Online Appendix to "Spillover bias in multigenerational income regressions"

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A Derivations

The following provides derivations of the probability limits shown in the main text of the paper, though here we do not assume stationarity as done in the paper. This means that $\sigma^2_{x_g}$ and $\sigma^2_{v_g}$ are allowed to vary across generations ($g = 1, 2$).

In the population, the true multigenerational process is:

$$y_{i0} = \gamma_1 x_{i1} + \gamma_2 x_{i2} + \epsilon_i. \tag{1}$$

We observe annual earnings measures, x^*_{it1} for fathers and x^*_{it2} for grandfathers:

$$x^*_{it1} = x_{i1} + v_{it1}, \tag{2a}$$
$$x^*_{it2} = x_{i2} + v_{it2}. \tag{2b}$$

So the equation we estimate with our data is:

$$y_{i0} = \gamma_1 x^*_{it1} + \gamma_2 x^*_{it2} + \epsilon^*_{it}. \tag{3}$$

A.1 OLS estimation

We can derive the OLS estimator of γ_1 using the Frisch-Waugh-Lovell theorem and some algebra:

$$\begin{aligned}
\hat{\gamma}_{1,OLS} &= (x_1^{*'} M_2 x_1^*)^{-1} x_1^{*'} M_2 y && \text{(4a)}\\
&= [x_1^{*'}(I - x_2^*(x_2^{*'}x_2^*)^{-1}x_2^{*'})x_1^*]^{-1} x_1^{*'}(I - x_2^*(x_2^{*'}x_2^*)^{-1}x_2^{*'})y && \text{(4b)}\\
&= [x_1^{*'}x_1^* - x_1^{*'}x_2^*(x_2^{*'}x_2)^{-1}x_2^{*'}x_1^*]^{-1}[x_1^{*'}y - x_1^{*'}x_2^*(x_2^{*'}x_2^*)^{-1}x_2^{*'}y] && \text{(4c)}\\
&= \left[\sum_{i=1}^N x_{i1}^{*2} - \sum_{i=1}^N x_{i1}^* x_{i2}^* \sum_{i=1}^N x_{i2}^{*2} \sum_{i=1}^N x_{i2}^* x_{i1}^*\right]^{-1} \left[\sum_{i=1}^N x_{i1}^* y_i - \sum_{i=1}^N x_{i1}^* x_{i2}^* \sum_{i=1}^N x_{i2}^{*2} \sum_{i=1}^N x_{i2}^* y_i\right] && \text{(4d)}\\
&\vdots\\
\hat{\gamma}_{1,OLS} &= \frac{\sum_{i=1}^N x_{i1}^* y_i \sum_{i=1}^N x_{i2}^{*2} - \sum_{i=1}^N x_{i1}^* x_{i2}^* \sum_{i=1}^N x_{i2}^* y_i}{\sum_{i=1}^N x_{i1}^{*2} \sum_{i=1}^N x_{i2}^{*2} - \left(\sum_{i=1}^N x_{i1}^* x_{i2}^*\right)^2} && \text{(4e)}
\end{aligned}$$

Similarly, for γ_2, we get:

$$\hat{\gamma}_{2,OLS} = \frac{\sum_{i=1}^N x_{i2}^* y_i \sum_{i=1}^N x_{i1}^{*2} - \sum_{i=1}^N x_{i1}^* x_{i2}^* \sum_{i=1}^N x_{i1}^* y_i}{\sum_{i=1}^N x_{i1}^{*2} \sum_{i=1}^N x_{i2}^{*2} - \left(\sum_{i=1}^N x_{i1}^* x_{i2}^*\right)^2} \tag{5}$$

Taking the probability limits gives us:

$$plim(\hat{\gamma}_{1,OLS}) = \frac{cov(y, x_1^*)var(x_2^*) - cov(y, x_2^*)cov(x_1^*, x_2^*)}{var(x_1^*)var(x_2^*) - cov(x_1^*, x_2^*)^2} \tag{6a}$$

$$plim(\hat{\gamma}_{2,OLS}) = \frac{cov(y, x_2^*)var(x_1^*) - cov(y, x_1^*)cov(x_1^*, x_2^*)}{var(x_1^*)var(x_2^*) - cov(x_1^*, x_2^*)^2} \tag{6b}$$

Now we substitute equations (2a) and (2b) and use assumptions underlying classical errors-in-variables (CEV): x_1 and x_2 are orthogonal to v_1 and v_2 as well as orthogonality between v_1 and v_2. For notation, we define $\sigma_{x_g}^2 \equiv var(x_{ig})$ and $\sigma_{v_g}^2 \equiv var(v_{itg})$ for $g = 1, 2$ and $\rho \equiv corr(x_1, x_2)$. Then the elements of the probability limits are:

$$\begin{aligned}
var(x_g^*) &= \sigma_{x_g}^2 + \sigma_{v_g}^2 && \text{(7a)}\\
cov(x_1^*, x_2^*) &= \rho\sigma_{x_1}\sigma_{x_2} && \text{(7b)}\\
cov(y, x_1^*) &= \gamma_1\sigma_{x_1}^2 + \gamma_2\rho\sigma_{x_1}\sigma_{x_2} && \text{(7c)}\\
cov(y, x_2^*) &= \gamma_2\sigma_{x_2}^2 + \gamma_1\rho\sigma_{x_1}\sigma_{x_2} && \text{(7d)}
\end{aligned}$$

Substituting these into (6a) and (6b) and rearranging gives us:

$$plim(\hat{\gamma}_{1,OLS}) = \gamma_1 \frac{\sigma^2_{x_1}}{\sigma^2_{x_1} + \sigma^2_{v_1}\left(\frac{\sigma^2_{x_2}+\sigma^2_{v_2}}{\sigma^2_{x_2}(1-\rho^2)+\sigma^2_{v_2}}\right)} + \gamma_2 \frac{\sigma_{x_1}\sigma_{x_2}\left(\frac{\rho\sigma^2_{v_2}}{\sigma^2_{x_2}(1-\rho^2)+\sigma^2_{v_2}}\right)}{\sigma^2_{x_1} + \sigma^2_{v_1}\left(\frac{\sigma^2_{x_2}+\sigma^2_{v_2}}{\sigma^2_{x_2}(1-\rho^2)+\sigma^2_{v_2}}\right)} \tag{8a}$$

$$plim(\hat{\gamma}_{2,OLS}) = \gamma_1 \frac{\sigma_{x_1}\sigma_{x_2}\left(\frac{\rho\sigma^2_{v_1}}{\sigma^2_{x_1}(1-\rho^2)+\sigma^2_{v_1}}\right)}{\sigma^2_{x_2} + \sigma^2_{v_2}\left(\frac{\sigma^2_{x_1}+\sigma^2_{v_1}}{\sigma^2_{x_1}(1-\rho^2)+\sigma^2_{v_1}}\right)} + \gamma_2 \frac{\sigma^2_{x_2}}{\sigma^2_{x_2} + \sigma^2_{v_2}\left(\frac{\sigma^2_{x_1}+\sigma^2_{v_1}}{\sigma^2_{x_1}(1-\rho^2)+\sigma^2_{v_1}}\right)} \tag{8b}$$

Although assuming that the transitory components are sources of classical measurement error does lend to the simplicity of these probability limits, it is generally believed that there is some persistence in the v_{itg} over time. So we can write the AR(1) process for the v_{it} where δ is the autocorrelation coefficient,

$$v_{itg} = \delta v_{it-1g} + e_{it}. \tag{9}$$

With this process for v_{itg}, each $\sigma^2_{v_g}$ is replaced with $\frac{\sigma^2_e}{1-\delta^2}$ in the probability limits above. Or when we use T-year averages of annual income, each $\sigma^2_{v_g}$ is replaced with:

$$\frac{1}{T_g}\frac{\sigma^2_e}{1-\delta^2}\left[1 + 2\delta\left(\frac{T_g - \frac{1-\delta^{T_g}}{1-\delta}}{T_g(1-\delta)}\right)\right]. \tag{10}$$

A.2 Instrumental variables (IV) estimation

Our IV approach uses log annual earnings in year s (z^*_{isg}) to instrument for log annual earnings in year t (x^*_{itg}) for that individual. So, in addition to equations (2a) and (2b) above, we have for our instruments:

$$z^*_{is1} = x_{i1} + v_{is1}, \tag{11a}$$

$$z^*_{is2} = x_{i2} + v_{is2}. \tag{11b}$$

We define $A_2 = I - x^*_2(z^{*\prime}_2 x^*_2)^{-1} z^{*\prime}_2$, and again use the Frisch-Waugh-Lovell theorem and some algebra to derive the IV estimators:

$$\hat{\gamma}_{1,IV} = (z_1^{*'} A_2 x_1^*)^{-1} z_1^{*'} A_2 y \tag{12a}$$

$$= [z_1^{*'}(I - x_2^*(z_2^{*'}x_2^*)^{-1}z_2^{*'})x_1^*]^{-1} z_1^{*'}(I - x_2^*(z_2^{*'}x_2^*)^{-1}z_2^{*'})y \tag{12b}$$

$$= [z_1^{*'}x_1^* - z_1^{*'}x_2^*(z_2^{*'}x_2^*)^{-1}z_2^{*'}x_1^*]^{-1}[z_1^{*'}y - z_1^{*'}x_2^*(z_2^{*'}x_2^*)^{-1}z_2^{*'}y] \tag{12c}$$

$$= \left[\sum_{i=1}^N z_{i1}^* x_{i1}^* - \sum_{i=1}^N z_{i1}^* x_{i2}^* \left(\sum_{i=1}^N z_{i2}^* x_{i2}^*\right)^{-1} \sum_{i=1}^N z_{i2}^* x_{i1}^*\right]^{-1} \left[\sum_{i=1}^N z_{i1}^* y_i - \sum_{i=1}^N z_{i1}^* x_{i2}^* \left(\sum_{i=1}^N z_{i2}^* x_{i2}^*\right)^{-1} \sum_{i=1}^N z_{i2}^* y_i \right] \tag{12d}$$

$$\vdots$$

$$\hat{\gamma}_{1,IV} = \frac{\sum_{i=1}^N z_{i1}^* y_i \sum_{i=1}^N z_{i2}^* x_{i2}^* - \sum_{i=1}^N z_{i1}^* x_{i2}^* \sum_{i=1}^N z_{i2}^* y_i}{\sum_{i=1}^N z_{i1}^* x_{i1}^* \sum_{i=1}^N z_{i2}^* x_{i2}^* - \sum_{i=1}^N z_{i1}^* x_{i2}^* \sum_{i=1}^N z_{i2}^* x_{i1}^*} \tag{12e}$$

Similarly, for γ_2, we get:

$$\hat{\gamma}_{2,IV} = \frac{\sum_{i=1}^N z_{i2}^* y_i \sum_{i=1}^N z_{i1}^* x_{i1}^* - \sum_{i=1}^N z_{i2}^* x_{i1}^* \sum_{i=1}^N z_{i1}^* y_i}{\sum_{i=1}^N z_{i2}^* x_{i2}^* \sum_{i=1}^N z_{i1}^* x_{i1}^* - \sum_{i=1}^N z_{i2}^* x_{i1}^* \sum_{i=1}^N z_{i1}^* x_{i2}^*} \tag{13}$$

Taking the probability limits we get:

$$plim(\hat{\gamma}_{1,IV}) = \frac{cov(z_1^*, y)cov(z_2^*, x_2^*) - cov(z_1^*, x_2^*)cov(z_2^*, y)}{cov(z_1^*, x_1^*)cov(z_2^*, x_2^*) - cov(z_1^*, x_2^*)cov(z_2^*, x_1^*)} \tag{14a}$$

$$plim(\hat{\gamma}_{2,IV}) = \frac{cov(z_2^*, y)cov(z_1^*, x_1^*) - cov(z_2^*, x_1^*)cov(z_1^*, y)}{cov(z_2^*, x_2^*)cov(z_1^*, x_1^*) - cov(z_2^*, x_1^*)cov(z_1^*, x_2^*)} \tag{14b}$$

Now we substitute equations (2a), (2b), (11a), and (11b) and use assumptions underlying classical errors-in-variables (CEV): x_1 and x_2 are orthogonal to v_1 and v_2; v_{it1} and v_{it2} are uncorrelated; v_{itg} and v_{isg} are uncorrelated. For notation, we define $\sigma_{x_g}^2 \equiv var(x_{ig})$ and $\sigma_{v_g}^2 \equiv var(v_{itg})$ for $g = 1, 2$ and $\rho \equiv corr(x_1, x_2)$, allowing us to write the elements of the probability limits as:

$$cov(z_g^*, x_g^*) = \sigma_{x_g}^2 + cov(v_{isg}, v_{itg}) = \sigma_{x_g}^2 \tag{15a}$$

$$cov(x_1^*, z_2^*) = cov(x_2^*, z_1^*) = \rho\sigma_{x_1}\sigma_{x_2} \tag{15b}$$

$$cov(y, z_1^*) = \gamma_1\sigma_{x_1}^2 + \gamma_2\rho\sigma_{x_1}\sigma_{x_2} \tag{15c}$$

$$cov(y, z_2^*) = \gamma_2\sigma_{x_2}^2 + \gamma_1\rho\sigma_{x_1}\sigma_{x_2} \tag{15d}$$

Substituting these into the probability limits in (14a) and (14b), and then doing some algebra shows that $plim(\hat{\gamma}_{1,IV}) = \gamma_1$ and $plim(\hat{\gamma}_{2,IV}) = \gamma_2$. However, if we consider the case of an AR(1) process for v_{itg}, then (15a) does not hold. Rather, $cov(v_{isg}, v_{itg}) = \delta^{T_g}\frac{\sigma_{e_g}^2}{1-\delta^2}$ where $T_g = t - s$ is the years between the earnings measures x_{itg} and z_{isg}. In this case, the probability limits of the IV estimators are the same as those for the OLS estimators in (8a) and (8b) except that $\sigma^2_{v_g}$ is replaced with $\delta^{T_g}\frac{\sigma^2_{e_g}}{1-\delta^2}$.

Table A.1 summarizes what takes the place of $\sigma^2_{v_g}$ for $g = 1, 2$ under the two different scenarios for the transitory component (CEV or AR(1)) for each of our estimation approaches.

