find both components increased by similar magnitudes; in the U.S., Gottschalk and Moffit (1994) find that transitory variance grew at a rate between two third and equal to that of permanent variance while Haider (2001) finds equal growth. Equal growth in permanent and transitory earnings variance suggests constant attenuation bias and so no change in earnings persistence estimates.

[3] The parameter values are $\gamma_1=0.2$, γ_2=0.075$, $r=0.03$, $R/P=4$, $k(18)=1$, $T=65$, and $\beta=[0.05,0.10,.15]$.

from changes in transitory earnings variance, this variance will be referred to as 'life cycle variance'. This positive relationship between age and earnings variance is found in both Canada and the U.S. as Figures 2 and 3 demonstrate.[4] The data in Figure 2 represent roughly 20,000 fathers drawn from the Canadian IID panel—the same population that will be used in the empirical work of the next section. As the year of observation is varied from 1978 to 1991 and as the fathers age, the variance in log earnings rises by more than 100%. In the American PSID, a similar pattern is shown in Figure 3. In this case, the population examined is *all* males aged 25-34 in 1967; small sample size requires the inclusion of men who are not necessarily fathers.

A simple two-period model proposed in Jenkins (1987) connects this model of life cycle earnings with earnings persistence estimates. (While Jenkins rightly points out that earnings variance need not be constant across the life cycle, he makes no connection with economic models of life cycle earnings and oddly assumes decreasing life cycle earnings variance. As a result, Jenkins stops short of identifying important patterns in empirical estimates of intergenerational mobility that are discussed below.) Suppose for simplicity that the working life is broken into two periods called "youth" (period 1) and "maturity" (period 2). As in Figure 1, experience effects increase the mean level of log earnings over the life cycle. Since all studies of earnings persistence include controls for age, suppose the data are adjusted to eliminate this trend. Let G_F represent the ex-ante expectation for father's average earnings, η_i the transitory shock to father's earnings in period i, and δ the persistence of transitory shocks. (δ most likely lies between 0 and 1. However, the value of δ is irrelevant to all results in this section.) Then father's log earnings in youth and maturity are

$$\begin{aligned}
&F_1 = \alpha_{f1} G_F + \nu_1 \\
&F_2 = \alpha_{f2} G_F + \delta \nu_1 + \nu_2 \\
&\nu_1 \perp \nu_2,\ \ \nu_1 \perp G_F,\ \ and\ \ \nu_2 \perp G_F \\
&E(\nu_1) = E(\nu_2) = 0.
\end{aligned} \tag{2}$$

The son's earnings follow a pattern analogous to that of the father. While the transitory portions of son's and father's earnings are assumed to be independent, the permanent components are related

$$G_S = \beta G_F + e. \tag{3}$$

Two alternative notions of earnings persistence are natural in this framework. The first captures the structural relationship in equation (3) between the ex-ante permanent earnings of the parent and the child—simply β. The second studies ex-post permanent earnings (including transitory components). The regression coefficient from a regression of son's cumulative earnings on father's cumulative earnings has probability limit

[4] Clearly, a portion of the observed change is also due to the increase in transitory earnings variance mentioned above.

$$\frac{\operatorname{cov}(S_1+S_2,F_1+F_2)}{\operatorname{var}(F_1+F_2)} \equiv \tilde{\beta} = \beta \frac{(\alpha_{s1}+\alpha_{s2})(\alpha_{f1}+\alpha_{f2})\sigma_G^2}{(\alpha_{f1}+\alpha_{f2})^2\sigma_G^2+(1+\delta)^2\sigma_{\nu1}^2+\sigma_{\nu2}^2} \leq \beta \tag{4}$$

where σ_G^2 is the variance of the fathers' permanent components G_F and $\sigma_{\upsilon i}^2$ is the variance of transitory components υ_i. This statistic will be denoted $\tilde{\beta}$. Depending on their purpose, economists seek methods to estimate either β or $\tilde{\beta}$.

Unfortunately, even the best panel data sets available cover little more than one-third of the life cycle for both fathers and sons. To demonstrate the bias which results from this data limitation, a 'life cycle bias', Jenkins first considers the typical study which utilizes observations for sons in youth and fathers in maturity. In the framework described above, the regression analysis examines

$$S_1 = \gamma_{12}F_2 + \varepsilon. \tag{5}$$

The probability limit of γ_{12} is

$$\frac{\operatorname{cov}(S_1,F_2)}{\operatorname{var}(F_2)} = \beta \frac{\alpha_{s1}\alpha_{f2}\sigma_G^2}{\alpha_{f2}{}^2\sigma_G^2+\delta^2\sigma_{\nu1}^2+\sigma_{\nu2}^2}. \tag{6}$$

It is clear that this is neither the ex-ante parameter β nor the ex-post parameter $\tilde{\beta}$. In general, it is impossible to sign the difference between *plim* (γ_{12}) and either of the parameters of interest.

As panel data sets have developed, some researchers have attempted to obtain observations for fathers and sons at the same point in the life cycle. (For example, see Bielsby and Hauserm, 1977 and Lillard and Kilburn, 1995.) Since some of these attempts rely on retrospective earnings histories, measurement error is obviously a concern. Supposing the problems of measurement error can be remedied, Jenkins also considers the results of the following same-period regressions:

$$\begin{aligned} S_1 &= \gamma_{11}F_1 + \varepsilon \\ S_2 &= \gamma_{22}F_2 + \varepsilon. \end{aligned} \tag{7}$$

In the first case, both fathers and sons are observed in their youth. (This is the most likely case using available panel data.) The probability limit of γ_{11} is

$$\frac{\operatorname{cov}(S_1,F_1)}{\operatorname{var}(F_1)} = \beta \frac{\alpha_{s1}\alpha_{f1}\sigma_G^2}{\alpha_{f1}{}^2\sigma_G^2+\sigma_{\nu1}^2}. \tag{8}$$

Again it is clear that this matches neither parameter of interest. It is easily shown that the sign of the bias is indeterminate for both β and $\tilde{\beta}$. Predictably, observing fathers and sons in maturity is no better. In this case, *plim* (γ_{22}) is

$$\frac{\operatorname{cov}(S_2, F_2)}{\operatorname{var}(F_2)} = \beta \frac{\alpha_{s2}\alpha_{f2}\sigma_G^2}{\alpha_{f2}{}^2\sigma_G^2 + \delta^2\sigma_{\nu1}^2 + \sigma_{\nu2}^2}. \tag{9}$$

In general, the life cycle bias cannot be corrected by observing sons and fathers at a similar point in their lives. Jenkins (1987) leaves off with the "destructive" conclusion that single-year observations are insufficient to consistently estimate the degree of earnings persistence regardless of the period of observation for fathers or sons.

However, a closer examination of the biased estimates γ_{12}, γ_{11}, and γ_{22} shows that much more can be said. Consider again the results when corrections for measurement errors have been made or the variance in transitory earnings $\sigma_{\upsilon i}^2$ is a constant fraction of earnings variance—as Gottschalk and Moffitt (1994), Baker and Solon (1999), and Haider (2001) have found in Canada and the U.S.

$$\begin{aligned} p\lim \gamma_{12} &= \beta \frac{\alpha_{s1}}{\alpha_{f2}} * m \\ p\lim \gamma_{11} &= \beta \frac{\alpha_{s1}}{\alpha_{f2}} * m \quad \textit{and} \\ p\lim \gamma_{22} &= \beta \frac{\alpha_{s2}}{\alpha_{f2}} * m \end{aligned} \tag{10}$$

where *m* is a multiplier capturing the attenuation bias (=1 when corrections are made). If the attenuation bias does not change too much across the life cycle or measurement-error corrections are made, these biased estimates can be ordered by magnitude. The life cycle increase in earnings variance implies that $\alpha_{f1} < \alpha_{f2}$ and $\alpha_{s1} < \alpha_{s2}$. And so, $\gamma 11 > \gamma_{12}$ and $\gamma_{22} > \gamma_{12}$.

The intuition of these results is easy to see with a simple example. Panel (a) of Figure 4 simulates the earnings of three individuals. Solid lines represent the expected paths of log earnings. Transitory shocks cause actual observations (stars) to deviate from the expected paths. In Panel (b), the mean trend in the expected paths and the transitory shocks have been eliminated. The example has been constructed consistent with the Ben-Porath model in that life cycle earnings variance is increasing.

Suppose that fathers and sons from the same family share an expected wage path; high-earning fathers have high-earning sons while low-earning fathers have low-earning sons. Once the common trend due to age is subtracted and classical measurement error has been eliminated, the age-earning profiles in the population follow the pattern shown in Panel (b) of Figure 4 with father and son following the same ray. If a lifetime of data were collected for both fathers and sons, a measurement-error corrected estimate of earnings persistence would equal 1. However, suppose only a single year's earnings is collected for both father and son. Fix a year in which to observe sons, say at age 30. If son's log earnings are regressed on father's log earnings,

$$y_s = \hat{\beta} y_f + \varepsilon, \tag{11}$$

how does the estimate of earnings persistence change as the year of observation for fathers is varied? For example, consider observing fathers at age 35 versus 55. As the observation point of fathers is moved later in the life cycle, the variance in fathers' earnings grows. A larger variance in fathers' earnings must explain the same variance in sons' earnings; the estimated degree of earnings persistence falls. Similarly, as the observation period for the sons moves later in the life cycle, holding the observation period of fathers constant, the estimated degree of earnings persistence rises. This variation in the estimates is an artifact of mis-measurement due to changes in life cycle earnings variance. Since (unlike transitory earnings variance) economic theory suggests that this variance is intrinsically connected with the life cycle, this will be referred to bias as 'life cycle bias.'[5]

III. EMPIRICAL EVIDENCE OF THE LIFE CYCLE BIAS

Only recently have panels of sufficient length existed so that the life cycle bias can be empirically studied.[6] The IID (Canada) contains data from 1978 through 1998 and the PSID (United States) includes observations from 1967 through 1992. In addition, sporadic earnings observations over more than a decade can be found in the NLS (United States). This studies the life cycle bias in all three of these data sets.

A. Estimation

Each data set contains multiple observations for both sons and fathers. For each combination of observation period for fathers and sons, an ordinary least squares regression is calculated.[7] Control variables include age and age-squared for both fathers and sons. For instance, in equation (12) sons' log incomes measured in 1993 are regressed on fathers' log incomes measured in 1987.

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[5] Given the secular U-shaped pattern of log earnings variance in very early years of observation, the bias may actually produce a U-shaped pattern across sons' ages if early observations of sons are used. If the U-shape in life cycle variance is produced by high-(lifetime) earning sons experiencing earnings below those of low-(lifetime) earnings sons (as in the stylized Ben-Porath model), we might predict negative estimates of earnings persistence when sons are observed very early in life. However, the U-shape pattern in earnings variance may also result from high-earning sons accepting jobs with initially slow earnings growth since these jobs include substantial on-the-job training. That is referred to here.