Table A.1: Elements that take place of $\sigma^2_{v_g}$ in $plim(\hat{\gamma}_1)$ and $plim(\hat{\gamma}_2)$

Estimation method	$v_{itg} \sim$ CEV	$v_{itg} \sim$AR(1)
OLS using annual income measures	$\sigma^2_{v_g}$	$\frac{\sigma^2_{e_g}}{1-\delta^2}$
OLS using T_g-year averages of income	$\frac{\sigma^2_{v_g}}{T_g}$	$\frac{1}{T_g}\frac{\sigma^2_{e_g}}{1-\delta^2}\left[1+2\delta\left(\frac{T_g-\frac{1-\delta^T_g}{1-\delta}}{T_g(1-\delta)}\right)\right]$
IV using annual incomes T_g years apart	*n.a.*	$\delta^{T_g}\frac{\sigma^2_{e_g}}{1-\delta^2}$

B Lifecycle Effects

B.1 Derivations: lifecycle effects in multigenerational regression

For the multigenerational regression, we consider lifecycle profiles in income for fathers and grandfathers separately, where the relationship between annual and lifetime or permanent income is written

$$x^*_{it1} = \lambda_{1t}x_{i1} + v_{it1}, \tag{16a}$$
$$x^*_{it2} = \lambda_{2t}x_{i2} + v_{it2}. \tag{16b}$$

Considering again the probability limits in equations (8a) and (8b) in Appendix A with the same orthogonality conditions, we can use the equations in (16a) and (16b) to write the elements of the probability limits as:

$$var(x^*_g) = \lambda_{gt}\sigma^2_{x_g} + \sigma^2_{v_g} \tag{17a}$$
$$cov(x^*_1, x^*_2) = \lambda_{1t}\lambda_{2t}\rho\sigma_{x_1}\sigma_{x_2} \tag{17b}$$
$$cov(y, x^*_1) = \lambda_{1t}\gamma_1\sigma^2_{x_1} + \lambda_{1t}\gamma_2\rho\sigma_{x_1}\sigma_{x_2} \tag{17c}$$
$$cov(y, x^*_2) = \lambda_{2t}\gamma_2\sigma^2_{x_2} + \lambda_{2t}\gamma_1\rho\sigma_{x_1}\sigma_{x_2} \tag{17d}$$

Then the OLS probability limits in equations (8a) and (8b) are now:

$$plim(\hat{\gamma}_{1,OLS}) = \gamma_1 \frac{\lambda_{1t}\sigma_{x_1}^2}{\lambda_{1t}^2\sigma_{x_1}^2 + \sigma_{v_1}^2\left(\frac{\lambda_{2t}^2\sigma_{x_2}^2+\sigma_{v_2}^2}{\lambda_{2t}^2\sigma_{x_2}^2(1-\rho^2)+\sigma_{v_2}^2}\right)} + \gamma_2 \frac{\lambda_{1t}\sigma_{x_1}\sigma_{x_2}\left(\frac{\rho\sigma_{v_2}^2}{\lambda_{2t}^2\sigma_{x_2}^2(1-\rho^2)+\sigma_{v_2}^2}\right)}{\lambda_{1t}^2\sigma_{x_1}^2 + \sigma_{v_1}^2\left(\frac{\lambda_{2t}^2\sigma_{x_2}^2+\sigma_{v_2}^2}{\lambda_{2t}^2\sigma_{x_2}^2(1-\rho^2)+\sigma_{v_2}^2}\right)} \tag{18a}$$

$$plim(\hat{\gamma}_{2,OLS}) = \gamma_1 \frac{\lambda_{2t}\sigma_{x_1}\sigma_{x_2}\left(\frac{\rho\sigma_{v_1}^2}{\lambda_{1t}^2\sigma_{x_1}^2(1-\rho^2)+\sigma_{v_1}^2}\right)}{\lambda_{2t}^2\sigma_{x_2}^2 + \sigma_{v_2}^2\left(\frac{\lambda_{1t}^2\sigma_{x_1}^2+\sigma_{v_1}^2}{\lambda_{1t}^2\sigma_{x_1}^2(1-\rho^2)+\sigma_{v_1}^2}\right)} + \gamma_2 \frac{\lambda_{2t}\sigma_{x_2}^2}{\lambda_{2t}^2\sigma_{x_2}^2 + \sigma_{v_2}^2\left(\frac{\lambda_{1t}^2\sigma_{x_1}^2+\sigma_{v_1}^2}{\lambda_{1t}^2\sigma_{x_1}^2(1-\rho^2)+\sigma_{v_1}^2}\right)}. \tag{18b}$$

The equations for our instruments can now be written:

$$z_{is1}^* = \lambda_{1s}x_{i1} + v_{is1}, \tag{19a}$$
$$z_{is2}^* = \lambda_{2s}x_{i2} + v_{is2}. \tag{19b}$$

With IV estimation, if we assume the v_{itg} are essentially white noise error, then the elements of the probability limits are:

$$cov(z_g^*, x_g^*) = \lambda_{gt}\lambda_{gs}\sigma_{x_g}^2 + cov(v_{isg}, v_{itg}) = \lambda_{gt}\lambda_{gs}\sigma_{x_g}^2 \tag{20a}$$
$$cov(x_1^*, z_2^*) = \lambda_{1t}\lambda_{2s}\rho\sigma_{x_1}\sigma_{x_2} \tag{20b}$$
$$cov(x_2^*, z_1^*) = \lambda_{2t}\lambda_{1s}\rho\sigma_{x_1}\sigma_{x_2} \tag{20c}$$
$$cov(y, z_1^*) = \lambda_{1s}\gamma_1\sigma_{x_1}^2 + \lambda_{1s}\gamma_2\rho\sigma_{x_1}\sigma_{x_2} \tag{20d}$$
$$cov(y, z_2^*) = \lambda_{2s}\gamma_2\sigma_{x_2}^2 + \lambda_{2s}\gamma_1\rho\sigma_{x_1}\sigma_{x_2}. \tag{20e}$$

The probability limits of the estimators are:

$$plim(\hat{\gamma}_{1,IV}) = \gamma_1 \frac{1}{\lambda_{1t}} \tag{21a}$$

$$plim(\hat{\gamma}_{2,IV}) = \gamma_2 \frac{1}{\lambda_{2t}}. \tag{21b}$$

This illustrates the fact that it is the age at which the endogenous income measure is observed that drives the direction and magnitude of the bias in the IV estimates.

With an AR(1) process for v_{itg}, the elements of the IV probability limits can be written:

$$cov(z_g^*, x_g^*) = \sigma_{x_g}^2 + cov(v_{isg}, v_{itg}) = \lambda_{gt}\lambda_{gs}\sigma_{x_g}^2 + \delta_g^{T_g}\left(\frac{\sigma_{e_g}^2}{1-\delta_g}\right) \tag{22a}$$
$$cov(x_1^*, z_2^*) = \lambda_{1t}\lambda_{2s}\rho\sigma_{x_1}\sigma_{x_2} \tag{22b}$$
$$cov(x_2^*, z_1^*) = \lambda_{2t}\lambda_{1s}\rho\sigma_{x_1}\sigma_{x_2} \tag{22c}$$
$$cov(y, z_1^*) = \lambda_{1s}\gamma_1\sigma_{x_1}^2 + \lambda_{1s}\gamma_2\rho\sigma_{x_1}\sigma_{x_2} \tag{22d}$$
$$cov(y, z_2^*) = \lambda_{2s}\gamma_2\sigma_{x_2}^2 + \lambda_{2s}\gamma_1\rho\sigma_{x_1}\sigma_{x_2}. \tag{22e}$$

The probability limits of the IV estimators are below, except that $\sigma^2_{v_g}$ is replaced by $\delta_g^{T_g}\left(\frac{\sigma^2_{e_g}}{1-\delta_g}\right)$:

$$plim(\hat{\gamma}_{1,IV}) = \gamma_1 \frac{\lambda_{1s}\sigma^2_{x_1}}{\lambda_{1s}\lambda_{1t}\sigma^2_{x_1} + \sigma^2_{v_1}\left(\frac{\lambda_{2s}\lambda_{2t}\sigma^2_{x_2}+\sigma^2_{v_2}}{\lambda_{2s}\lambda_{2t}\sigma^2_{x_2}(1-\rho^2)+\sigma^2_{v_2}}\right)} + \gamma_2 \frac{\lambda_{1s}\sigma_{x_1}\sigma_{x_2}\left(\frac{\rho\sigma^2_{v_2}}{\lambda_{2s}\lambda_{2t}\sigma^2_{x_2}(1-\rho^2)+\sigma^2_{v_2}}\right)}{\lambda_{1s}\lambda_{1t}\sigma^2_{x_1} + \sigma^2_{v_1}\left(\frac{\lambda_{2s}\lambda_{2t}\sigma^2_{x_2}+\sigma^2_{v_2}}{\lambda_{2s}\lambda_{2t}\sigma^2_{x_2}(1-\rho^2)+\sigma^2_{v_2}}\right)} \tag{23a}$$

$$plim(\hat{\gamma}_{2,IV}) = \gamma_1 \frac{\lambda_{2s}\sigma_{x_1}\sigma_{x_2}\left(\frac{\rho\sigma^2_{v_1}}{\lambda_{1s}\lambda_{1t}\sigma^2_{x_1}(1-\rho^2)+\sigma^2_{v_1}}\right)}{\lambda_{2s}\lambda_{2t}\sigma^2_{x_2} + \sigma^2_{v_2}\left(\frac{\lambda_{1s}\lambda_{1t}\sigma^2_{x_1}+\sigma^2_{v_1}}{\lambda_{1s}\lambda_{1t}\sigma^2_{x_1}(1-\rho^2)+\sigma^2_{v_1}}\right)} + \gamma_2 \frac{\lambda_{2s}\sigma^2_{x_2}}{\lambda_{2s}\lambda_{2t}\sigma^2_{x_2} + \sigma^2_{v_2}\left(\frac{\lambda_{1s}\lambda_{1t}\sigma^2_{x_1}+\sigma^2_{v_1}}{\lambda_{1s}\lambda_{1t}\sigma^2_{x_1}(1-\rho^2)+\sigma^2_{v_1}}\right)}. \tag{23b}$$

Although an AR(1) process for v_{itg} complicates the probability limits, it still holds that the lifecycle bias is primarily driven by the age at which the endogenous income measure is observed.

B.2 Simulation results with lifecycle effects

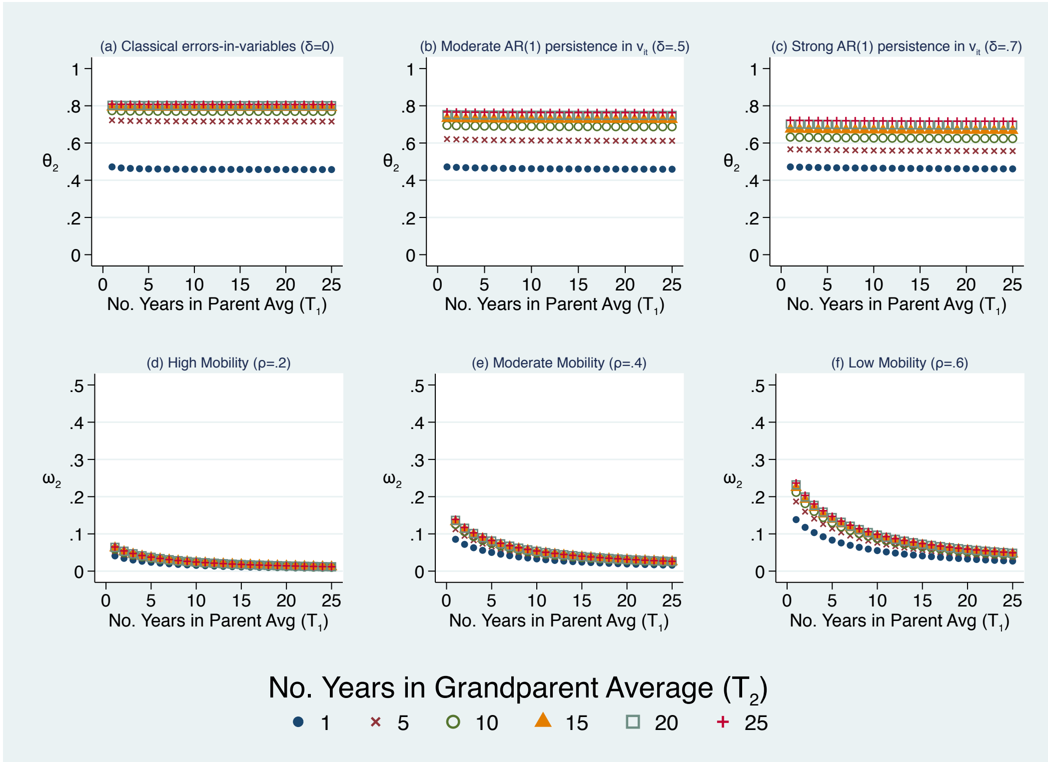
This section provides figures showing how the attenuation and spillover biases change with the point in the lifecycle at which income is measured for fathers and grandfathers (varying λ_{1t} and λ_{2t}). Figures B.1 and B.2 show that the attenuation factor for OLS estimates is larger when $\lambda_{gt} > 1$ and can be an amplification factor when $\lambda_{gt} < 1$, respectively. This is the same pattern shown previously for two-generation (e.g., father-son) regressions. The changes in the magnitude of the spillover factor reinforce the attenuation or amplification bias.

For IV estimates, lifecycle bias is driven by the age at which the endogenous measure is observed. Figures B.3 and B.4 show that the attenuation and spillover factors are affected similarly to those for OLS. The attenuation factor for IV estimates is larger when $\lambda_{gt} > 1$ (Figure B.3) and is an amplification factor when $\lambda_{gt} < 1$ (Figure B.4). The changes in the magnitude of the spillover factor reinforce the attenuation or amplification bias.

B.3 Bounding with IV: empirical illustration of lifecycle effects

In our main results, we use income at age 43 as the endogenous income measure to abstract from lifecycle bias. Ideally, λ_{gt} is approximately one at this age, but even if not, we still know that λ_{gt} is constant as we change our instrument income measure. Our instrument is thus taken from subsequent later ages as we increased the years between the income measures to reduce correlation in the transitory component, which was our primary focus. However, we can also use the fact that the direction and magnitude of the lifecycle bias in IV estimates are driven by the age of the endogenous income measure to bound the true parameter. As discussed above, measuring the endogenous income measure when $\lambda_{gt} < 1$ (measuring income too young) can cause amplification bias while $\lambda_{gt} > 1$ (too old of ages)

Figure B.1: Attenuation and spillover in OLS estimates when $\lambda_{1t} = \lambda_{2t} = 1.2$



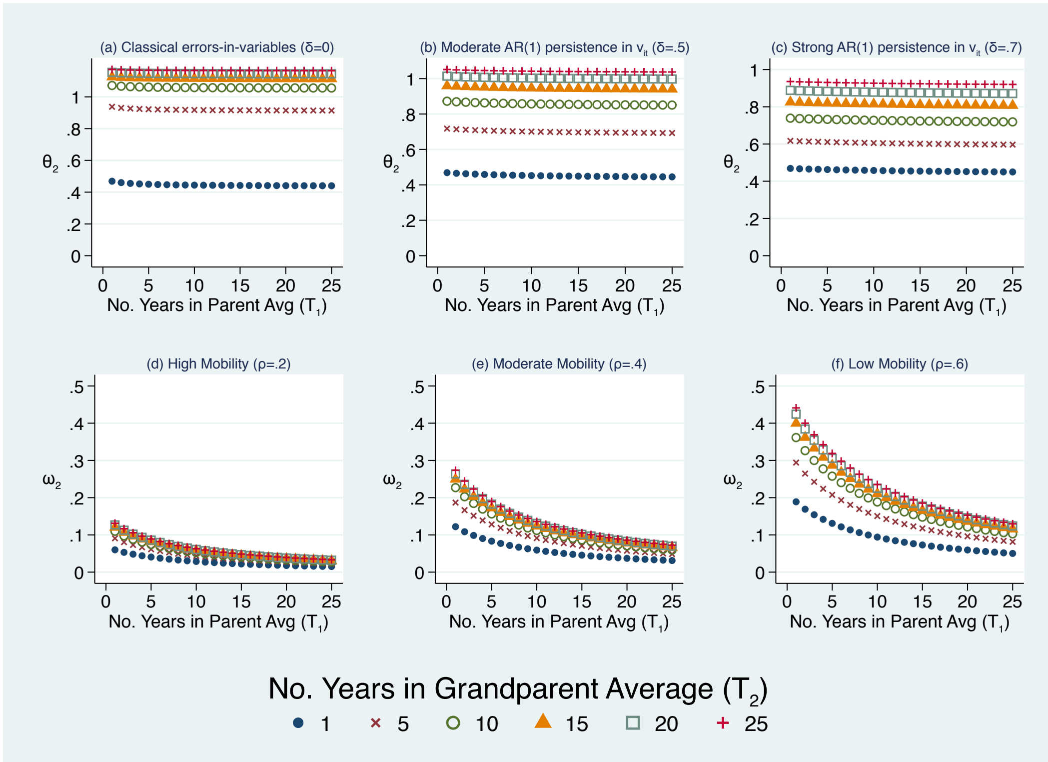
Note: This figure shows the values of the attenuation factor (θ_2) and spillover factor (ω_2) in the OLS probability limit for the grandparent coefficient, $plim(\hat{\gamma}_{2,OLS}) = \gamma_2\theta_2 + \gamma_1\omega_2$. In graphs (a) - (c) , δ is set to 0, 0.5, 0.7, respectively, while $\rho = 0.4$ is constant. In graphs (d) - (f), ρ is set to 0.2, 0.4, and 0.6, respectively, while $\delta = 0.5$ does not change. Within a graph, moving along a dotted line corresponds to improving the parental income measure, and going from one line to another reflects changes in the grandparent measure.

causes attenuation bias. This means we can perform two sets of IV estimations to bound the true population parameters: one set where we treat the younger age income as endogenous (thus potentially causing amplification bias), and another set where we treat the older age income as endogenous (potentially causing attenuation bias).

We first illustrate the bounding in Figure B.5 with estimates from two-generation regressions, where the left is for son-father regressions and the right for son-grandfather regressions. As in our main approach, the endogenous income measure is that observed at age 43, and the instrument is T years later. We see the father-son estimates rising as we increase T in the first graph, consistent with the correlation in the transitory component of income declining over time. Our second set of estimates below this ("Reverse IV") are from swapping the instrument and endogenous measures, so that λ_{gt} may be greater than one as we are using the older ages as the endogenous measure. In this case, our estimates tend to be smaller than the main IV results, consistent with the algebraic result that the estimates are further attenuated due to measuring endogenous income at older ages.

The graphs on the right side of Figure B.5 are for regressions relating sons' income to grandfathers' income. The IV estimates grow somewhat as we increase T, which is consistent with the decreasing correlation in the transitory component, since we are holding λ_{2t} fixed.

Figure B.2: Attenuation and spillover in OLS estimates when $\lambda_{1t} = \lambda_{2t} = 0.8$



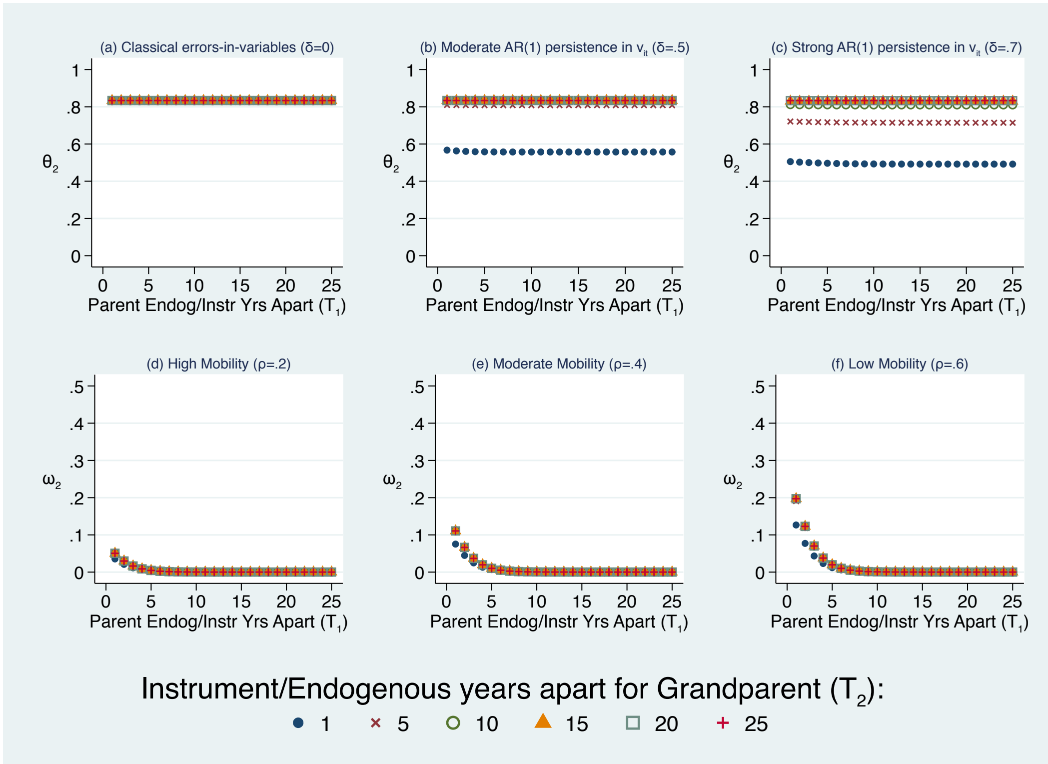
Note: This figure shows the values of the attenuation factor (θ_2) and spillover factor (ω_2) in the OLS probability limit for the grandparent coefficient, $plim(\hat{\gamma}_{2,OLS}) = \gamma_2\theta_2 + \gamma_1\omega_2$. In graphs (a) - (c) , δ is set to 0, 0.5, 0.7, respectively, while $\rho = 0.4$ is constant. In graphs (d) - (f), ρ is set to 0.2, 0.4, and 0.6, respectively, while $\delta = 0.5$ does not change. Within a graph, moving along a dotted line corresponds to improving the parental income measure, and going from one line to another reflects changes in the grandparent measure.

To explore the role of lifecycle effects, we turn to estimates from our reverse IV approach treating the older age income as endogenous, provided in the bottom (right) graph of Figure B.5. These estimates are very similar, suggesting the lifecycle profile in λ_{2t} may not vary substantially during this age span for grandfathers.

The graphs in Figure B.6 present the IV results from our main results for the multigenerational regression as well as analogous results from our reverse IV approach. The difference is the same as discussed with the intergenerational case—we are now varying the age at which we are measuring the income measure treated as endogenous, to assess lifecycle effects. Our set of estimates in the top graphs use age 43 income as the endogenous measure, and our set of estimates in the bottom graphs use the older age (43+T) income as the endogenous measure.

We first adjust the instrument for both fathers' and grandfathers' income at the same age, using, respectively, fathers' and grandfathers' annual log income from a later year, increasing the distance between years measured for endogenous and instrument income measures as indicated on the x-axis. Similar to the intergenerational case, the coefficient on fathers' income does appear somewhat sensitive to lifecycle bias, showing the same pattern but at slightly lower levels than the intergenerational regression. The grandfather coefficient

Figure B.3: Attenuation and spillover in IV estimates when $\lambda_{1t} = \lambda_{2t} = 1.2$, $\lambda_{1s} = \lambda_{2s} = 1$

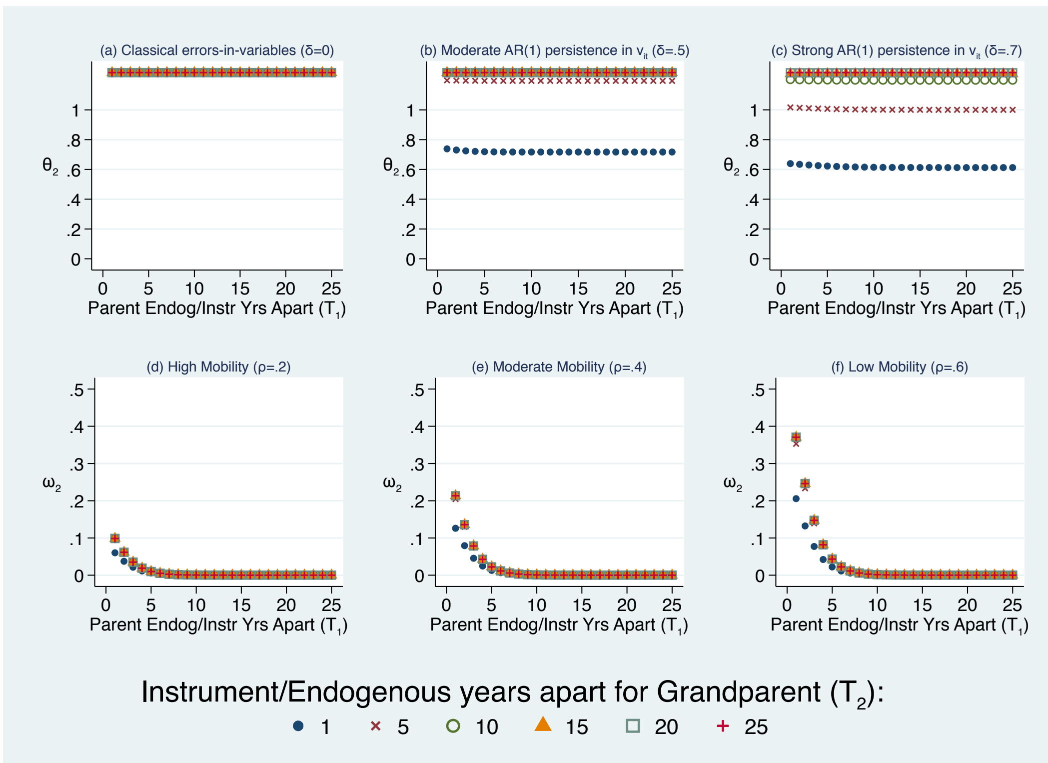


Note: This figure shows the values of the attenuation factor (θ_2) and spillover factor (ω_2) in the IV probability limit for the grandparent coefficient, $plim(\hat{\gamma}_{2,IV}) = \gamma_2\theta_2 + \gamma_1\omega_2$. In graphs (a) - (c) , δ is set to 0, 0.5, 0.7, respectively, while $\rho = 0.4$ is constant. In graphs (d) - (f), ρ is set to 0.2, 0.4, and 0.6, respectively, while $\delta = 0.5$ does not change. Within a graph, moving along a dotted line corresponds to improving the parental income measure, and going from one line to another reflects changes in the grandparent measure.

estimates are similar to the main results, with the exception of the 10-year estimate, though these estimates are based on a smaller sample as noted in the main text.

Next we vary father and grandfather income measures separately to more carefully examine spillover bias. We first use the 6-year instrument for fathers' income while changing the instrument for grandfathers' income. The coefficient on fathers' income remains steady, and the reverse IV results are very similar to the main results. We then isolate the effects of measurement issues arising from fathers' income measures by using a "good" measure for grandfathers' (the 6-year instrument) in all estimations, while varying the instrument for fathers' income. These results are similar to the results in (d) where both fathers' and grandfathers' income measures are varied simultaneously.

Figure B.4: Attenuation and spillover in IV estimates when $\lambda_{1t} = \lambda_{2t} = 0.8$, $\lambda_{1s} = \lambda_{2s} = 1$

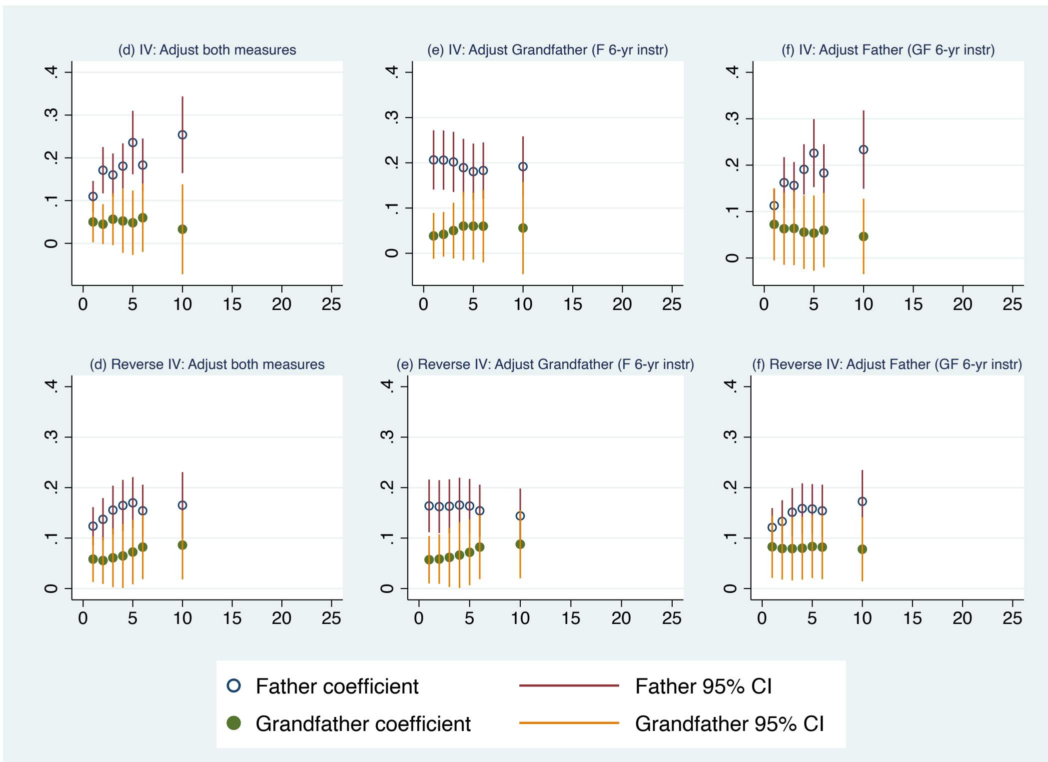


Note: This figure shows the values of the attenuation factor (θ_2) and spillover factor (ω_2) in the IV probability limit for the grandparent coefficient, $plim(\hat{\gamma}_{2,IV}) = \gamma_2\theta_2 + \gamma_1\omega_2$. In graphs (a) - (c) , δ is set to 0, 0.5, 0.7, respectively, while $\rho = 0.4$ is constant. In graphs (d) - (f), ρ is set to 0.2, 0.4, and 0.6, respectively, while $\delta = 0.5$ does not change. Within a graph, moving along a dotted line corresponds to improving the parental income measure, and going from one line to another reflects changes in the grandparent measure.