[6] Reville (1995) does examine the dependence of persistence estimates on father's age. Son-age dependence and the connection to life cycle models of earnings are not explored.

[7] Obviously, single-year measures of earnings contain measurement error and so the level of earnings persistence estimated in the following section are lower than the true value. However, in identifying the importance of a life cycle bias, we are interested in the *trend* in estimates over the life cycle. This trend is easier to identify when we have a large number of estimates from a wide range of ages. When the analysis is repeated using three-year averages of earnings, the same qualitative results obtain. But with one-third the number of observations, it is more difficult to see the trend.

$$y_{s,93} = \alpha + \gamma_1 age_{s,93} + \gamma_2 age^2_{s,93} + \gamma_3 age_{f,87} + \gamma age^2_{f,87} + \beta y_{f,87} \qquad (12)$$

A decomposition of the estimated slope coefficient is useful in differentiating effects driven by life cycle earnings variance from those caused by transitory earnings variance. If r_j (j=s,f) is log earnings controlled for father and son age, then the estimate of earnings persistence can be decomposed

$$\beta = \frac{\text{cov}(r_s, r_f)}{\text{var}(r_f)} = \frac{\text{cov}(r_s, r_f)}{\sqrt{\text{var}(r_f)\,\text{var}(r_s)}} \frac{\sqrt{\text{var}(r_s)}}{\sqrt{\text{var}(r_f)}} = \rho_{rs,rf} \frac{\sqrt{\text{var}(r_s)}}{\sqrt{\text{var}(r_f)}} \qquad (13)$$

where $\rho_{rs,rf}$ denotes the correlation between r_s and $r_{f.}$ Table 2 compares the effects of increasing transitory earnings variance with those of increasing life cycle earnings variance. (It is presumed in the second case the transitory earnings variance is present, but constant.) Two patterns distinguish the two causes. First, while the correlation coefficient is diminished if transitory earnings variance increases with age of either father or son, the correlation is increased as life cycle variance grows (and the signal-to-noise ratio increases). And while the life cycle bias predicts a positive relationship between earnings persistence estimates and son's age, persistence estimates are not related to son's age due to changes in transitory earnings variance. Comparing the effects on ρ and relative earnings variance also differentiates the two sources of variance. While a change in transitory earnings variance affects ρ and relative earnings variance in the same direction across the father's life cycle, a change in life cycle earnings variance produces opposing effects. The reverse is true across the son's life cycle.

One issue that slightly complicates the predictions in Table 2 is the sorting of young men into occupations and jobs. If earnings of young men are particularly error ridden, then even as transitory earnings variance has increased over time, transitory components among young men may have been diminishing over the observed portion of their life cycle. This is supported by Björklund (1993) who finds that earnings are more correlated with permanent income later in life and that mobility in earnings decreases with age. And so we may not see a decrease in the correlation coefficient across son's age—it may even increase—when the son is young. Similarly, if high-(permanent) earning sons accept jobs with initially low earnings growth, the life cycle bias predicts a U-shaped pattern across the early years of the son's career. In total, we should expect to see changes in earnings persistence estimates most clearly across the father's life cycle.

B. Results

National Longitudinal Survey

Zimmerman (1992) reports earnings persistence estimates for multiple observations of both fathers and sons in the Original Cohort NLS. This is precisely the data required to explore life cycle bias. Zimmerman's results are consistent with the presence of a large life cycle bias; β decreases (increases) as fathers (sons) age and the correlation is positively correlated with son's, but not father's, age. But the study restricts the sample to only include fathers and sons who are employed at least 30 hours per week and 30 weeks per year. The analysis is updated using the more common restriction that respondents must report positive earnings to be included in the sample.

The pattern in the NLS of earnings persistence as fathers age (see Figure 6) is consistent with both a life cycle bias and growing transitory earnings variance. (All of the graphs in this section are constructed in a similar fashion. For each year of father (son) observation there are multiple years of son (father) observation from which to choose. Earnings persistence estimates are computed for each possible father-son observation pair. These estimates are represented by points in the figure. For instance, there are five NLS son observations that can be paired with each father observation. So, for each year of father observation, there are five estimates of earnings persistence. In the NLS and PSID, the standard errors are relatively large, approximately 0.05 to 0.10. For this reason, we focus on the trend in the *average* of the persistence estimates represented by a solid line.) The results show a more than 50% drop in estimated earnings persistence as the fathers age by only 5 years; a result even more dramatic than that found in Zimmerman (1992). However, while earnings persistence decreases with father's age, the correlation is nearly constant (see Figure 6). This is *inconsistent* with rising transitory earnings variance in the sample, but consistent with a life cycle bias. In total, the patterns as fathers age are consistent only with the life cycle bias.

When the data are studied across years of son observations, again the observations are consistent with the life cycle bias. Figure 7 reports a U-shaped pattern in earnings persistence as sons age. No evidence of rising transitory earnings variance is found, though this is not surprising given the young age of the sons.

When the persistence estimates are decomposed into correlation and variance portions in Figure 8, it is difficult to see incontrovertible trends in the data; while the data do not appear in conflict with a significant life cycle bias, it is difficult to draw strong conclusions.

There are two limitations in the NLS data that cause this ambiguity. First, the data are collected only sporadically. Second, the data cover only a short window of time for both fathers and sons. For example, the interpretation of the pattern across son's age is largely driven by the last year. Two other North American data sets provide data that address both of these issues: the Canadian IID and the American PSID.

Intergenerational Income Data

With observations spanning 15 years for fathers and 8 years for sons, the Canadian IID provides a better examination of the life cycle bias. Figure 9 shows a substantial and sustained trend toward less earnings persistence as fathers age. (Since the IID sample size is so large, standard errors for each of the estimates—or points in the figure—are very small, around 0.006 to 0.009.) The estimated earnings persistence falls by more than one-third when the year of father observation is increased 15 years. But is this a life cycle bias or simply the result of rising transitory earnings variance? Decomposing the persistence estimates (see Figure 10), we see that none of the drop in estimated earnings persistence is attributable to a change in earnings correlations. This is again inconsistent with increasing transitory earnings variance, but predicted by a significant life cycle bias.

When persistence estimates across son's age are considered, we find a life cycle pattern that, while not inconsistent with life cycle bias, appears more related to changes in transitory variance. In Figure 11, the effect of altering the year of son observation by 8 years is to increase estimated earnings persistence by more than 50 percent. This is consistent with either a life cycle bias or sorting into jobs—a transitory earnings story.

Again, an examination of the intergenerational correlations helps us to differentiate the two stories (see Figure 12). The entire trend can be explained by changes in earnings correlations, consistent with sorting. It is not surprising to find little trend in life cycle bias among the sons since these men are only 26-29 years old in 1991 at the beginning of the study. Referring back to the plots of earnings variance in Canada and the U.S., growth in earnings variance is relatively slow early in the life cycle. While this means that we should not expect to find a strong trend across son's age, this does not mean that persistence estimates for young sons are not affected by life cycle bias. As the Canadian sons age, we must expect that persistence estimates will continue to grow as the variance of sons' earnings increases with age.

Panel Study of Income Dynamics

By way of comparison, the PSID also contains multiple earnings observations for both fathers and sons over a relatively long time span. The PSID is of special importance since it is the basis of most U.S. studies of intergenerational earnings persistence. Figure 13 plots the resulting earnings persistence estimates as the period of observation for fathers is varied from 1967 to 1981. A clear downward trend is evident, as predicted by both rising transitory earnings variance and a life cycle bias. In total, estimated earnings persistence falls by approximately 50%.

The magnitude of this drop is comparable to that found in the NLS, but the interpretation is very different. Figure 14 shows that the entire effect can be explained by changes in earnings correlations. This finding suggests that if the U.S. had not experienced an increase in transitory earnings variance, earnings persistence estimates would not have been sensitive to father's age.

Persistence patterns across son's age provide a second opportunity to identify a life cycle bias. Figure 15 plots the estimates of earnings persistence against year of son observation for each period of father's observation. As sons age by 10 years, estimated earnings persistence increases by about 33%. The decomposition of this rise in Figure 16 suggests that both sorting and a life cycle bias are present. In particular, the trend in earnings correlations does not fully account for the trend in persistence estimates. And much like the prediction made in Mincer (1974), the variance in sons' earnings falls initially before increasing again—a U-shaped pattern.

Unlike the NLS, the patterns in the PSID present a mixed picture of the life cycle bias. This conflict with the NLS, like that between the estimated level of intergenerational earnings persistence in Altonji and Dunn (1991) and Solon (1992), suggests that U.S. intergenerational researchers would greatly benefit from having access to administrative data. However, one advantage the NLS and PSID share is that the data include many variables other than earnings. In particular, both data sets include measures of education. If education is a valid instrument for father's earnings, then the effects of transitory earnings can be eliminated. If education is not a valid instrument (as hypothesized by Solon (1992) and empirically confirmed in Lillard and Kilburn 1995 and Grawe 2001), then a bias is introduced. (Indeed, in the following figure the *IV* estimates of persistence are sometimes *much* higher than the *OLS* estimates suggesting substantial endogeneity bias.) But the percent by which endogeneity biases the results is independent of the age at which fathers or sons are measured and so the *trend* in persistence estimates remains. And so instrumental variables estimation provides another exploration of life cycle bias.

Figure 17 plots IV estimates of earnings persistence for both the NLS and PSID. Unfortunately, the conflict between the NLS and PSID is not diminished. The patterns found in the NLS confirm a life cycle bias with downward trend across father's age and a U-shape across son's age. But in the PSID, there is no evidence of a life cycle bias across father's age; there is only scant evidence of a rising trend across son's age. In the PSID, we must conclude that while the age at which earnings are observed is critical to non-IV persistence estimates, this may simply reflect the importance of changes in transitory earnings variance in that sample.

IV. Reconciling a Wide Range of Persistence Estimates

The strong age-dependence of persistence estimates found in the previous section suggests that differences in the age of father observation might explain a significant portion of the variation between published studies. (The age of son observation could also be important. But since the studies do not differ much in this dimension, the focus is on father's age.) Since log earnings variance follows a U-shaped pattern, the relationship between father's age and persistence estimates should be non-linear (an inverted U).