Figure B.5: Two-generation IV estimates when income at younger versus older age is used as the endogenous measure

Note: This figure shows the IV and "Reverse IV" coefficient estimates and 95% confidence intervals from son-father regressions and son-grandfather regressions. The x-axis indexes the number of years between the instrument income and endogenous income. For IV, the endogenous measure is at age 43 and instrument at age 43+T, while these are swapped for Reverse IV.

Figure B.6: Three-generation IV estimates when income at younger versus older age is used as the endogenous measure



Note: This figure shows the IV and "Reverse IV" coefficient estimates and 95% confidence intervals from a series of multigenerational regressions. The x-axis indexes the number of years between the instrument income and endogenous income for the generation(s) for which the measure is being adjusted. For IV, the endogenous measure is at age 43 and instrument at age 43+T, while these are swapped for Reverse IV.

C Using income ranks in the multigenerational regression

C.1 Derivations for multigenerational regression with income ranks

The following provides derivations of probability limits analogous to those shown in the main text of the paper, though here we are using (normalized) ranks of error-ridden incomes as the status measure for each generation in the multigenerational model.

With classical measurement error, the attenuation bias in the IGE is driven by the increased variance of observed incomes (through the variance of the transitory component). With ranked incomes, by definition the variance of the (normalized) observed rank and true rank are both 1/12.

When income ranks are used instead of (log) incomes, the nature of the measurement error is complicated by the fact that there is necessarily (negative) correlation between the true rank and the measurement error. This negative correlation arises from the fact that ranks at the top (bottom) of the distribution cannot be misreported to be higher (lower) ranks.

Given this, a classical measurement error framework is not appropriate. We follow the approach of Nybom and Stuhler (2017) and Haider and Solon (2006) for modeling non-classical measurement error with a linear projection of the observed outcome on the true value.

We now consider x^*_{itg}, x_{ig}, and v_{itg} to be the observed (annual) income *rank*, true (lifetime) income *rank*, and the (annual) error *in ranks*, respectively (for $g = 1, 2$ for parents, grandparents). ρ denotes the parent-grandparent correlation in x_{ig}. Approximating the non-classical measurement error with linear projections gives us the measurement equations:

$$x^*_{it1} = \lambda_{1t} x_{i1} + v_{it1}, \tag{24a}$$
$$x^*_{it2} = \lambda_{2t} x_{i2} + v_{it2}, \tag{24b}$$

where λ_{gt} now reflects the quality of the observed income rank (i.e., how well it reflects the true rank). The idea is that this reflects the non-classical nature of the measurement error since λ_1 and λ_2 are less than (or equal to) one, and by definition of a linear projection, the true values are orthogonal to the errors.

We can use the measurement equations above to write the elements of the probability limits as:

$$var(x^*_g) = 1/12 \text{ by definition} \tag{25a}$$
$$cov(x^*_1, x^*_2) = \lambda_{1t}\lambda_{2t}\rho(1/12) \tag{25b}$$
$$cov(y, x^*_1) = \lambda_{1t}\gamma_1(1/12) + \lambda_{1t}\gamma_2\rho(1/12) \tag{25c}$$
$$cov(y, x^*_2) = \lambda_{2t}\gamma_2(1/12) + \lambda_{2t}\gamma_1\rho(1/12). \tag{25d}$$

Substituting these into the probability limits in (6a) and (6b) and rearranging gives us:

$$plim(\hat{\gamma}_{1,OLS}) = \gamma_1 \ \lambda_{1t} \left(\frac{1 - \lambda_{2t}^2 \rho^2}{1 - \lambda_{1t}^2 \lambda_{2t}^2 \rho^2} \right) + \gamma_2 \ \lambda_{1t} \left(\frac{\rho(1 - \lambda_{2t}^2)}{1 - \lambda_{1t}^2 \lambda_{2t}^2 \rho^2} \right) \tag{26a}$$

$$plim(\hat{\gamma}_{2,OLS}) = \gamma_2 \ \lambda_{2t} \left(\frac{1 - \lambda_{1t}^2 \rho^2}{1 - \lambda_{1t}^2 \lambda_{2t}^2 \rho^2} \right) + \gamma_1 \ \lambda_{2t} \left(\frac{\rho(1 - \lambda_{1t}^2)}{1 - \lambda_{1t}^2 \lambda_{2t}^2 \rho^2} \right). \tag{26b}$$

The determinants of the size of bias follow the case with log incomes. Focusing on the grandparent coefficient, attenuation is alleviated by using a better grandparent income measure, and to a lesser degree by using a worse parent income measure or with lower intergenerational persistence levels. The spillover bias is primarily alleviated by using a better parental income measure, and to a lesser degree by using a worse grandparent income measure (the counterintuitive result found with log incomes). Again, countries with higher persistence levels are susceptible to larger spillover bias.

For the IV approach, using rank income in year s to instrument for rank income in year t, we write the analogous measurement equations for our instruments:

$$z_{is1}^* = \lambda_{1s} x_{i1} + v_{is1}, \tag{27a}$$

$$z_{is2}^* = \lambda_{2s} x_{i2} + v_{is2}. \tag{27b}$$

Assuming v_{isg} and v_{itg} are uncorrelated (as in CEV) leads to consistency of IV in the log income case but does not lead to consistent estimates when using income ranks.[1] The probability limits of the estimators are:

$$plim(\hat{\gamma}_{1,IV}) = \gamma_1 \frac{1}{\lambda_{1t}} (1 - \rho^2) \tag{28a}$$

$$plim(\hat{\gamma}_{2,IV}) = \gamma_2 \frac{1}{\lambda_{2t}} (1 - \rho^2) \tag{28b}$$

Attenuation depends on how strong the income measure is for one's own generation (λ_{gt}) as well as the level of mobility (ρ). With no correlation between v_{isg} and v_{itg}, there is no spillover bias. Yet in our empirical results, we find evidence of spillover bias because the grandfather coefficients decline as we improve the income measure for fathers (holding the grandfather measure constant).

Kitagawa *et al.* (2018, p. 4) note, regarding the use of the linear projection approximation and the resulting proposed correction in Nybom and Stuhler (2017), *"While this property is shown to hold approximately in their data, it is not generally known what assumptions on the underlying distributions that can guarantee it."* Thus, instead of using a simple "simulation"

[1] This is also true of the parent-child regression, as noted in footnote 13 of Nybom and Stuhler (2017). With λ_{yt} as the slope coefficient in the linear projection for child income ranks, the parent-child regression yields $plim(\hat{\beta}_{1,IV}) = \beta_1 \frac{\lambda_{yt}}{\lambda_{1t}}$. We do not address measurement error in child income ranks, consistent with the rest of our paper where we do not vary child income measures, but λ_{yt} would similarly enter the probability limits as a multiplicative factor.

as we had done for the log income case in the main text, we use a simulation to generate a synthetic sample to further evaluate how measurement error in income plays out in coefficient estimates from the multigenerational model with rank incomes used as status measures. This is discussed in the next section.

C.2 Simulating measurement error with income ranks

As described in Section 2, some studies of multigenerational mobility are based on linear regressions on income ranks rather than the conventional IGE setup. To verify that the biases we document in this article are not exclusive to the log-log (IGE) specification, we conduct a supplementary simulation exercise with rank-rank regressions.

We again consider a process (as in equation (2)),

$$y_{i0} = \gamma_1 x_{i1} + \gamma_2 x_{i2} + \epsilon_i. \tag{29}$$

In the benchmark analysis, y and x refer to log income. We here supplement this with an analysis where y and x refer to an individual's rank in the income distribution of their own generation. As the errors in income ranks are non-classical, we do not solve for measurement error in closed form (as in equations (4a) and (4b)). Rather, we construct a simulated (synthetic) sample with known parameters and examine the rank coefficients that emerge from an estimation on this synthetic sample.

The synthetic sample consists of 10,000 lineages. Each generation has a latent income x, and has 25 annual income observations with a given error structure (discussed below). We do not consider life cycle variation in this exercise. Each generation has exactly one descendant, who inherits the latent income with parameter γ_1 from the generation before and γ_2 from two generations before.

Initial incomes (the latent individual component) are drawn from a log-normal distribution where the true parental coefficient γ_1 is 0.4 and the true grandparental coefficient γ_2 is zero. In the following, we consider parameters on log incomes, though ranks are still constructed based on the underlying incomes (e.g., on averages of incomes, not averages of log incomes).

The error structure is either classical errors-in-variables (see equation (3)) or AR(1) (equation (5)). We set $\sigma_x^2 = \sigma_v^2 = 1$, $\delta = 0.5$. In the CEV case the error term is drawn from $N(0, \sqrt{(\sigma_v^2)})$. In the AR(1) case the error term for the first period is drawn similarly to the error term for the CEV case. Subsequent error terms are given by $\delta \log(v_{t-1}) + (1-\delta)e$ where e is drawn from $N\left(0, \sqrt{\frac{1-\delta^2}{(1-\delta)^2}}\right)$.

Each lineage is simulated for 10 generations. Within each generation, 25 time periods are simulated. We discard information from the five first generations, and verify that the calculated coefficients are stable for generations 5-10. From a given simulation, we then get six calculations for each parameter for the population of 10,000 lineages. We repeat the simulation ten times.[2]

[2] We verify that the reported averages of coefficients do not depend on the "age" of the synthetic individual at the time of measurement.

Table C.2 reports the regression results for the synthetic sample. Each line reports regression coefficients on grandparents for regressions on six generations and 10,000 dynasties, where the "true" grandparental coefficient is zero. The first panel lists results where the error structure is classical errors-in-variables, while the second panel lists results where the error structure is AR(1).

Table C.2: Simulation results

Error structure and number of years	True β_2	OLS (log-log) (Analytical)	OLS (log-log) (Simulated)	IV (log-log) (Analytical)	IV (log-log) (Simulated)	Rank-Rank (Simulated)
CEV, $T = 1$	0	0.0417	0.0418	0.0000	0.0009	0.0517
CEV, $T = 3$	0	0.0330	0.0340	0.0000	-0.0005	0.0400
CEV, $T = 5$	0	0.0250	0.0256	0.0000	-0.0020	0.0320
CEV, $T = 10$	0	0.0152	0.0159	0.0000	0.0028	0.0233
CEV, $T = 20$	0	0.0085	0.0090	0.0000	0.0006	0.0165
AR(1), $T = 1$	0	0.0404	0.0415	0.0407	0.0399	0.0476
AR(1), $T = 3$	0	0.0416	0.0402	0.0222	0.0181	0.0429
AR(1), $T = 5$	0	0.0399	0.0369	0.0072	0.0048	0.0387
AR(1), $T = 10$	0	0.0335	0.0302	0.0002	0.0005	0.0318
AR(1), $T = 20$	0	0.0239	0.0202	0.0000	0.0022	0.0230

Notes: Error structure is either CEV (classical errors-in-variables) or AR(1). T refers to the number of years over which income is averaged (for OLS and for the construction of ranks) or the distance between instrument and instrumented for IV.

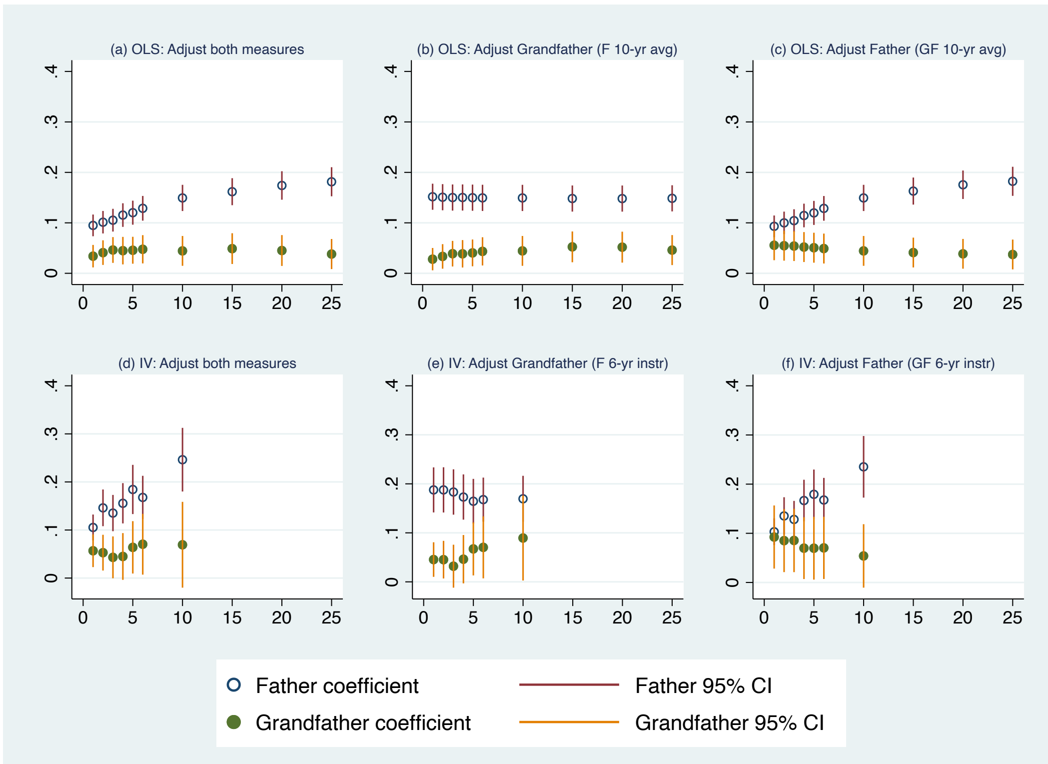
We observe from Table C.2 that the simulation corresponds well to the analytical results from Section 3 and 4; the first two columns compare analytical and simulated results for OLS, while the third and fourth do the same for IV. We therefore turn to the fifth column, reporting rank-rank regression results, where an analytical calculation is not available.

We see from this rightmost column that the use of rank correlations does not remove the issues concerning spillover bias. With a true coefficient of zero and a CEV error structure, using ranks on one year of income gives a rank coefficient of 0.05. Increasing the number of years of incomes over which the ranks are constructed reduces the coefficient somewhat, but even with averages over 20 years a positive coefficient of around 0.016 is obtained. With AR(1) the problem is even larger, with an average estimated coefficient of 0.023 even with 20 years of income averages. Hence, we conclude that the issues of spillover bias documented in this paper are not limited to IGE (log-log) measures of multigenerational persistence.

D Robustness check using men and women

Below are the figures (analogous to the main results) for the sample with men and women in the youngest generation.

Figure D.7: OLS and IV estimates from three-generation regressions. Men and women in final generation.



Note: This figure shows the OLS and IV coefficient estimates and 95% confidence intervals from a series of multigenerational regressions with men and women included in the offspring generation. For OLS, the x-axis indexes the number of years used in the average income measure for the generation(s) for which the measure is being adjusted. For IV, this is instead the number of years between the instrument and endogenous incomes (measured at age 43).

E Two generation regressions

E.1 Biases in the child-parent regression

Our results for the attenuation factors in the multigenerational regression closely follow what has been shown previously for income measurement related biases for the intergenerational regression in equation (1). We provide a brief review of such findings here.

In the simple case of classical measurement error—or classical errors-in-variables (CEV)—there are no lifecycle effects and parental log annual income in year t, x_{i1t}, is decomposed into a permanent component x_{i1} and a white noise error or transitory component, v_{i1t}:

$$x_{i1t} = x_{i1} + v_{i1t}. \tag{30}$$

In this case, we know that the OLS estimate of β_1 is attenuated:

$$plim(\hat{\beta}_{1,OLS}) = \beta_1 \frac{\sigma^2_{x1}}{\sigma^2_{x1} + \sigma^2_{v1}}, \tag{31}$$

where $\sigma^2_{x1} = var(x_{i1})$ and $\sigma^2_{v1} = var(v_{i1t})$. Taking the average over T years of parental log income reduces the attenuation bias because σ^2_{v1} is then replaced by $\sigma^2_{v1} \,/\, T$ in (31) (e.g., Solon 1992). Under the strong assumptions of classical measurement error, instrumental variables estimation (IV) (with a valid instrument) provides consistent estimates of β_1 (e.g., Solon 1992; Altonji and Dunn 1991).

Now suppose the transitory component, v_{i1t}, follows an AR(1) process with persistence parameter δ:

$$v_{i1t} = \delta v_{i1t-1} + e_{i1t}. \tag{32}$$

Then the OLS estimate converges to:[3]

$$plim(\hat{\beta}_{1,OLS}) = \beta_1 \frac{\sigma^2_{x1}}{\sigma^2_{x1} + \frac{1}{T}\left(\frac{\sigma^2_{e1}}{1-\delta^2}\right)\phi}, \tag{33}$$

where

$$\phi = 1 + 2\delta \frac{T - \frac{1-\delta^T}{1-\delta}}{T(1-\delta)}. \tag{34}$$

In this case, the attenuation bias is not reduced to the same extent by taking multi-year averages (since $0 > \delta > 1$). The implications for IV are also less promising, in that the correlation in the transitory components mean using an annual income measure in year s to instrument for income in year t (or an average ending in year t) no longer provides a consistent estimate. However, the bias shrinks as s gets further from t, as can be seen in

[3]Solon (1992) originally noted this more complicated probability limit in footnote 17 of his paper, and Mazumder (2005) subsequently examined the empirical implications.

(35). Defining $T = s - t$, the probability limit of the IV estimator is:

$$plim(\hat{\beta}_{1,IV}) = \beta_1 \frac{\sigma^2_{x1}}{\sigma^2_{x1} + \delta^T \frac{\sigma^2_{e1}}{1-\delta^2}}. \tag{35}$$

So for both OLS and IV estimation, we know that some bias remains, and use income measurement strategies to minimize the extant bias.[4]

Two features of the lifecycle patterns in income have been shown to bias estimates of intergenerational persistence. First, there is lifecycle variation in the size of σ^2_{v1}, which has been found to be U-shaped with the smallest level being in the early 40s (e.g., Mazumder 2001, 2005). When taking longer term averages of annual income that may extend into too young or too old of ages, σ^2_v/T can get larger if σ^2_{v1t} grows fast enough, thus exacerbating attenuation bias rather than reducing it.

Second, the relationship between annual incomes and permanent income changes over the lifecycle, and this can lead to attenuation or amplification bias (e.g., Haider and Solon 2006). To model this lifecycle variation, equation (3) becomes $x_{i1t} = \lambda_{1t} x_{i1} + v_{i1t}$. λ_{1t} tends to be less than one at younger ages, reaches one around the early 40s when annual income is a reasonable measure of average lifetime income, and then is greater than one at older ages. Incorporating λ_{1t} leads to

$$plim(\hat{\beta}_{1,OLS}) = \beta_1 \frac{\lambda_{1t}\sigma^2_{x1}}{\lambda^2_{1t}\sigma^2_{x1} + \sigma^2_{v1}} \tag{36}$$

for OLS estimates from using an annual income measure for parents. If an annual measure is used for offspring as well, $plim(\hat{\beta}_1)$ in (36) is multiplied by $\lambda_{0\tau}$ (the analogous parameter relating annual income in year τ to permanent income for offspring). When a T-year average of income is used, again σ^2_{v1} is replaced by σ^2_{v1}/T and λ_{1t} is replaced by the average over the included years, $\bar{\lambda}_{1T}$.

In our proposed IV approach using one annual income measure (x_{i1t}) to instrument for another (x_{i1s}), $plim(\hat{\beta}_1)$ simplifies to $\beta_1 \frac{\lambda_{0\tau}}{\lambda_{1t}}$, meaning it is the age at which the endogenous income measure is observed that drives the size of the lifecycle bias. Further, this means at too young of ages, $\lambda_{1t} < 1$ so the bias is actually an amplification bias, while at too old of ages, $\lambda_{1t} > 1$, resulting in attenuation bias. This means that two sets of IV estimates—one set with young ages as the endogenous measure and another set with older ages as the endogenous measure—can be used as a supplementary exercise to bound the true population parameter.

In summary, the lifecycle related bias in OLS or IV estimates can be attenuating or amplifying in nature, as shown by studies emphasizing the importance of measuring annual incomes during the age ranges for which λ_{1t} and $\lambda_{0\tau}$ (or $\bar{\lambda}_{1T}$) are approximately 1 (Haider and Solon 2006; Nybom and Stuhler 2014).

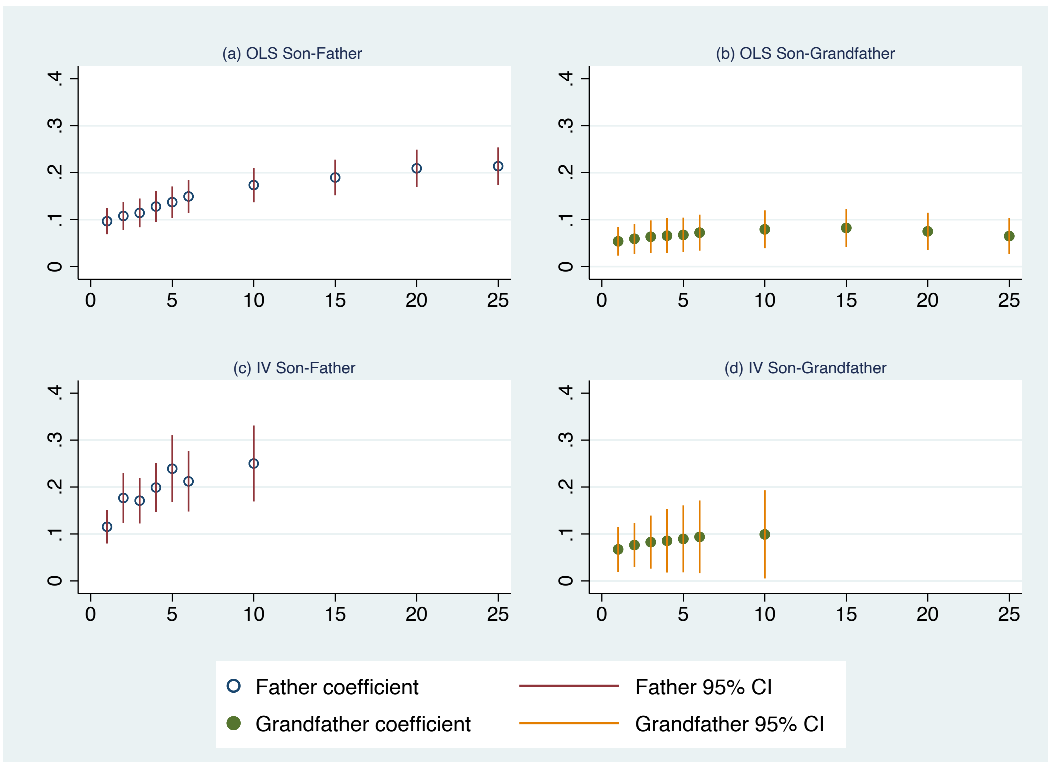
[4]For example, Mazumder (2005) shows that there may be about 10% attenuation bias remaining even when using a 30-year income average. More recently, Vosters and Nybom (2017) and Vosters (2018) look for evidence of more substantial attenuation bias from measurement error with respect to a latent construct of socioeconomic status, finding that the remaining bias is in line with earlier intergenerational studies.

E.2 Empirical results

We also provide results for two-generation models using son-father pairs and son-grandfather pairs to both show that our data follows the results on well-known biases and to serve as a reference point for our multigenerational regressions including grandparents. Figure E.8 provides the OLS estimates (top panel) and IV estimates (bottom panel), along with 95% confidence intervals.

As expected, the father-son intergenerational income elasticities in Figure E.8(a) rise as we average over more years of income for fathers (ranging from about 0.10 to 0.21).

Figure E.8: OLS and IV estimates from two-generation regressions



Note: This figure shows the OLS and IV coefficient estimates and 95% confidence intervals from son-father regressions and son-grandfather regressions. For OLS, the x-axis indexes the number of years used in the average income measure for the oldest generation in each regression. For IV, this is instead the number of years between the instrument income and endogenous income (measured at age 43).

Figure E.8(c) shows the estimates from our IV approach, using one log annual income measure to instrument for another. To the extent that the transitory component is persistent over time, we expect the estimates to increase as we increase the years between the endogenous measure and instrument (proceeding left to right). In general, this is what we see for the father-son persistence estimates. The estimates range from 0.12 for the case using income only one year later as the instrument to 0.21 when using income measures 6 years apart, and 0.25 when using measures 10 years apart.[5]

[5] As with the main results, in all IV estimations, the Kleibergen-Paap F-statistics confirm that our first

Figures E.8(b) and E.8(d) provide the analogous results for a regression relating sons' income to only grandfathers' income. We see the expected pattern of OLS estimates increasing as we average over more annual log income measures, with the estimates ranging from 0.05 when using annual log income to about 0.08 when using longer term averages. There is a slight decline in the estimate based on the 25-year averages of log income to 0.07, which may arise from lifecycle effects in the form of either increasing $\bar{\lambda}_{2T}$ or increasing σ^2_{vt}.

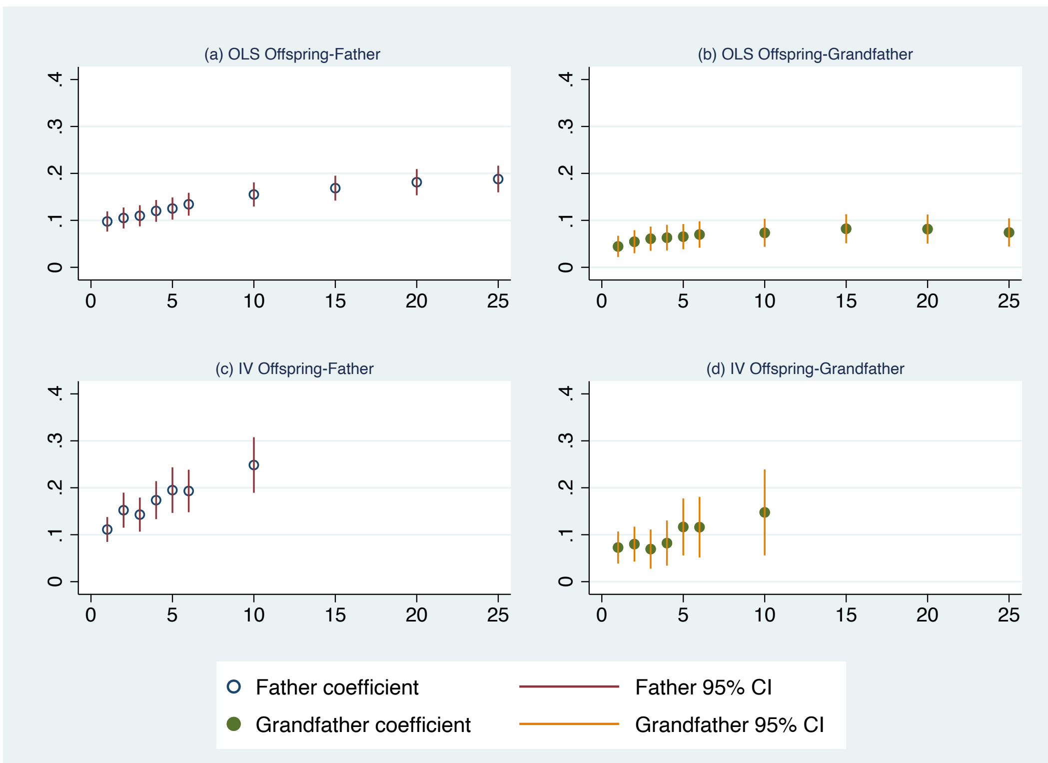
The IV estimates in Figure E.8(d) exhibit a similar pattern, with estimates growing as the years between the endogenous and instrument income measures increases from one to six years, ranging from 0.07 to 0.09, and still similar at 0.10 for 10 years though this estimate is less precise.[6]

Figure E.9 provides results for the two-generation regressions with the sample including men and women in the youngest generation. The patterns are very similar to the results for the main sample.

stage is sufficiently strong ($F \geq 32$ in all regressions, and $F = 112$ on average for regressions with income at age 43 as the endogenous measure).

[6]The samples were slightly reduced again as T_2 increased, with the following sample sizes for T_2=3, 4, 5, 6, and 10 year estimates; N=4,908 (97%), N=4,769 (94%), N=4,712 (93%), N=4,701 (93%), and N=4,470 (88%), respectively. However, estimating these regressions on the most restrictive sample produces similar results, so sample composition changes are not driving our results.

Figure E.9: OLS and IV estimates from two-generation regressions. Men and women in final generation.



Note: This figure shows the OLS and IV coefficient estimates and 95% confidence intervals from offspring-father regressions and offspring-grandfather regressions. For OLS, the x-axis indexes the number of years used in the average income measure for the oldest generation in each regression. For IV, this is instead the number of years between the instrument income and endogenous income (measured at age 43).

F Tables of regression coefficients for all empirical results

F.1 Tables for Men only (main sample)

Table F.3: OLS estimates from two-generation models. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31.Estimates from Figure E.8 (panels a and b) in bold.