Tables 3 and 4 and Figure 18 explore this hypothesis, comparing the mean age of fathers in the study to the estimate of earnings persistence. In Table 3, the studies are approximately ordered by the mean age of fathers. When possible, the persistence estimate is chosen in each study corresponding most closely to the selection rules in Solon (1992): a) positive annual earnings required in several years which are averaged to control for measurement error and b) include only the oldest son available. Björklund and Jäntti (1997), Dearden et al. (1997), and Wiegand (1997) deviate from the first rule, employing IV methods. Some studies do not report average ages of the fathers. In these cases, the table reports a reasonable range for the average age based on other information in the study. In cases in which it is particularly difficult to infer the average age of the father, a question mark is included after the range. This will add measurement error to the analysis and decrease the potential to explain differences using the age of the father.

Figure 18 plots the reported estimates and includes regression lines. Table 4 summarizes the regression results. The dashed line plots the regression line predicted for IV estimates; the solid line plots the regression line predicted for studies using multi-year averages of father's earnings as the independent variable. IV estimates are higher by 0.12 on average suggesting either that multi-year averages of father's earnings fail to effectively eliminate measurement error or that the instrument is endogenous. As predicted, the relationship between the age of the father and the estimated earnings persistence is strongly negative and concave. A 15-year change in the age of the father results in a 0.18- to 0.21-point decrease in estimated persistence; this difference is significant in both quadratic and linear models. In total, 23 percent of the variance in the estimates can be explained by the error correction methodology (IV vs. averaging of father earnings); of the variance remaining, 36 percent is explained by life cycle bias. The method of error correction and father's age combine to explain fully one-half of the existing variation.

These results substantially alter perceptions of 'outliers' among the studies. For instance, Couch and Dunn's (1997) estimates of roughly 0.1 for both Germany and the U.S. are changed from being "far too low" to "just about right given the age of the fathers in the samples". This example also makes clear the danger in meta-analysis—the use of existing parameter estimates in subsequent studies (for instance, comparing the results in Behrman and Taubman 1985 to Corak and Heisz 1999 to study mobility differences in the U.S. and Canada). If the age of fathers in the utilized studies differ substantially, then the resulting comparison is biased.

Finally, given the wide range of published results, it is natural to wonder which of the studies appears to come closest to the true degree of earnings persistence. The theoretical work of the previous sections makes it clear that it is impossible to confidently answer this question without data covering the entire life cycles of fathers and sons. However, using the rule of thumb that it is better to use measurements near *mid-life for both father and son (where* $\alpha_f \approx \alpha_s$*)*, it would seem that recent studies which observe fathers in their forties and sons in their late-twenties to mid-thirties are most accurate. (See Altonji and Dunn (1991), Solon (1992), and Corak and Heisz (1999), for example.) Since the sons are very young even in the best surveys, we should expect that these studies slightly underestimate earnings persistence.

V. A POSITIVE APPLICATION: TESTING FOR INTERGENERATIONAL CREDIT CONSTRAINTS

In addition to studying questions of measurement, economists attempt to discriminate between alternative models of economic behavior. The life cycle bias identified in this paper can be applied to empirical tests for credit constraints that limit education choices. Noting that theory predicts stronger earnings persistence when credit constraints bind Becker and Tomes (1986) and Behrman and Taubman (1990) report that estimated earnings persistence is greater when fathers are observed during the child's high school years rather than at a point later in the life cycle. But does this result reflect credit market failure?

Since life cycle models of earnings predict increasing earnings variance over the life cycle *by construction* estimates of mobility should be lower when parents' earnings are measured at earlier points in the life cycle. Estimates based on observations of fathers in the 1970s and 1980s are especially prone to this effect since increases in transitory inequality during this period may amplify the life cycle profile of earnings variance. The observed pattern in estimated earnings persistence cannot stand alone as evidence for or against credit constraint models.

Some may point to the decreasing trend in father-son earnings correlation across years of father observation in the PSID as evidence in favour of credit constraints. First, this pattern is not found in the NLS or IID data sets. Second, in work not reported here intergenerational earnings correlations in the PSID constraining sons to be between the ages of 10 and 12 in 1968. Given these sample restrictions, it is possible to observe earnings correlations before, during, and after the sons' college education decisions were made. There are no discernible breaks in trend corresponding to the college decision. While credit constraints may indeed be present, this method of testing potentially confounds credit-constraint effects with life cycle or attenuation bias.

VI. CONCLUSION

The development of new panel data sets allows students of intergenerational mobility to compare experiences across several countries and groups. However, when looking across studies, economists must keep in mind both economic models of life cycle investment and the general increase in transitory earnings variance experienced by Canada, the U.S., and some other countries in the 1970s-1980s. In particular, increases in earnings variance over the life cycle lead to smaller estimates of earnings persistence when fathers are observed late in life rather than early; earnings persistence estimates decrease by roughly 50% when fathers are observed at age 55 rather than at age 40. Similarly, as the age at which sons are observed increases, we can expect persistence estimates to increase. In both the Canadian IID and the American NLS, there is evidence that the economic model of life cycle investment produces a life cycle bias. In the American PSID, the changes in earnings persistence appear related to an increase in transitory earnings variance with no life cycle bias.

These results assists in our understanding of several empirical observations in the literature. First, we can explain a significant portion of the variation observed between studies. Among studies with similar methodologies, one-third of the variance in estimated earnings persistence can be attributed to cross-country differences in fathers' ages. Second, this paper demonstrates that care must be taken in interpreting trends in earnings persistence estimates as evidence for (or against) alternative models of family choice. If the observed patterns can also be explained by changes in earnings variance, alternative tests of the models must be explored. This principle is applied to the issue of intergenerational credit constraints, raising questions concerning previously cited evidence for binding constraints.

DATA APPENDIX

National Longitudinal Survey

Father's wage and salary incomes are recorded in 1966, 1967, 1969, and 1971 for the year prior to the survey. Fathers are restricted to be no older than 55 in 1966 to ensure that a selection bias is not introduced as older fathers retire in later periods. Positive earnings must be reported to be included in the sample.

The sons drawn from the Young Men Cohort are restricted to be no older than 18 in 1966 to avoid oversampling of sons who live at home after high school. Sons' wage and salary labour incomes from the previous year are reported in 1971, 1973, 1975, 1976, 1978, 1980, and 1981. Given the young age of the respondents, the 1971 and 1973 data are not used. To be included in the sample, the son must report positive earnings. In cases in which more than one son is available from a given household, only the oldest son in the sample is used. Note that this may not be the oldest son in the family since an older son may not have been included in the survey or the sample. The sample sizes range from 270 to 367 depending on the observation years of fathers and sons.

Intergenerational Income Data

The construction of the IID from Canadian tax files is described in detail in Corak and Heisz (1999). The sample studies families with children ages 16-19 in 1982. A one-in-ten sample was taken from the full data set and then, from this sample, the oldest available son for each family was selected. (Note, the oldest available son may or may not be the oldest son in the family.) This resulted in 56,141 father-son pairs. The data was then limited to those fathers born between 1932 and 1942 (inclusive) in order to avoid attrition bias since fathers' labour incomes were recorded from 1978 to 1992. Sons' labour incomes were recorded from 1991 to 1998. The sample includes only observations with positive earnings reports.

Through an examination of the mean and variance of reported incomes, several coding irregularities were found. It appears that a significant number of observations in 1978-1982 were assigned a value of $1 when, in other years, they would have been reported as $0. Similarly, in 1996, a significant number of observations were assigned earnings of $2. It was not possible to determine why the data included these anomalies. "Positive earnings reports" refer to incomes greater than $1 in 1978-1982 and greater than $2 in 1996.

Panel Study of Income Dynamics

Sons, 9 to 17 years old at the time of the initial 1968 PSID survey, are observed from 1983 to 1992. The exclusion of younger sons ensures that the observations of the sons' incomes are not overly affected by non-representative observations at the beginning of the career. Exclusion of older sons avoids over-representation of sons who live with their parents beyond high school. Since head labour income is used to measure earnings, the son must be the head of household in the observation period in question in order to be included in the sample. Non-positive earnings reports are excluded. In families in which there is more than one son which fits these restrictions, the sample includes only the oldest available son.[8]

"Fathers" in the sample are the male heads of the households in which the sons lived in 1968. They are observed in the years 1967 to 1981. Fathers are eliminated from the sample if their age does not fall between 30 and 46 (inclusive) in 1967. Inclusion of older fathers who will likely retire during the observation period would introduce a sampling bias. Again, fathers must be heads of household in the observation period in question and report positive earnings. The resulting sample sizes range from 199 to 260 depending on the observation years of fathers and sons.

[8] The study was replicated using the sample of all sons. The results do not change substantially with this alternative sample definition.

Table 1
Estimates of intergenerational income persistence organized by mean father age

Author	Estimate	Location
Lillard & Kilburn (1995)	0.27 (0.070)	Malaysia
Corak & Heisz (1999)	0.23 (0.006)	Canada
Mulligan (1997)	0.33 (0.040)	U.S.
Björklund & Jäntti (1997)	0.28 (0.094)	Sweden
Shea (2000)	0.36 (0.043)	U.S.
Solon (1992)	0.41 (0.093)	U.S.
Björklund & Jäntti (1997)	0.42 (0.121)	U.S.
Peters (1992)	0.14 (0.013)	U.S.
Behrman & Taubman (1983)	0.27 (0.050)	U.S.
Dearden et al. (1997)	0.58 (0.059)	UK
Tsai (1983)	0.28 (0.018)	Wisconsin
Österbacka (2001)	0.13 (0.005)	Finland
Couch & Dunn (1997)	0.11 (0.063)	Germany
Wiegand (1997)	0.20 (0.270)	Germany
Altonji and Dunn (1991)	0.18 (0.028)	U.S.
Couch & Dunn (1997)	0.13 (0.061)	U.S.
Behrman & Taubman (1985)	0.09 (0.045)	U.S. Military

Note: *Standard errors in parentheses*

Table 2
Effects of changes in transitory and life cycle earnings variance

	Effect of Rise in Transitory Earnings Variance		**Effect of Rise in Life Cycle Earnings Variance**	
	Increase in… father's age	son's age	Increase in… father's age	son's age
β	-	0	?	+
$\rho_{rs,rf}$	-	-	+	+
$\sqrt{\frac{\text{var}(r_s)}{\text{var}(r_f)}}$	-	+	-	+

Table 3
Estimates of intergenerational income persistence organized by mean father age

Author	Father Mean Age	Estimate	Location
Lillard & Kilburn (1995)	30-40?	0.27	Malaysia
Corak & Heisz (1999)	40-45	0.23	Canada
Mulligan (1997)	40-45	0.33	U.S.
Björklund & Jäntti (1997)	43	0.28	Sweden
Shea (2000)	44	0.36	U.S.
Solon (1992)	44	0.41	U.S.
Björklund & Jäntti (1997)	45	0.42	U.S.
Peters (1992)	47	0.14	U.S.
Behrman & Taubman (1983)	45-50	0.27	U.S.
Dearden et al. (1997)	45-50	0.58	UK
Tsai (1983)	45-50?	0.28	Wisconsin
Österbacka (2001)	48.5	0.13	Finland
Couch & Dunn (1997)	51	0.11	Germany
Wiegand (1997)	51	0.20	Germany
Altonji and Dunn (1991)	52	0.18	U.S.
Couch & Dunn (1997)	53	0.13	U.S.
Behrman & Taubman (1985)	55-59	0.09	U.S. Military

Table 4
Explaining cross-study estimate variation using age of father at observation

Effect of Father's Age on Estimates of Earnings Persistence

	Quadratic Model	Linear Model
Father's age (a_f)	0.069 (1.078)	-0.012 (2.259)
Father's age^2 (a_f^2)	-0.001 (-1.270)	NA
IV dummy	0.121 (2.014)	0.140 (2.251)
E[$\hat{\beta}$ | a_f=40]- E[$\hat{\beta}$ | a_f=55]	0.211 (2.669)	0.180 (2.259)
R-square	0.509	0.448

Note: *t-values in parenthesis*

Figure 1
Life cycle pattern in earnings

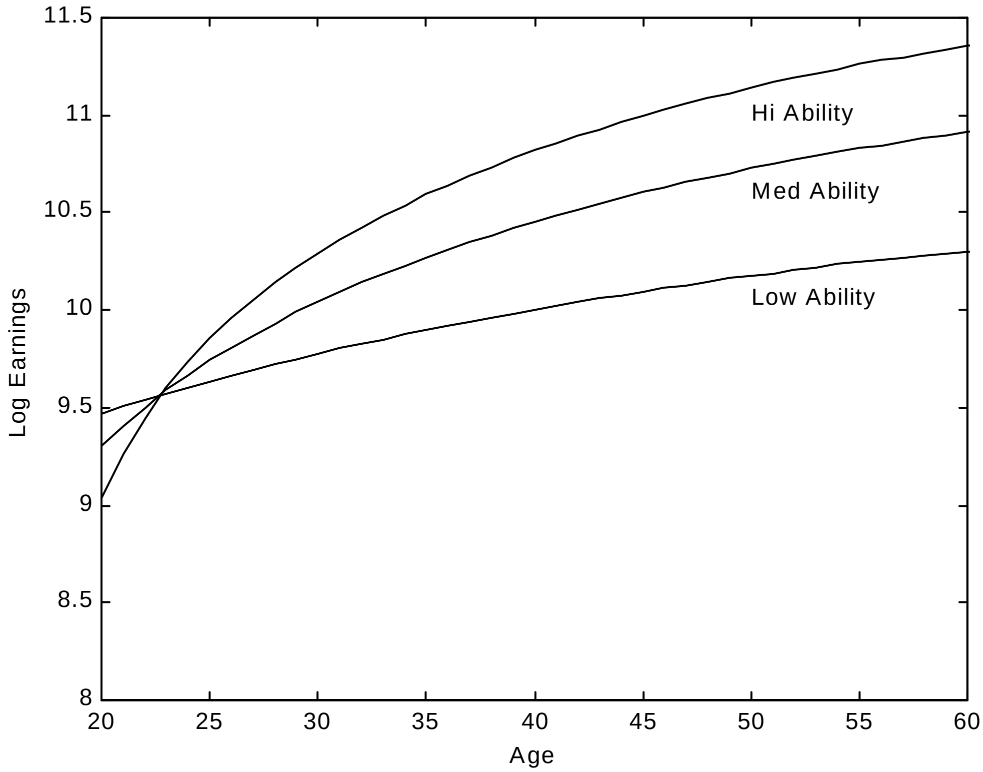


Figure 2
Increasing earnings variance over the life cycle in the Canadian IID panel

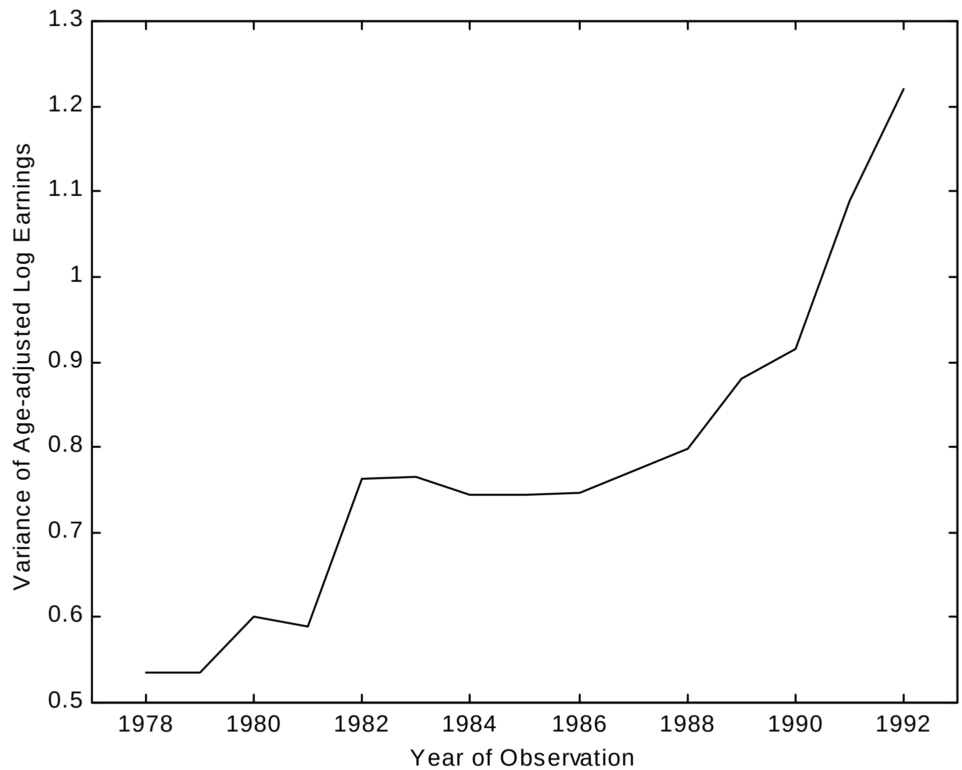


Figure 3
Increasing earnings variance over the life cycle in the U.S. PSID panel

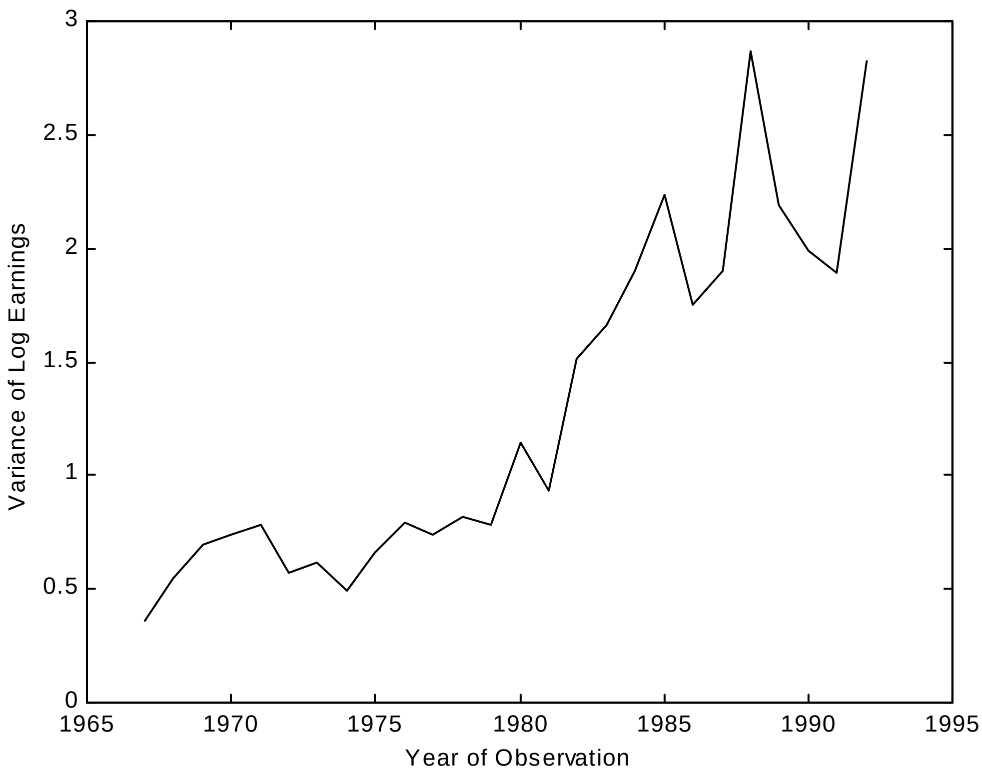
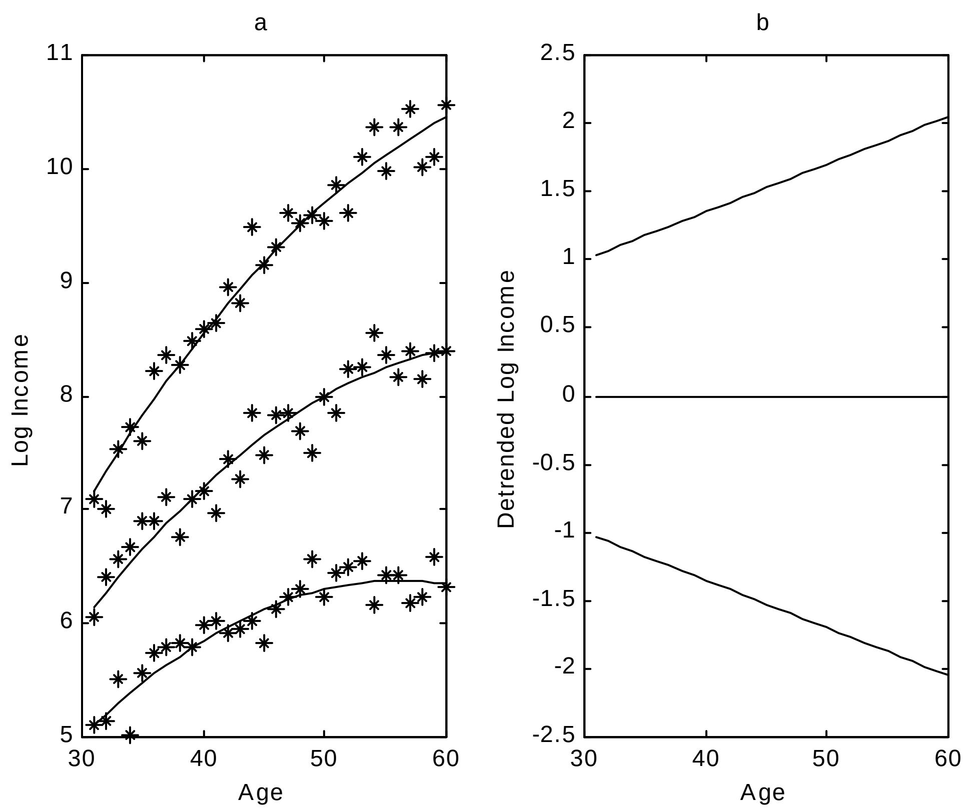


Figure 4
Age-income profiles before and after detrending and measurement error correction.