(a) Sons and fathers

Income averaged over...	Age starting from... 39	40	41	42	43	44	45
1 years	0.137	0.119	0.107	0.091	**0.097**	0.086	0.100
	(0.020)	(0.017)	(0.016)	(0.015)	**(0.014)**	(0.015)	(0.015)
2 years	0.148	0.131	0.117	**0.108**	0.105	0.108	
	(0.019)	(0.018)	(0.017)	**(0.015)**	(0.015)	(0.015)	
3 years	0.153	0.136	0.124	**0.114**	0.119		
	(0.020)	(0.018)	(0.017)	**(0.016)**	(0.016)		
4 years	0.155	0.141	**0.128**	0.126			
	(0.019)	(0.018)	**(0.017)**	(0.016)			
5 years	0.158	0.142	**0.137**				
	(0.019)	(0.018)	**(0.017)**				
6 years	0.158	**0.149**					
	(0.019)	**(0.018)**					
10 years	**0.174**						
	(0.019)						
15 years	**0.190**						
	(0.019)						
20 years	**0.209**						
	(0.020)						
25 years	**0.214**						
	(0.020)						

(b) Sons and grandfathers

Income averaged over...	Age starting from... 39	40	41	42	43	44	45
1 years	0.070	0.054	0.043	0.048	**0.054**	0.045	0.041
	(0.019)	(0.020)	(0.019)	(0.015)	**(0.016)**	(0.016)	(0.013)
2 years	0.073	0.058	0.054	**0.059**	0.059	0.051	
	(0.020)	(0.021)	(0.018)	**(0.016)**	(0.017)	(0.016)	
3 years	0.071	0.063	0.062	**0.063**	0.060		
	(0.022)	(0.020)	(0.018)	**(0.018)**	(0.017)		
4 years	0.073	0.068	**0.066**	0.065			
	(0.021)	(0.019)	**(0.019)**	(0.018)			
5 years	0.077	0.071	**0.067**				
	(0.020)	(0.020)	**(0.019)**				
6 years	0.078	**0.072**					
	(0.021)	**(0.020)**					
10 years	**0.079**						
	(0.021)						
15 years	**0.082**						
	(0.021)						
20 years	**0.075**						
	(0.020)						
25 years	**0.065**						
	(0.019)						

Table F.4: IV estimates from two-generation models. Estimates from Figure E.8 (panels c and d) in bold.

(a) Sons and fathers

Time difference obs. - instr.	Age starting from... 39	40	41	42	43	44	45
1 years	0.154	0.147	0.138	0.133	**0.115**	0.149	0.127
	(0.022)	(0.024)	(0.021)	(0.020)	**(0.018)**	(0.023)	(0.018)
2 years	0.167	0.167	0.172	0.146	**0.177**	0.159	0.160
	(0.026)	(0.025)	(0.025)	(0.023)	**(0.027)**	(0.023)	(0.022)
3 years	0.180	0.199	0.174	0.214	**0.171**	0.190	0.192
	(0.027)	(0.030)	(0.028)	(0.033)	**(0.025)**	(0.026)	(0.030)
4 years	0.207	0.191	0.248	0.192	**0.199**	0.234	0.171
	(0.031)	(0.031)	(0.037)	(0.028)	**(0.027)**	(0.036)	(0.026)
5 years	0.202	0.261	0.224	0.221	**0.239**	0.205	0.205
	(0.032)	(0.039)	(0.031)	(0.029)	**(0.036)**	(0.032)	(0.025)
6 years	0.270	0.237	0.257	0.247	**0.212**	0.247	0.234
	(0.041)	(0.034)	(0.033)	(0.037)	**(0.033)**	(0.031)	(0.031)
10 years	0.277	0.320	0.363	0.279	**0.250**	0.258	0.214
	(0.044)	(0.040)	(0.049)	(0.046)	**(0.041)**	(0.041)	(0.035)

(b) Sons and grandfathers

Time difference obs. - instr.	Age starting from... 39	40	41	42	43	44	45
1 years	0.086	0.059	0.077	0.077	**0.067**	0.067	0.059
	(0.034)	(0.027)	(0.024)	(0.022)	**(0.024)**	(0.021)	(0.021)
2 years	0.072	0.088	0.103	0.082	**0.076**	0.072	0.065
	(0.033)	(0.027)	(0.029)	(0.030)	**(0.024)**	(0.025)	(0.027)
3 years	0.105	0.109	0.101	0.093	**0.083**	0.072	0.077
	(0.034)	(0.031)	(0.036)	(0.028)	**(0.029)**	(0.030)	(0.031)
4 years	0.128	0.103	0.117	0.092	**0.086**	0.079	0.081
	(0.037)	(0.037)	(0.035)	(0.033)	**(0.035)**	(0.032)	(0.035)
5 years	0.114	0.116	0.114	0.091	**0.090**	0.085	0.089
	(0.040)	(0.035)	(0.039)	(0.037)	**(0.036)**	(0.036)	(0.041)
6 years	0.135	0.105	0.114	0.104	**0.094**	0.099	0.012
	(0.040)	(0.038)	(0.045)	(0.042)	**(0.040)**	(0.046)	(0.036)
10 years	0.145	0.142	0.016	0.054	**0.099**	0.041	-0.004
	(0.061)	(0.065)	(0.048)	(0.053)	**(0.048)**	(0.058)	(0.053)

Table F.5: “Reverse IV” estimates from two-generation models.

(a) Sons and fathers

Time difference obs. - instr.	Age starting from... 39	40	41	42	43	44	45
1 years	0.192	0.164	0.147	0.119	0.130	0.109	0.121
	(0.026)	(0.024)	(0.022)	(0.018)	(0.019)	(0.017)	(0.017)
2 years	0.232	0.199	0.163	0.147	0.145	0.132	0.141
	(0.032)	(0.029)	(0.025)	(0.022)	(0.021)	(0.021)	(0.020)
3 years	0.265	0.212	0.186	0.157	0.162	0.143	0.155
	(0.036)	(0.031)	(0.029)	(0.023)	(0.024)	(0.022)	(0.022)
4 years	0.274	0.228	0.194	0.161	0.173	0.150	0.169
	(0.037)	(0.034)	(0.029)	(0.025)	(0.025)	(0.023)	(0.025)
5 years	0.300	0.227	0.200	0.168	0.172	0.151	0.162
	(0.041)	(0.033)	(0.031)	(0.025)	(0.025)	(0.025)	(0.024)
6 years	0.292	0.234	0.206	0.157	0.171	0.148	0.160
	(0.040)	(0.035)	(0.031)	(0.023)	(0.026)	(0.024)	(0.025)
10 years	0.297	0.241	0.203	0.167	0.188	0.156	0.160
	(0.046)	(0.036)	(0.033)	(0.029)	(0.031)	(0.028)	(0.024)

(b) Sons and grandfathers

Time difference obs. - instr.	Age starting from... 39	40	41	42	43	44	45
1 years	0.092	0.083	0.053	0.064	0.079	0.059	0.064
	(0.025)	(0.032)	(0.023)	(0.020)	(0.023)	(0.022)	(0.020)
2 years	0.109	0.085	0.059	0.081	0.079	0.071	0.066
	(0.029)	(0.033)	(0.026)	(0.027)	(0.024)	(0.025)	(0.022)
3 years	0.109	0.088	0.068	0.080	0.086	0.064	0.064
	(0.029)	(0.034)	(0.031)	(0.027)	(0.028)	(0.026)	(0.027)
4 years	0.111	0.098	0.069	0.083	0.090	0.063	0.075
	(0.030)	(0.038)	(0.031)	(0.030)	(0.031)	(0.030)	(0.027)
5 years	0.116	0.097	0.074	0.091	0.103	0.077	0.076
	(0.031)	(0.038)	(0.034)	(0.030)	(0.033)	(0.030)	(0.028)
6 years	0.120	0.091	0.068	0.112	0.107	0.069	0.066
	(0.033)	(0.039)	(0.035)	(0.034)	(0.031)	(0.032)	(0.027)
10 years	0.139	0.102	0.054	0.097	0.110	0.081	0.066
	(0.040)	(0.050)	(0.035)	(0.034)	(0.033)	(0.036)	(0.028)

Table F.6: OLS estimates from three-generation models. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Estimates from Figure 4 (panel a) in bold.

Income averaged over...		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.133	0.116	0.105	0.088	**0.093**	0.083	0.097
		(0.020)	(0.017)	(0.016)	(0.015)	**(0.014)**	(0.015)	(0.015)
	G	0.048	0.039	0.027	0.036	**0.043**	0.037	0.030
		(0.019)	(0.020)	(0.019)	(0.015)	**(0.015)**	(0.016)	(0.013)
2 years	F	0.143	0.127	0.113	**0.103**	0.100	0.105	
		(0.020)	(0.018)	(0.017)	**(0.015)**	(0.015)	(0.016)	
	G	0.047	0.037	0.034	**0.044**	0.046	0.038	
		(0.021)	(0.021)	(0.018)	**(0.016)**	(0.017)	(0.016)	
3 years	F	0.148	0.131	0.119	**0.109**	0.114		
		(0.020)	(0.018)	(0.017)	**(0.016)**	(0.016)		
	G	0.043	0.039	0.041	**0.047**	0.044		
		(0.022)	(0.020)	(0.018)	**(0.018)**	(0.017)		
4 years	F	0.150	0.135	**0.123**	0.121			
		(0.020)	(0.018)	**(0.017)**	(0.016)			
	G	0.043	0.044	**0.045**	0.046			
		(0.021)	(0.020)	**(0.019)**	(0.017)			
5 years	F	0.152	0.136	**0.132**				
		(0.019)	(0.018)	**(0.017)**				
	G	0.046	0.046	**0.044**				
		(0.021)	(0.020)	**(0.019)**				
6 years	F	0.152	**0.143**					
		(0.019)	**(0.018)**					
	G	0.047	**0.045**					
		(0.021)	**(0.020)**					
10 years	F	**0.167**						
		(0.019)						
	G	**0.044**						
		(0.021)						
15 years	F	**0.183**						
		(0.020)						
	G	**0.043**						
		(0.021)						
20 years	F	**0.204**						
		(0.021)						
	G	**0.032**						
		(0.020)						
25 years	F	**0.210**						
		(0.021)						
	G	**0.023**						
		(0.019)						

Table F.7: OLS estimates from three-generation models, long-term average for fathers. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Estimates from Figure 4 (panel b) in bold.

Income averaged over...		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.168	0.170	0.171	0.170	**0.169**	0.170	0.170
		(0.019)	(0.019)	(0.019)	(0.019)	**(0.019)**	(0.019)	(0.019)
	G	0.043	0.032	0.016	0.023	**0.033**	0.025	0.023
		(0.019)	(0.020)	(0.019)	(0.015)	**(0.015)**	(0.016)	(0.013)
2 years	F	0.168	0.170	0.170	**0.168**	0.168	0.169	
		(0.019)	(0.019)	(0.019)	**(0.019)**	(0.019)	(0.019)	
	G	0.044	0.030	0.024	**0.033**	0.035	0.029	
		(0.021)	(0.021)	(0.018)	**(0.016)**	(0.017)	(0.015)	
3 years	F	0.169	0.169	0.169	**0.168**	0.168		
		(0.019)	(0.019)	(0.019)	**(0.019)**	(0.019)		
	G	0.039	0.032	0.032	**0.036**	0.035		
		(0.022)	(0.020)	(0.018)	**(0.018)**	(0.017)		
4 years	F	0.168	0.168	**0.168**	0.168			
		(0.019)	(0.019)	**(0.019)**	(0.019)			
	G	0.039	0.037	**0.035**	0.036			
		(0.021)	(0.020)	**(0.019)**	(0.017)			
5 years	F	0.168	0.168	**0.168**				
		(0.019)	(0.019)	**(0.019)**				
	G	0.042	0.039	**0.036**				
		(0.021)	(0.020)	**(0.019)**				
6 years	F	0.167	**0.168**					
		(0.019)	**(0.019)**					
	G	0.043	**0.040**					
		(0.021)	**(0.020)**					
10 years	F	**0.167**						
		(0.019)						
	G	**0.044**						
		(0.021)						
15 years	F	**0.167**						
		(0.019)						
	G	**0.048**						
		(0.021)						
20 years	F	**0.168**						
		(0.019)						
	G	**0.041**						
		(0.020)						
25 years	F	**0.169**						
		(0.019)						
	G	**0.033**						
		(0.019)						

Table F.8: OLS estimates from three-generation models, long-term average for grandfathers. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Estimates from Figure 4 (panel c) in bold.

Income averaged over...		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.132	0.114	0.101	0.086	**0.092**	0.081	0.096
		(0.020)	(0.017)	(0.016)	(0.015)	**(0.014)**	(0.015)	(0.015)
	G	0.048	0.055	0.058	0.062	**0.061**	0.064	0.059
		(0.021)	(0.021)	(0.021)	(0.021)	**(0.021)**	(0.021)	(0.021)
2 years	F	0.142	0.125	0.110	**0.102**	0.099	0.103	
		(0.020)	(0.018)	(0.017)	**(0.015)**	(0.015)	(0.016)	
	G	0.047	0.053	0.056	**0.059**	0.060	0.059	
		(0.021)	(0.021)	(0.021)	**(0.021)**	(0.021)	(0.021)	
3 years	F	0.147	0.129	0.118	**0.108**	0.113		
		(0.020)	(0.018)	(0.017)	**(0.016)**	(0.016)		
	G	0.047	0.052	0.055	**0.058**	0.057		
		(0.021)	(0.021)	(0.021)	**(0.021)**	(0.021)		
4 years	F	0.149	0.134	**0.122**	0.120			
		(0.020)	(0.018)	**(0.017)**	(0.016)			
	G	0.047	0.052	**0.055**	0.055			
		(0.021)	(0.021)	**(0.021)**	(0.021)			
5 years	F	0.151	0.136	**0.131**				
		(0.019)	(0.018)	**(0.017)**				
	G	0.047	0.052	**0.053**				
		(0.021)	(0.021)	**(0.021)**				
6 years	F	0.152	**0.143**					
		(0.019)	**(0.018)**					
	G	0.048	**0.050**					
		(0.021)	**(0.021)**					
10 years	F	**0.167**						
		(0.019)						
	G	**0.044**						
		(0.021)						
15 years	F	**0.184**						
		(0.020)						
	G	**0.040**						
		(0.021)						
20 years	F	**0.203**						
		(0.021)						
	G	**0.036**						
		(0.021)						
25 years	F	**0.208**						
		(0.021)						
	G	**0.035**						
		(0.021)						

Table F.9: IV estimates from three-generation models. Estimates from Figure 4 (panel d) in bold.