Note: *(a)* Raw age-income profiles; (*b)* Detrended, error-purged age-income profiles

Figure 5
Pattern of earnings persistence across year of father observation in the NLS

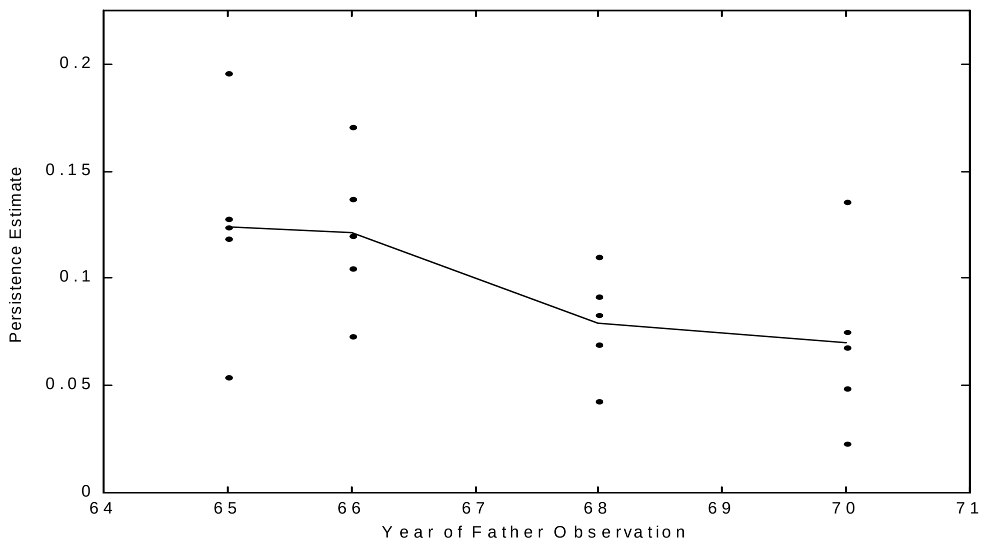
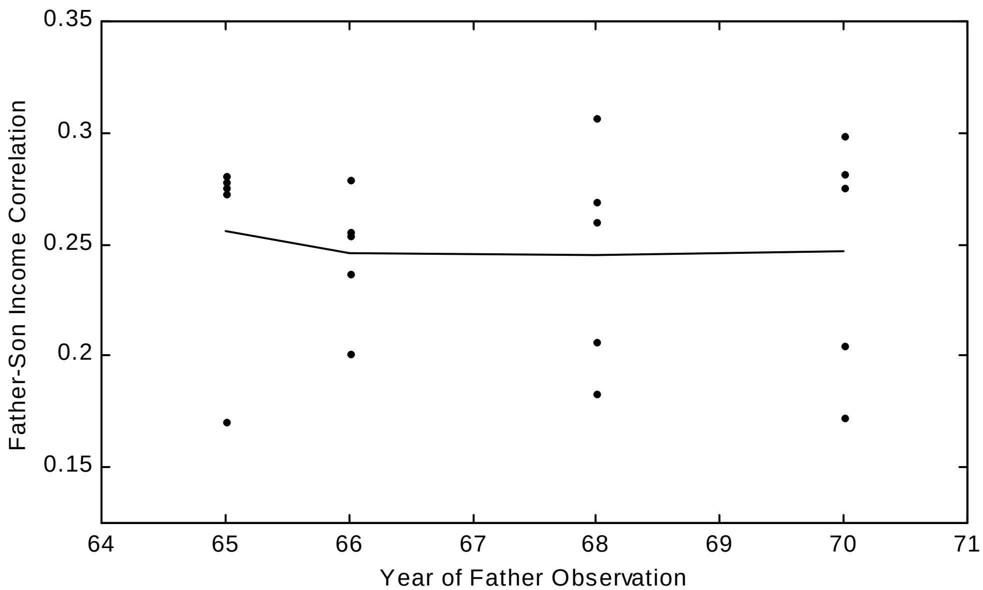


Figure 6
Decomposition of persistence estimates across year of father observation in the NLS



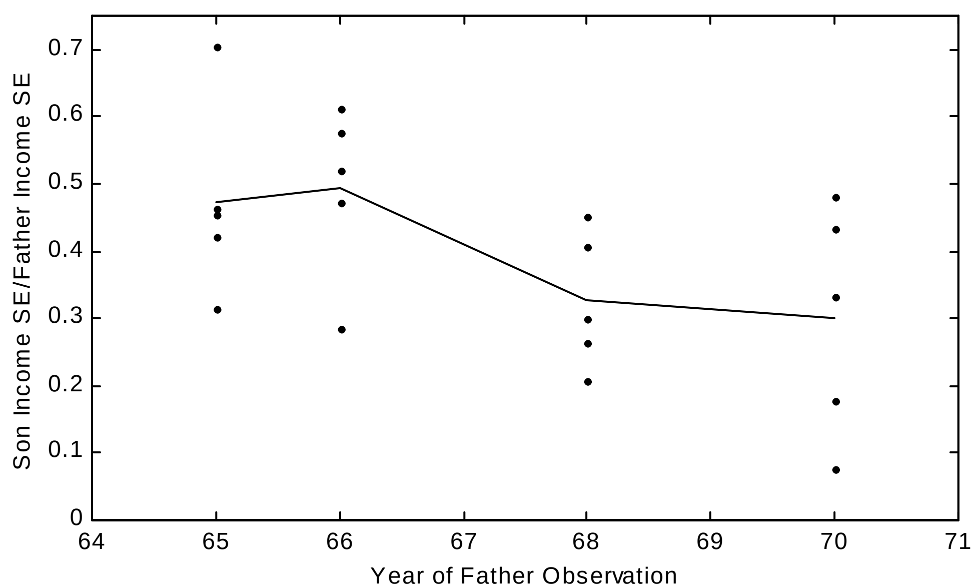


Figure 7
Pattern of earnings persistence across year of son observation in the NLS

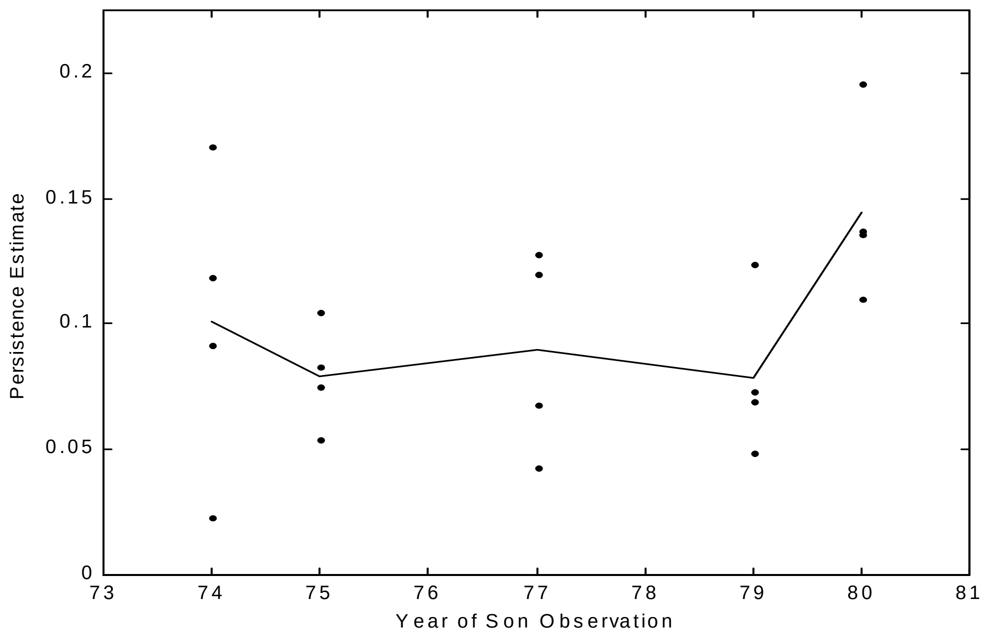
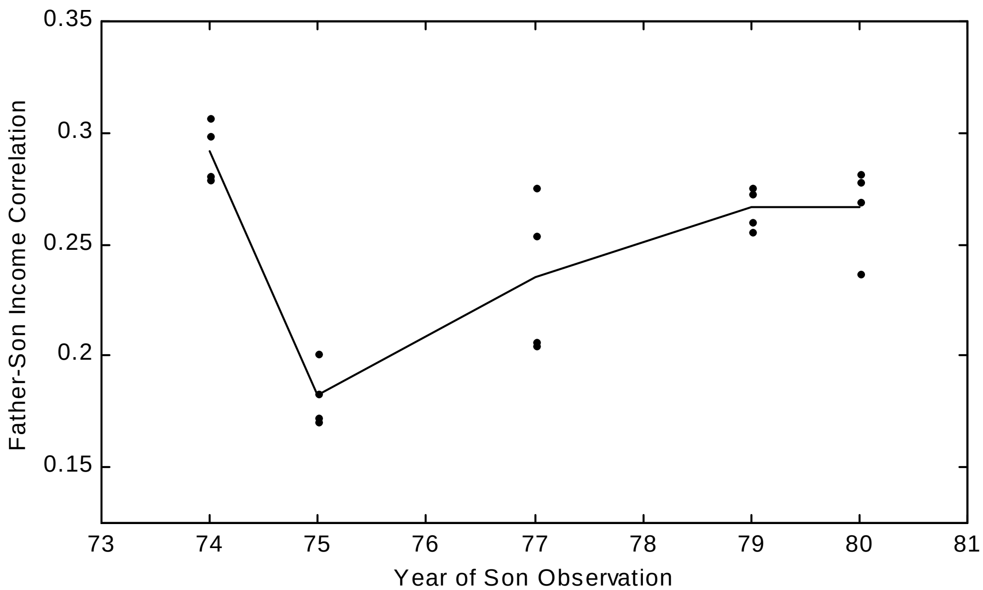


Figure 8
Decomposition of persistence estimates across year of son observation in the NLS



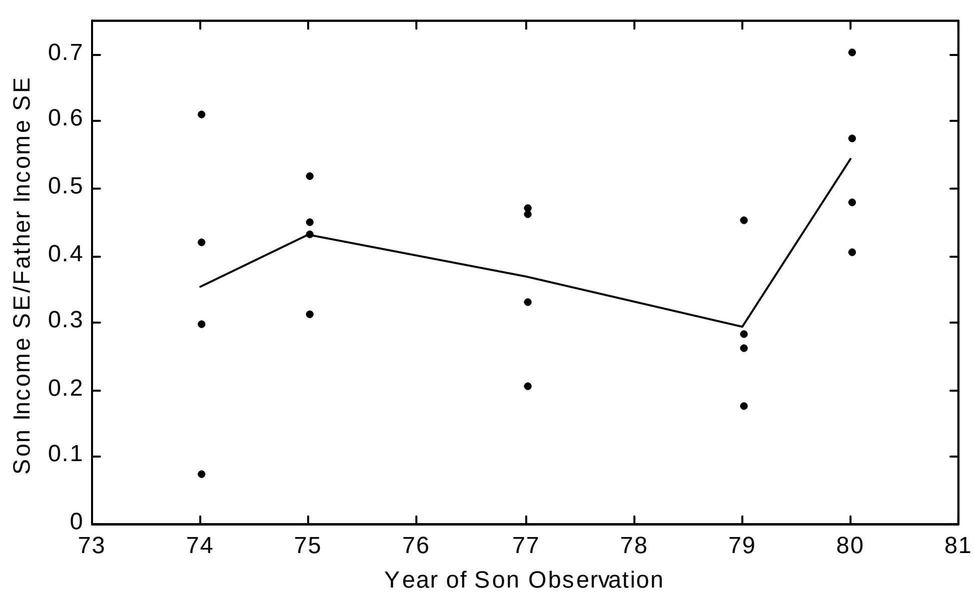


Figure 9
Pattern of earnings persistence across year of father observation in the IID

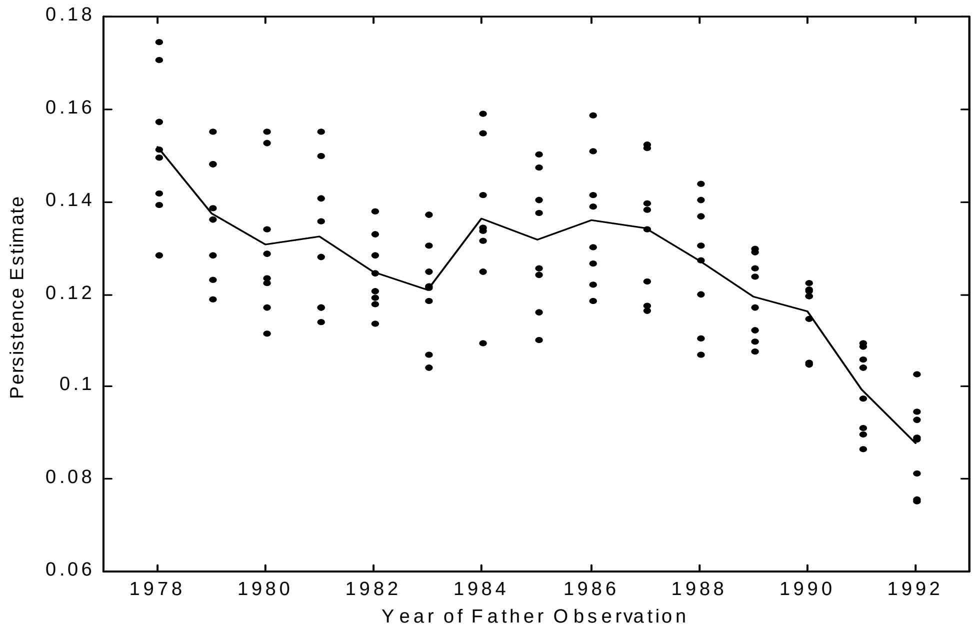
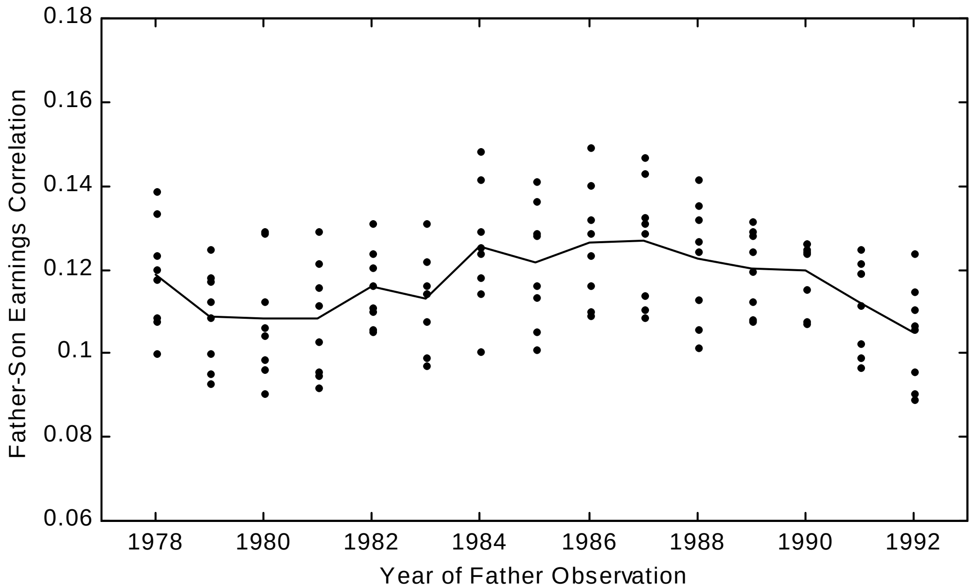


Figure 10
Decomposition of persistence estimates across year of father observation in the IID



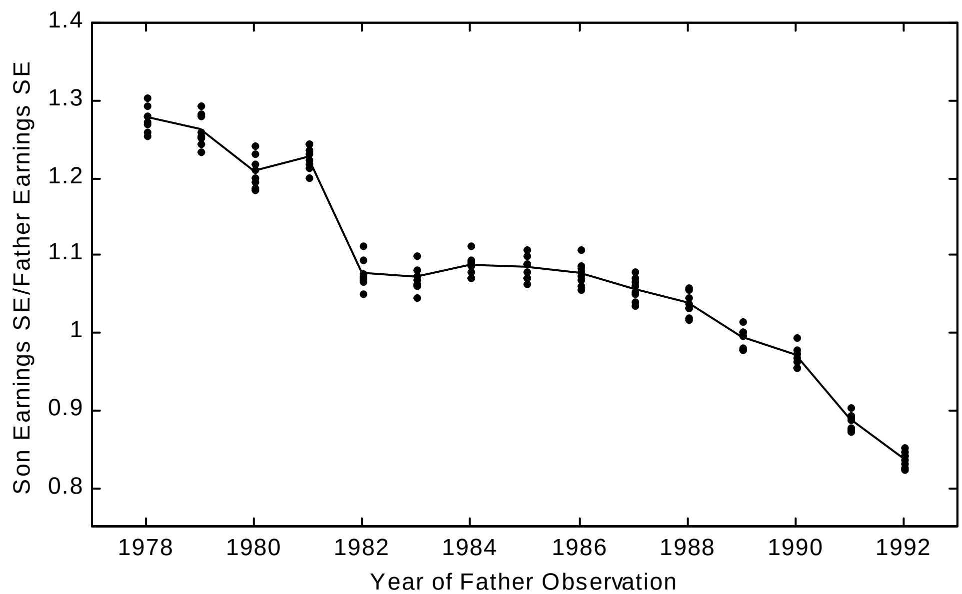


Figure 11
Pattern of earnings persistence across year of son observation in the IID

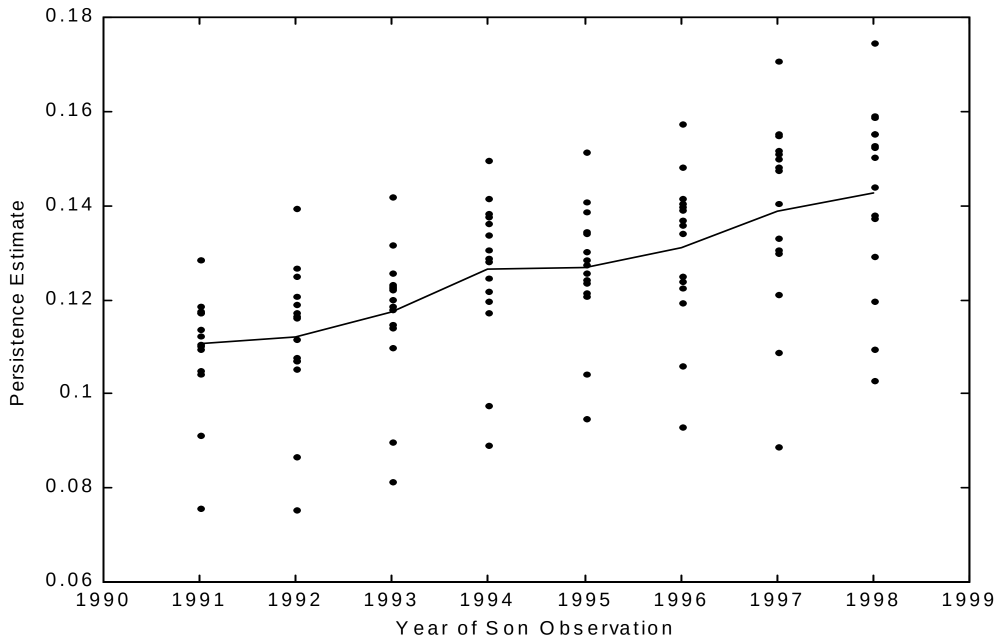
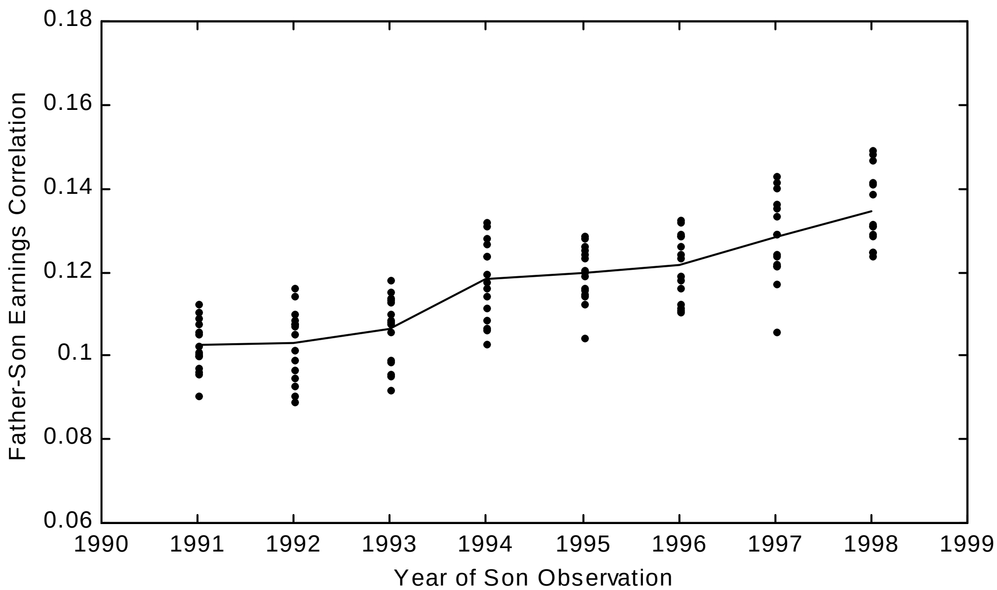