Time difference obs. - instr.		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.148	0.144	0.132	0.127	**0.110**	0.144	0.119
		(0.023)	(0.024)	(0.021)	(0.020)	**(0.018)**	(0.023)	(0.018)
	G	0.051	0.028	0.048	0.054	**0.050**	0.043	0.045
		(0.034)	(0.027)	(0.024)	(0.022)	**(0.024)**	(0.021)	(0.022)
2 years	F	0.164	0.161	0.162	0.138	**0.171**	0.149	0.147
		(0.027)	(0.026)	(0.025)	(0.024)	**(0.028)**	(0.024)	(0.022)
	G	0.025	0.046	0.064	0.054	**0.045**	0.050	0.039
		(0.034)	(0.029)	(0.029)	(0.030)	**(0.024)**	(0.026)	(0.028)
3 years	F	0.172	0.190	0.166	0.206	**0.160**	0.174	0.192
		(0.028)	(0.031)	(0.029)	(0.034)	**(0.026)**	(0.026)	(0.031)
	G	0.044	0.064	0.055	0.045	**0.056**	0.045	0.048
		(0.036)	(0.032)	(0.037)	(0.030)	**(0.031)**	(0.032)	(0.032)
4 years	F	0.197	0.183	0.243	0.178	**0.181**	0.230	0.151
		(0.032)	(0.033)	(0.039)	(0.029)	**(0.027)**	(0.038)	(0.025)
	G	0.065	0.053	0.032	0.061	**0.052**	0.051	0.054
		(0.039)	(0.039)	(0.038)	(0.036)	**(0.038)**	(0.033)	(0.035)
5 years	F	0.193	0.255	0.213	0.198	**0.236**	0.176	0.192
		(0.034)	(0.041)	(0.034)	(0.031)	**(0.038)**	(0.031)	(0.026)
	G	0.053	0.036	0.051	0.054	**0.048**	0.061	0.054
		(0.043)	(0.038)	(0.042)	(0.041)	**(0.038)**	(0.036)	(0.041)
6 years	F	0.263	0.227	0.236	0.243	**0.183**	0.230	0.244
		(0.044)	(0.036)	(0.034)	(0.040)	**(0.032)**	(0.033)	(0.034)
	G	0.036	0.050	0.046	0.049	**0.060**	0.053	-0.045
		(0.047)	(0.044)	(0.048)	(0.045)	**(0.041)**	(0.046)	(0.039)
10 years	F	0.239	0.302	0.382	0.293	**0.254**	0.243	0.247
		(0.044)	(0.043)	(0.053)	(0.051)	**(0.046)**	(0.044)	(0.042)
	G	0.069	0.044	-0.107	-0.056	**0.033**	-0.040	-0.085
		(0.066)	(0.067)	(0.055)	(0.058)	**(0.054)**	(0.064)	(0.057)

Table F.10: IV estimates from three-generation models, six year time difference for fathers. Estimates from Figure 4 (panel e) in bold.

Time difference obs. - instr.		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.205	0.210	0.207	0.203	**0.206**	0.206	0.204
		(0.034)	(0.033)	(0.033)	(0.034)	**(0.033)**	(0.033)	(0.034)
	G	0.050	0.016	0.036	0.048	**0.038**	0.037	0.036
		(0.036)	(0.028)	(0.025)	(0.023)	**(0.026)**	(0.022)	(0.023)
2 years	F	0.209	0.207	0.203	0.204	**0.206**	0.202	0.191
		(0.034)	(0.033)	(0.034)	(0.034)	**(0.033)**	(0.034)	(0.032)
	G	0.020	0.043	0.064	0.048	**0.042**	0.043	0.046
		(0.035)	(0.030)	(0.030)	(0.032)	**(0.025)**	(0.027)	(0.030)
3 years	F	0.205	0.204	0.204	0.203	**0.202**	0.189	0.182
		(0.034)	(0.034)	(0.034)	(0.034)	**(0.034)**	(0.033)	(0.032)
	G	0.050	0.069	0.058	0.053	**0.050**	0.049	0.052
		(0.036)	(0.033)	(0.038)	(0.031)	**(0.031)**	(0.032)	(0.032)
4 years	F	0.200	0.205	0.203	0.199	**0.189**	0.180	0.184
		(0.034)	(0.034)	(0.034)	(0.034)	**(0.033)**	(0.032)	(0.032)
	G	0.081	0.061	0.064	0.058	**0.060**	0.054	0.051
		(0.039)	(0.041)	(0.037)	(0.036)	**(0.039)**	(0.034)	(0.035)
5 years	F	0.202	0.204	0.200	0.186	**0.181**	0.182	0.189
		(0.034)	(0.034)	(0.034)	(0.033)	**(0.032)**	(0.032)	(0.033)
	G	0.066	0.067	0.067	0.066	**0.060**	0.054	0.046
		(0.044)	(0.039)	(0.042)	(0.043)	**(0.038)**	(0.037)	(0.041)
6 years	F	0.201	0.201	0.188	0.177	**0.183**	0.186	0.199
		(0.034)	(0.034)	(0.033)	(0.032)	**(0.032)**	(0.033)	(0.033)
	G	0.076	0.068	0.077	0.071	**0.060**	0.052	-0.034
		(0.044)	(0.043)	(0.048)	(0.044)	**(0.041)**	(0.046)	(0.039)
10 years	F	0.178	0.186	0.200	0.203	**0.192**	0.209	0.223
		(0.033)	(0.033)	(0.034)	(0.035)	**(0.034)**	(0.036)	(0.037)
	G	0.094	0.075	-0.045	-0.003	**0.056**	-0.035	-0.070
		(0.064)	(0.066)	(0.051)	(0.057)	**(0.052)**	(0.066)	(0.057)

Table F.11: IV estimates from three-generation models, six year time difference for grandfathers. Estimates from Figure 4 (panel f) in bold.

Time difference obs. - instr.		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.150	0.138	0.128	0.128	**0.113**	0.138	0.120
		(0.023)	(0.025)	(0.021)	(0.021)	**(0.018)**	(0.024)	(0.019)
	G	0.063	0.067	0.069	0.065	**0.072**	0.073	0.070
		(0.039)	(0.039)	(0.040)	(0.039)	**(0.040)**	(0.039)	(0.040)
2 years	F	0.160	0.154	0.166	0.145	**0.162**	0.147	0.154
		(0.028)	(0.026)	(0.026)	(0.023)	**(0.028)**	(0.024)	(0.023)
	G	0.061	0.064	0.062	0.061	**0.063**	0.071	0.063
		(0.040)	(0.040)	(0.040)	(0.040)	**(0.040)**	(0.040)	(0.040)
3 years	F	0.168	0.190	0.174	0.199	**0.156**	0.182	0.182
		(0.028)	(0.031)	(0.028)	(0.034)	**(0.026)**	(0.026)	(0.031)
	G	0.059	0.057	0.060	0.049	**0.064**	0.065	0.062
		(0.040)	(0.040)	(0.040)	(0.040)	**(0.040)**	(0.040)	(0.040)
4 years	F	0.202	0.192	0.233	0.179	**0.191**	0.220	0.150
		(0.034)	(0.032)	(0.039)	(0.029)	**(0.028)**	(0.037)	(0.025)
	G	0.053	0.057	0.049	0.053	**0.056**	0.064	0.063
		(0.041)	(0.040)	(0.040)	(0.040)	**(0.040)**	(0.041)	(0.040)
5 years	F	0.202	0.248	0.210	0.218	**0.226**	0.177	0.196
		(0.033)	(0.042)	(0.034)	(0.031)	**(0.037)**	(0.031)	(0.027)
	G	0.053	0.046	0.053	0.043	**0.054**	0.068	0.051
		(0.041)	(0.040)	(0.041)	(0.040)	**(0.041)**	(0.040)	(0.039)
6 years	F	0.254	0.221	0.251	0.237	**0.183**	0.232	0.224
		(0.043)	(0.036)	(0.035)	(0.038)	**(0.032)**	(0.033)	(0.032)
	G	0.042	0.051	0.044	0.043	**0.060**	0.056	0.034
		(0.041)	(0.041)	(0.041)	(0.041)	**(0.041)**	(0.040)	(0.040)
10 years	F	0.244	0.309	0.347	0.274	**0.234**	0.232	0.208
		(0.043)	(0.042)	(0.050)	(0.050)	**(0.043)**	(0.042)	(0.038)
	G	0.044	0.035	0.013	0.023	**0.046**	0.052	0.050
		(0.042)	(0.040)	(0.042)	(0.042)	**(0.041)**	(0.042)	(0.041)

Table F.12: “Reverse IV” estimates from three-generation models.

Time difference obs. - instr.		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.185	0.157	0.143	0.114	0.124	0.104	0.116
		(0.027)	(0.025)	(0.023)	(0.018)	(0.019)	(0.018)	(0.017)
	G	0.053	0.053	0.025	0.044	0.058	0.044	0.050
		(0.025)	(0.032)	(0.024)	(0.020)	(0.023)	(0.022)	(0.020)
2 years	F	0.222	0.189	0.159	0.140	0.137	0.129	0.135
		(0.032)	(0.030)	(0.025)	(0.022)	(0.021)	(0.021)	(0.021)
	G	0.061	0.049	0.025	0.051	0.056	0.050	0.042
		(0.030)	(0.034)	(0.027)	(0.026)	(0.024)	(0.027)	(0.024)
3 years	F	0.256	0.204	0.180	0.149	0.155	0.144	0.154
		(0.037)	(0.032)	(0.030)	(0.024)	(0.025)	(0.022)	(0.024)
	G	0.043	0.046	0.031	0.044	0.061	0.037	0.038
		(0.032)	(0.034)	(0.032)	(0.027)	(0.030)	(0.028)	(0.027)
4 years	F	0.264	0.218	0.188	0.156	0.165	0.157	0.159
		(0.039)	(0.035)	(0.031)	(0.026)	(0.026)	(0.024)	(0.026)
	G	0.045	0.051	0.023	0.049	0.065	0.033	0.047
		(0.032)	(0.039)	(0.033)	(0.033)	(0.032)	(0.031)	(0.027)
5 years	F	0.290	0.216	0.195	0.164	0.170	0.152	0.154
		(0.043)	(0.035)	(0.033)	(0.026)	(0.026)	(0.025)	(0.025)
	G	0.045	0.049	0.027	0.046	0.072	0.042	0.042
		(0.034)	(0.040)	(0.037)	(0.033)	(0.033)	(0.031)	(0.028)
6 years	F	0.283	0.222	0.203	0.152	0.154	0.154	0.160
		(0.042)	(0.036)	(0.033)	(0.024)	(0.026)	(0.025)	(0.027)
	G	0.038	0.060	0.018	0.070	0.082	0.023	0.027
		(0.036)	(0.045)	(0.038)	(0.035)	(0.032)	(0.033)	(0.028)
10 years	F	0.283	0.227	0.206	0.158	0.165	0.145	0.149
		(0.048)	(0.038)	(0.036)	(0.031)	(0.034)	(0.030)	(0.027)
	G	0.050	0.039	-0.011	0.049	0.086	0.038	0.032
		(0.046)	(0.053)	(0.039)	(0.037)	(0.035)	(0.038)	(0.030)

Table F.13: "Reverse IV" estimates from three-generation models, six year time difference for fathers.

Time difference obs. - instr.		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.164	0.164	0.168	0.166	0.164	0.166	0.165
		(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
	G	0.060	0.053	0.024	0.033	0.057	0.033	0.042
		(0.027)	(0.034)	(0.025)	(0.022)	(0.024)	(0.023)	(0.021)
2 years	F	0.161	0.163	0.167	0.166	0.162	0.166	0.168
		(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.028)
	G	0.070	0.057	0.028	0.041	0.058	0.039	0.044
		(0.032)	(0.037)	(0.028)	(0.028)	(0.025)	(0.028)	(0.024)
3 years	F	0.160	0.162	0.167	0.165	0.163	0.169	0.168
		(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.028)	(0.027)
	G	0.071	0.058	0.032	0.043	0.062	0.031	0.035
		(0.032)	(0.037)	(0.033)	(0.029)	(0.030)	(0.029)	(0.028)
4 years	F	0.160	0.163	0.166	0.165	0.165	0.170	0.159
		(0.027)	(0.027)	(0.027)	(0.028)	(0.028)	(0.027)	(0.026)
	G	0.073	0.065	0.033	0.041	0.066	0.025	0.047
		(0.033)	(0.042)	(0.034)	(0.033)	(0.033)	(0.031)	(0.028)
5 years	F	0.161	0.161	0.166	0.167	0.164	0.159	0.160
		(0.027)	(0.027)	(0.028)	(0.028)	(0.027)	(0.026)	(0.027)
	G	0.075	0.067	0.033	0.052	0.072	0.040	0.049
		(0.034)	(0.043)	(0.036)	(0.034)	(0.033)	(0.031)	(0.029)
6 years	F	0.159	0.163	0.170	0.165	0.154	0.164	0.163
		(0.028)	(0.028)	(0.028)	(0.028)	(0.026)	(0.027)	(0.028)
	G	0.081	0.061	0.028	0.063	0.082	0.027	0.033
		(0.037)	(0.045)	(0.038)	(0.036)	(0.032)	(0.034)	(0.028)
10 years	F	0.153	0.158	0.166	0.162	0.144	0.151	0.152
		(0.027)	(0.028)	(0.028)	(0.028)	(0.028)	(0.029)	(0.028)
	G	0.092	0.064	0.010	0.050	0.088	0.044	0.037
		(0.043)	(0.054)	(0.036)	(0.036)	(0.034)	(0.039)	(0.029)

Table F.14: "Reverse IV" estimates from three-generation models, six year time difference for grandfathers.

Time difference obs. - instr.		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.187	0.158	0.140	0.108	0.121	0.106	0.116
		(0.028)	(0.026)	(0.024)	(0.019)	(0.020)	(0.017)	(0.018)
	G	0.069	0.073	0.077	0.085	0.083	0.085	0.087
		(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.032)
2 years	F	0.232	0.193	0.155	0.132	0.133	0.132	0.127
		(0.034)	(0.030)	(0.026)	(0.022)	(0.021)	(0.021)	(0.021)
	G	0.057	0.066	0.075	0.081	0.079	0.083	0.086
		(0.032)	(0.032)	(0.031)	(0.032)	(0.031)	(0.032)	(0.032)
3 years	F	0.265	0.205	0.175	0.138	0.151	0.141	0.142
		(0.039)	(0.033)	(0.030)	(0.023)	(0.024)	(0.022)	(0.023)
	G	0.050	0.064	0.072	0.078	0.079	0.083	0.087
		(0.032)	(0.031)	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)
4 years	F	0.273	0.223	0.179	0.143	0.159	0.147	0.155
		(0.041)	(0.036)	(0.030)	(0.025)	(0.025)	(0.023)	(0.026)
	G	0.050	0.062	0.070	0.081	0.080	0.086	0.082
		(0.031)	(0.032)	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)
5 years	F	0.294	0.218	0.188	0.149	0.158	0.148	0.155
		(0.044)	(0.034)	(0.032)	(0.025)	(0.025)	(0.024)	(0.026)
	G	0.048	0.061	0.071	0.082	0.083	0.083	0.066
		(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
6 years	F	0.282	0.226	0.189	0.137	0.154	0.149	0.153
		(0.041)	(0.036)	(0.032)	(0.023)	(0.026)	(0.024)	(0.027)
	G	0.048	0.063	0.074	0.087	0.082	0.067	0.068
		(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.031)	(0.032)
10 years	F	0.281	0.235	0.189	0.150	0.173	0.156	0.145
		(0.047)	(0.038)	(0.034)	(0.030)	(0.032)	(0.028)	(0.026)
	G	0.057	0.048	0.060	0.077	0.078	0.072	0.072
		(0.033)	(0.032)	(0.032)	(0.033)	(0.032)	(0.033)	(0.034)

F.2 Tables for sample of men and women

Table F.15: OLS estimates from two-generation models. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31.