Figure 12
Decomposition of persistence estimates across year of son observation in the IID



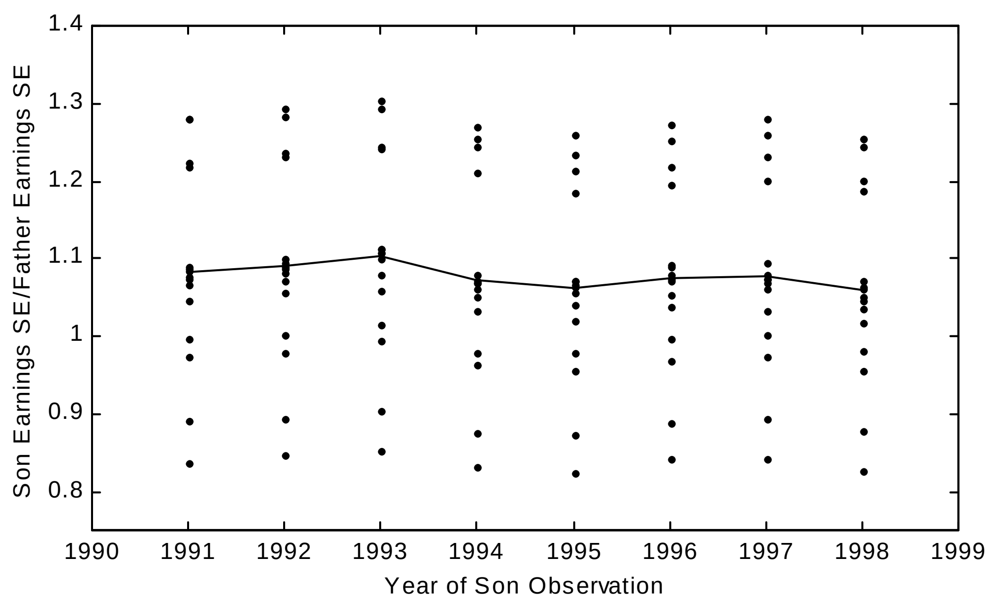


Figure 13
Pattern of earnings persistence across year of father observation in the PSID

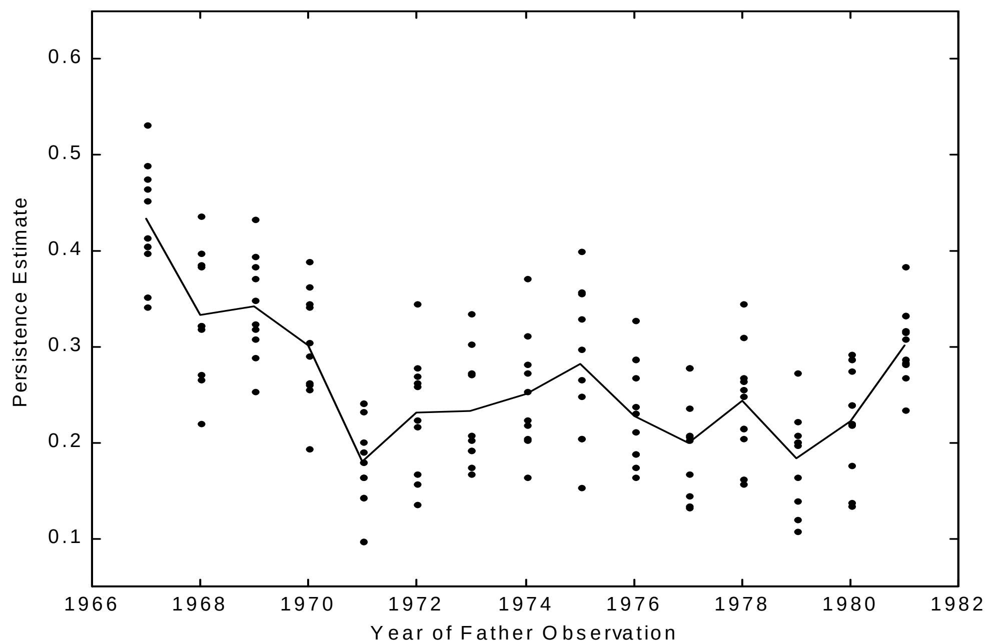
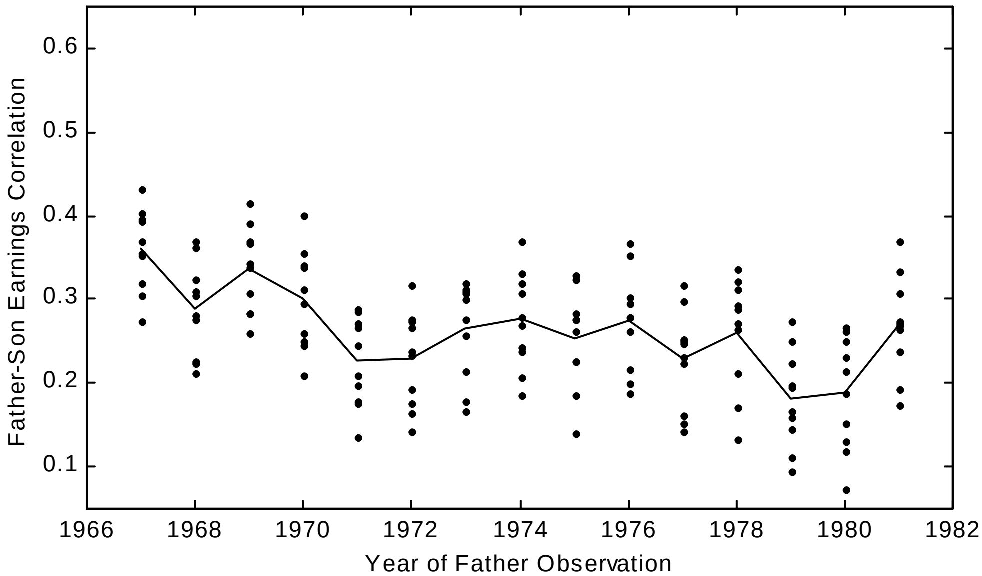


Figure 14
Decomposition of persistence estimates across year of father observation in the PSID



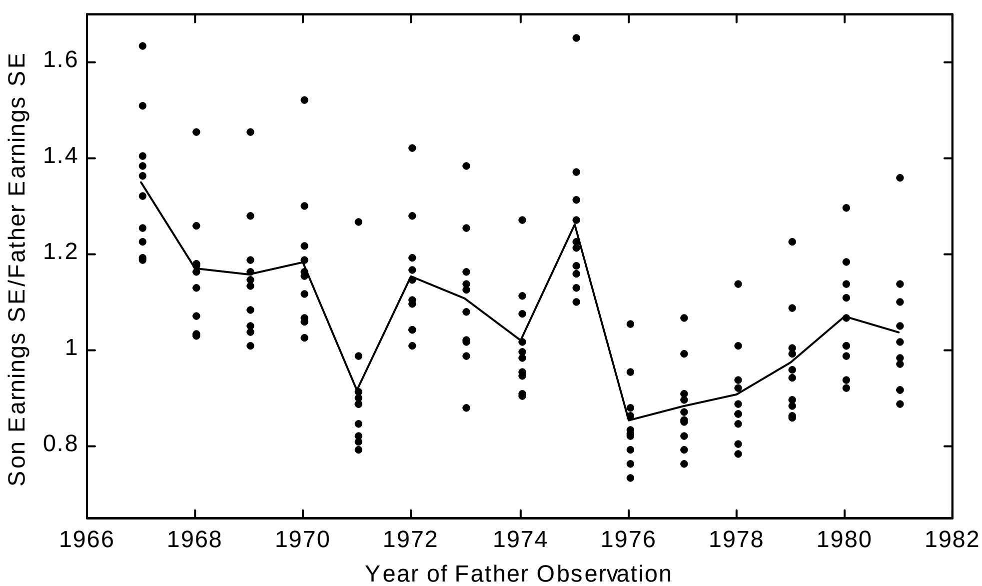


Figure 15
Pattern of earnings persistence across year of son observation in the PSID

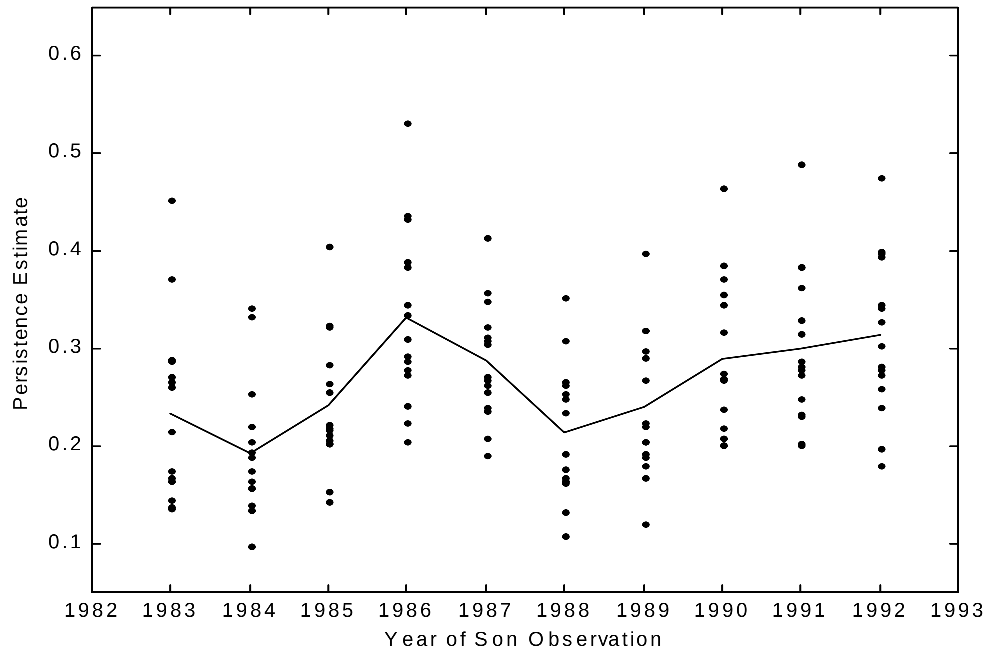


Figure 16
Decomposition of persistence estimates across year of son observation in the PSID

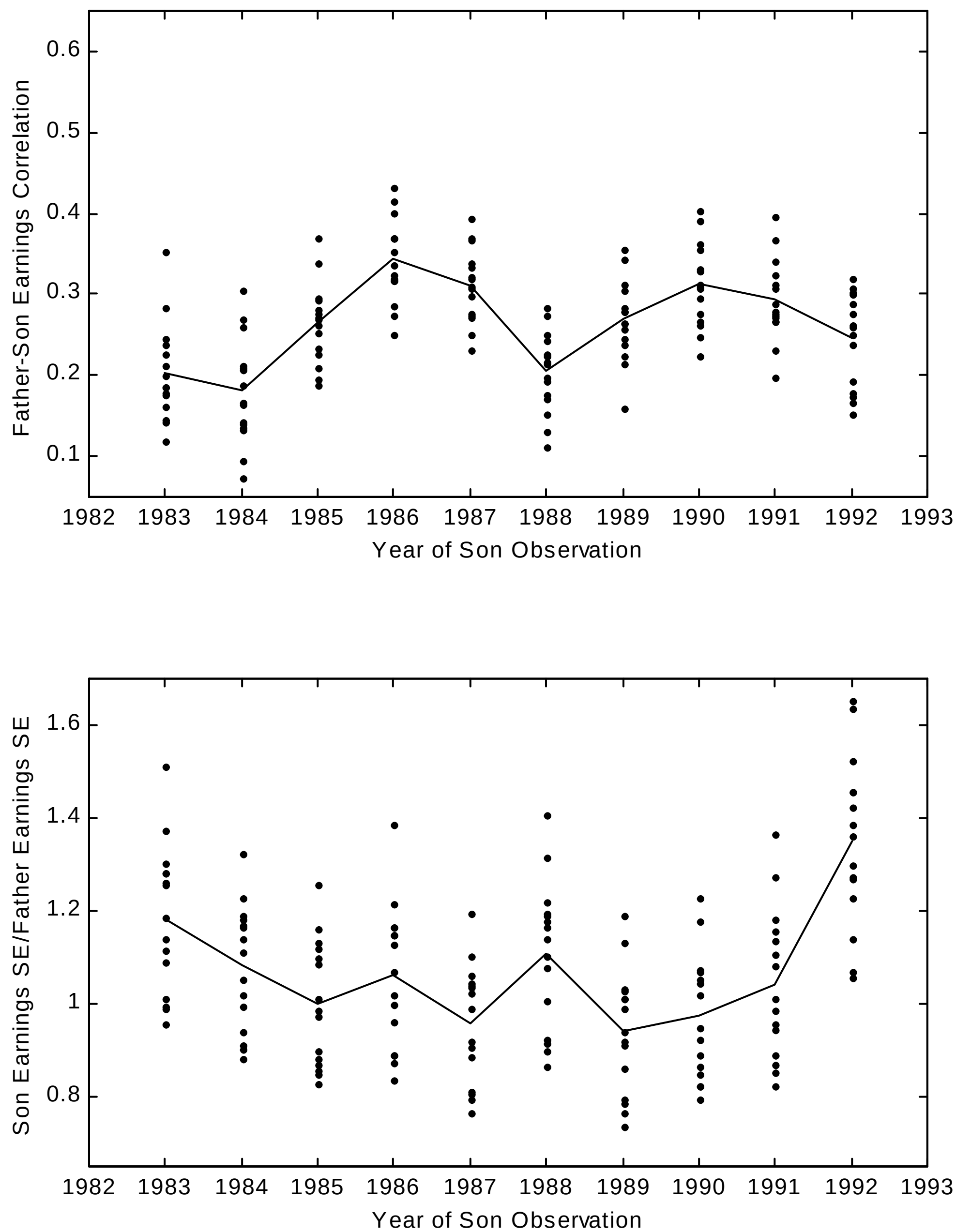


Figure 17

Pattern of earnings persistence across year of son observation in the NLS and PSID using instrumental variables estimation

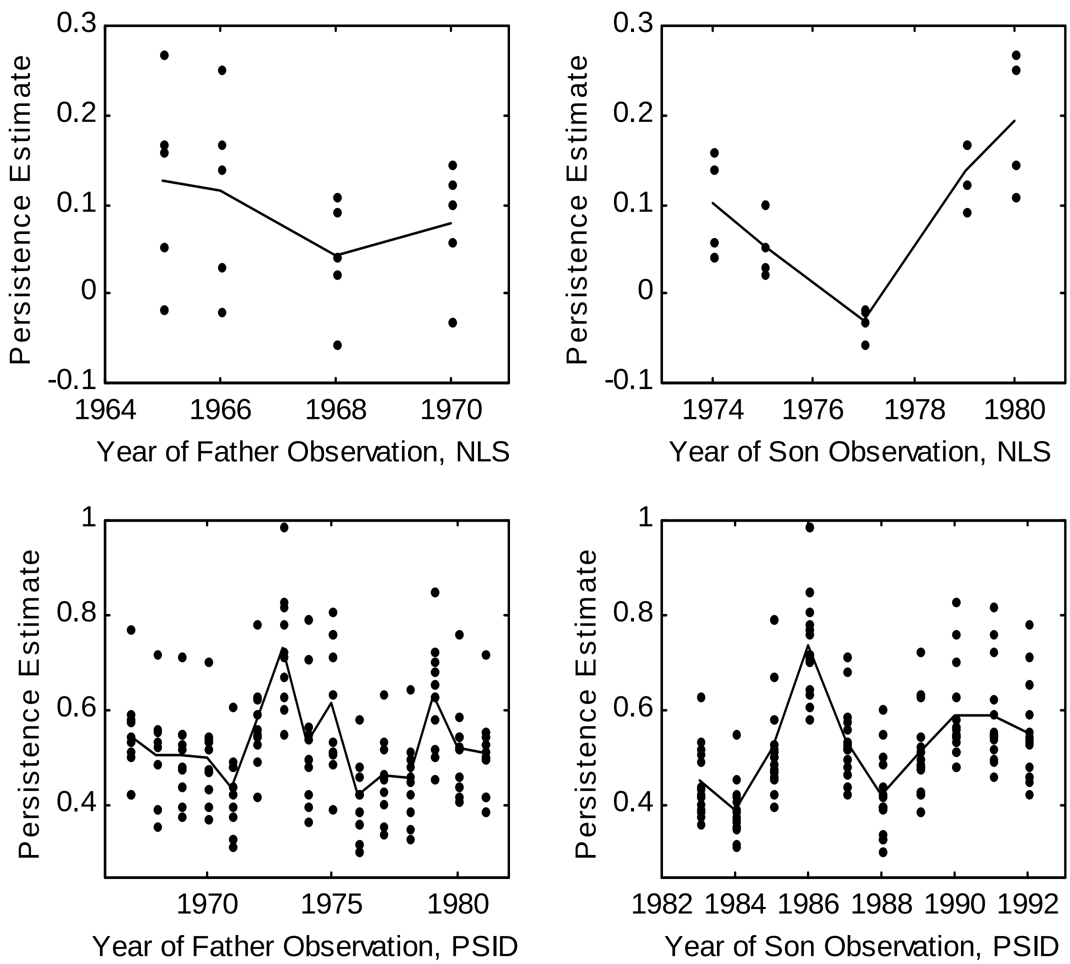
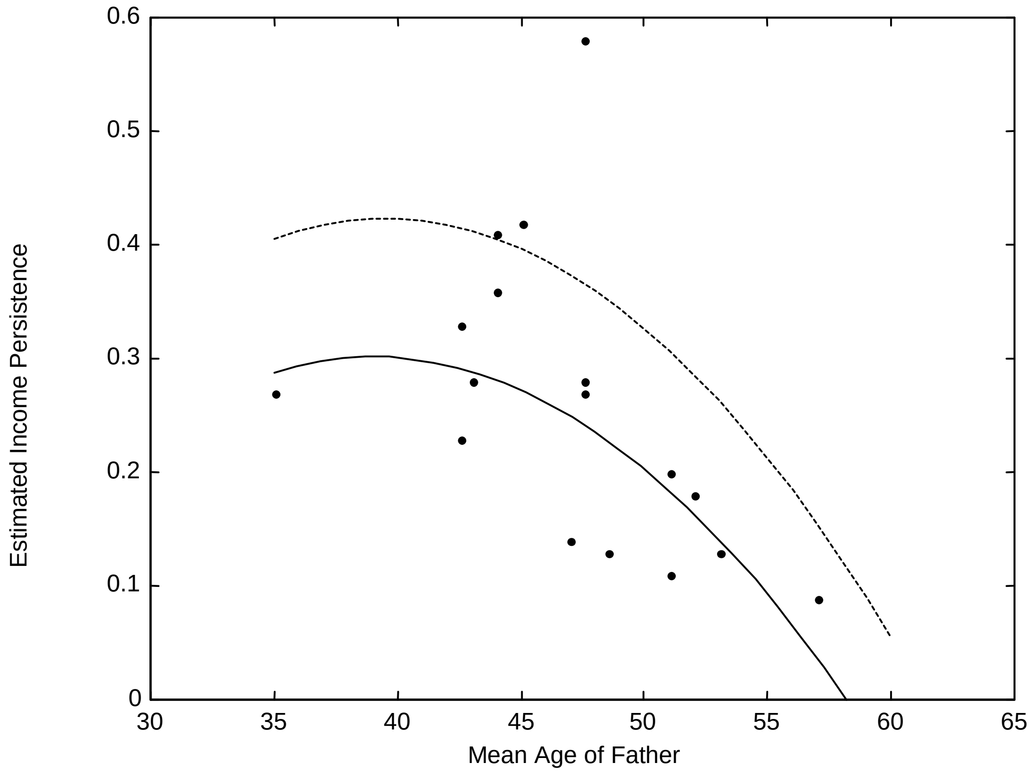


Figure 18
Age-dependence of income persistence estimates



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