(a) Sons/daughters and fathers

Income averaged over...	Age starting from... 39	40	41	42	43	44	45
1 years	0.126	0.100	0.094	0.086	0.098	0.080	0.084
	(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)
2 years	0.130	0.113	0.105	0.105	0.102	0.094	
	(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	
3 years	0.134	0.120	0.117	0.110	0.109		
	(0.013)	(0.012)	(0.012)	(0.011)	(0.011)		
4 years	0.137	0.128	0.120	0.116			
	(0.013)	(0.012)	(0.012)	(0.012)			
5 years	0.143	0.130	0.125				
	(0.013)	(0.012)	(0.012)				
6 years	0.144	0.134					
	(0.013)	(0.012)					
10 years	0.155						
	(0.013)						
15 years	0.169						
	(0.014)						
20 years	0.181						
	(0.014)						
25 years	0.188						
	(0.014)						

(b) Sons/daughters and grandfathers

Income averaged over...	Age starting from... 39	40	41	42	43	44	45
1 years	0.056	0.053	0.043	0.049	0.044	0.048	0.040
	(0.017)	(0.015)	(0.014)	(0.012)	(0.012)	(0.012)	(0.010)
2 years	0.065	0.057	0.054	0.054	0.055	0.052	
	(0.016)	(0.015)	(0.014)	(0.013)	(0.013)	(0.011)	
3 years	0.065	0.062	0.058	0.061	0.058		
	(0.016)	(0.015)	(0.014)	(0.013)	(0.012)		
4 years	0.069	0.064	0.063	0.063			
	(0.016)	(0.015)	(0.014)	(0.013)			
5 years	0.070	0.068	0.065				
	(0.015)	(0.015)	(0.014)				
6 years	0.073	0.070					
	(0.015)	(0.014)					
10 years	0.073						
	(0.015)						
15 years	0.082						
	(0.016)						
20 years	0.081						
	(0.016)						
25 years	0.074						
	(0.015)						

Table F.16: IV estimates from two-generation models. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31.

(a) Sons/daughters and fathers

Time difference	Age starting from...						
obs. - instr.	39	40	41	42	43	44	45
1 years	0.137	0.130	0.119	0.131	0.111	0.121	0.106
	(0.015)	(0.016)	(0.014)	(0.015)	(0.014)	(0.016)	(0.014)
2 years	0.153	0.142	0.161	0.137	0.152	0.129	0.138
	(0.017)	(0.017)	(0.018)	(0.017)	(0.019)	(0.017)	(0.017)
3 years	0.158	0.180	0.153	0.176	0.143	0.161	0.157
	(0.018)	(0.021)	(0.019)	(0.022)	(0.019)	(0.019)	(0.020)
4 years	0.196	0.165	0.193	0.155	0.174	0.183	0.156
	(0.022)	(0.021)	(0.024)	(0.021)	(0.021)	(0.024)	(0.019)
5 years	0.181	0.202	0.170	0.189	0.195	0.181	0.186
	(0.022)	(0.024)	(0.022)	(0.023)	(0.025)	(0.022)	(0.019)
6 years	0.218	0.181	0.209	0.198	0.193	0.212	0.196
	(0.027)	(0.024)	(0.025)	(0.025)	(0.023)	(0.023)	(0.023)
10 years	0.236	0.267	0.276	0.226	0.248	0.239	0.197
	(0.029)	(0.027)	(0.031)	(0.031)	(0.030)	(0.031)	(0.024)

(b) Sons/daughters and grandfathers

Time difference	Age starting from...						
obs. - instr.	39	40	41	42	43	44	45
1 years	0.083	0.060	0.076	0.064	0.073	0.066	0.047
	(0.024)	(0.019)	(0.018)	(0.016)	(0.017)	(0.016)	(0.015)
2 years	0.072	0.087	0.081	0.087	0.080	0.058	0.063
	(0.023)	(0.020)	(0.020)	(0.021)	(0.019)	(0.018)	(0.019)
3 years	0.101	0.087	0.102	0.094	0.069	0.071	0.098
	(0.025)	(0.022)	(0.024)	(0.021)	(0.021)	(0.022)	(0.026)
4 years	0.100	0.108	0.110	0.076	0.082	0.104	0.096
	(0.026)	(0.025)	(0.025)	(0.023)	(0.025)	(0.027)	(0.028)
5 years	0.121	0.115	0.090	0.089	0.117	0.102	0.109
	(0.028)	(0.026)	(0.028)	(0.026)	(0.031)	(0.029)	(0.031)
6 years	0.133	0.088	0.106	0.132	0.116	0.122	0.088
	(0.030)	(0.027)	(0.032)	(0.034)	(0.033)	(0.034)	(0.037)
10 years	0.171	0.174	0.121	0.110	0.148	0.084	0.035
	(0.048)	(0.049)	(0.051)	(0.048)	(0.047)	(0.041)	(0.040)

Table F.17: OLS estimates from three-generation models. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Men and women in final generation

Income averaged over...		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.123	0.097	0.092	0.083	0.095	0.077	0.081
		(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)
	G	0.039	0.040	0.030	0.039	0.034	0.041	0.032
		(0.016)	(0.015)	(0.014)	(0.012)	(0.011)	(0.011)	(0.009)
2 years	F	0.126	0.110	0.102	0.101	0.098	0.091	
		(0.013)	(0.012)	(0.012)	(0.011)	(0.011)	(0.011)	
	G	0.045	0.040	0.039	0.041	0.043	0.042	
		(0.016)	(0.015)	(0.014)	(0.012)	(0.012)	(0.011)	
3 years	F	0.130	0.115	0.113	0.105	0.105		
		(0.013)	(0.012)	(0.012)	(0.011)	(0.011)		
	G	0.043	0.043	0.040	0.046	0.044		
		(0.016)	(0.015)	(0.014)	(0.013)	(0.012)		
4 years	F	0.133	0.123	0.115	0.111			
		(0.013)	(0.012)	(0.012)	(0.012)			
	G	0.045	0.044	0.045	0.047			
		(0.016)	(0.015)	(0.014)	(0.013)			
5 years	F	0.138	0.125	0.120				
		(0.013)	(0.012)	(0.012)				
	G	0.045	0.047	0.046				
		(0.015)	(0.015)	(0.014)				
6 years	F	0.139	0.129					
		(0.013)	(0.012)					
	G	0.048	0.048					
		(0.015)	(0.014)					
10 years	F	0.149						
		(0.013)						
	G	0.044						
		(0.015)						
15 years	F	0.162						
		(0.014)						
	G	0.049						
		(0.016)						
20 years	F	0.174						
		(0.014)						
	G	0.045						
		(0.016)						
25 years	F	0.181						
		(0.015)						
	G	0.038						
		(0.015)						

Table F.18: OLS estimates from three-generation models, long-term average for fathers. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Men and women in final generation

Income averaged over...		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.151	0.151	0.153	0.151	0.152	0.151	0.151
		(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
	G	0.034	0.033	0.021	0.029	0.028	0.033	0.026
		(0.016)	(0.015)	(0.013)	(0.012)	(0.011)	(0.011)	(0.009)
2 years	F	0.150	0.151	0.151	0.151	0.151	0.150	
		(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	
	G	0.040	0.032	0.030	0.033	0.036	0.034	
		(0.016)	(0.015)	(0.014)	(0.012)	(0.012)	(0.011)	
3 years	F	0.150	0.150	0.151	0.150	0.150		
		(0.013)	(0.013)	(0.013)	(0.013)	(0.013)		
	G	0.038	0.036	0.034	0.039	0.038		
		(0.016)	(0.015)	(0.014)	(0.013)	(0.012)		
4 years	F	0.150	0.150	0.150	0.150			
		(0.013)	(0.013)	(0.013)	(0.013)			
	G	0.041	0.038	0.039	0.040			
		(0.016)	(0.015)	(0.014)	(0.013)			
5 years	F	0.150	0.150	0.150				
		(0.013)	(0.013)	(0.013)				
	G	0.042	0.042	0.040				
		(0.015)	(0.015)	(0.014)				
6 years	F	0.150	0.150					
		(0.013)	(0.013)					
	G	0.045	0.043					
		(0.015)	(0.014)					
10 years	F	0.149						
		(0.013)						
	G	0.044						
		(0.015)						
15 years	F	0.148						
		(0.013)						
	G	0.052						
		(0.016)						
20 years	F	0.148						
		(0.013)						
	G	0.052						
		(0.016)						
25 years	F	0.149						
		(0.013)						
	G	0.046						
		(0.015)						

Table F.19: OLS estimates from three-generation models, long-term average for grandfathers. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Men and women in final generation

Income averaged over...		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.122	0.096	0.090	0.082	0.093	0.075	0.079
		(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)
	G	0.050	0.055	0.056	0.059	0.056	0.060	0.058
		(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
2 years	F	0.125	0.108	0.100	0.100	0.097	0.089	
		(0.013)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	
	G	0.050	0.053	0.055	0.055	0.055	0.056	
		(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	
3 years	F	0.129	0.114	0.111	0.104	0.104		
		(0.013)	(0.012)	(0.012)	(0.012)	(0.011)		
	G	0.049	0.052	0.052	0.054	0.054		
		(0.015)	(0.015)	(0.015)	(0.015)	(0.015)		
4 years	F	0.132	0.123	0.115	0.111			
		(0.013)	(0.012)	(0.012)	(0.012)			
	G	0.049	0.050	0.052	0.052			
		(0.015)	(0.015)	(0.015)	(0.015)			
5 years	F	0.138	0.125	0.120				
		(0.013)	(0.012)	(0.012)				
	G	0.047	0.050	0.051				
		(0.015)	(0.015)	(0.015)				
6 years	F	0.139	0.129					
		(0.013)	(0.013)					
	G	0.047	0.049					
		(0.015)	(0.015)					
10 years	F	0.149						
		(0.013)						
	G	0.044						
		(0.015)						
15 years	F	0.163						
		(0.014)						
	G	0.041						
		(0.015)						
20 years	F	0.175						
		(0.014)						
	G	0.039						
		(0.015)						
25 years	F	0.182						
		(0.015)						
	G	0.037						
		(0.015)						

Table F.20: IV estimates from three-generation models. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Men and women in final generation

Time difference		Age starting from...						
obs. - instr.		39	40	41	42	43	44	45
1 years	F	0.132	0.127	0.113	0.126	0.105	0.117	0.101
		(0.015)	(0.016)	(0.014)	(0.015)	(0.014)	(0.016)	(0.014)
	G	0.057	0.036	0.054	0.045	0.057	0.049	0.034
		(0.024)	(0.019)	(0.018)	(0.016)	(0.017)	(0.016)	(0.015)
2 years	F	0.150	0.135	0.154	0.128	0.146	0.122	0.124
		(0.018)	(0.017)	(0.019)	(0.017)	(0.019)	(0.018)	(0.017)
	G	0.037	0.057	0.048	0.064	0.053	0.040	0.037
		(0.023)	(0.021)	(0.021)	(0.021)	(0.019)	(0.019)	(0.019)
3 years	F	0.150	0.172	0.144	0.167	0.135	0.144	0.149
		(0.019)	(0.021)	(0.020)	(0.023)	(0.019)	(0.020)	(0.022)
	G	0.059	0.056	0.070	0.058	0.043	0.041	0.061
		(0.025)	(0.022)	(0.024)	(0.022)	(0.022)	(0.021)	(0.023)
4 years	F	0.188	0.154	0.184	0.145	0.156	0.171	0.138
		(0.023)	(0.021)	(0.025)	(0.022)	(0.021)	(0.025)	(0.019)
	G	0.056	0.074	0.056	0.048	0.045	0.065	0.063
		(0.027)	(0.026)	(0.026)	(0.025)	(0.025)	(0.025)	(0.027)
5 years	F	0.169	0.192	0.160	0.167	0.184	0.157	0.174
		(0.023)	(0.025)	(0.024)	(0.024)	(0.026)	(0.022)	(0.020)
	G	0.078	0.061	0.045	0.051	0.064	0.068	0.069
		(0.029)	(0.028)	(0.029)	(0.027)	(0.028)	(0.028)	(0.030)
6 years	F	0.206	0.171	0.186	0.184	0.168	0.198	0.186
		(0.029)	(0.025)	(0.026)	(0.027)	(0.023)	(0.024)	(0.025)
	G	0.070	0.044	0.049	0.076	0.070	0.071	0.038
		(0.032)	(0.030)	(0.032)	(0.031)	(0.032)	(0.034)	(0.040)
10 years	F	0.201	0.250	0.261	0.217	0.246	0.226	0.202
		(0.030)	(0.029)	(0.035)	(0.034)	(0.034)	(0.033)	(0.028)
	G	0.094	0.084	0.028	0.007	0.069	0.018	-0.027
		(0.049)	(0.049)	(0.056)	(0.045)	(0.046)	(0.046)	(0.045)

Table F.21: IV estimates from three-generation models, long-term average for fathers. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Men and women in final generation

Time difference obs. - instr.		Age starting from... 39	40	41	42	43	44	45
1 years	F	0.187	0.191	0.188	0.187	0.188	0.188	0.184
		(0.024)	(0.024)	(0.023)	(0.024)	(0.023)	(0.024)	(0.024)
	G	0.044	0.021	0.041	0.039	0.045	0.037	0.022
		(0.025)	(0.020)	(0.018)	(0.017)	(0.018)	(0.016)	(0.015)
2 years	F	0.190	0.187	0.187	0.184	0.188	0.183	0.173
		(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
	G	0.025	0.048	0.048	0.055	0.045	0.027	0.036
		(0.024)	(0.021)	(0.021)	(0.022)	(0.020)	(0.019)	(0.019)
3 years	F	0.185	0.187	0.185	0.184	0.183	0.173	0.164
		(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.023)
	G	0.056	0.053	0.064	0.055	0.032	0.039	0.057
		(0.025)	(0.023)	(0.025)	(0.023)	(0.022)	(0.022)	(0.023)
4 years	F	0.185	0.185	0.185	0.181	0.173	0.164	0.168
		(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.023)	(0.023)
	G	0.061	0.069	0.063	0.036	0.046	0.060	0.058
		(0.027)	(0.027)	(0.027)	(0.025)	(0.025)	(0.025)	(0.027)
5 years	F	0.183	0.185	0.182	0.170	0.164	0.167	0.172
		(0.024)	(0.024)	(0.024)	(0.024)	(0.023)	(0.023)	(0.024)
	G	0.077	0.068	0.041	0.051	0.067	0.062	0.062
		(0.030)	(0.029)	(0.029)	(0.028)	(0.028)	(0.028)	(0.031)
6 years	F	0.183	0.182	0.171	0.160	0.168	0.170	0.171
		(0.024)	(0.024)	(0.024)	(0.024)	(0.023)	(0.024)	(0.025)
	G	0.077	0.042	0.059	0.078	0.070	0.069	0.045
		(0.032)	(0.029)	(0.032)	(0.031)	(0.032)	(0.035)	(0.039)
10 years	F	0.162	0.169	0.169	0.178	0.169	0.186	0.194
		(0.024)	(0.025)	(0.025)	(0.025)	(0.024)	(0.026)	(0.027)
	G	0.105	0.101	0.063	0.031	0.089	0.025	-0.018
		(0.048)	(0.050)	(0.055)	(0.044)	(0.044)	(0.046)	(0.044)

Table F.22: IV estimates from three-generation models, long-term average for grandfathers. Note: 10-year averages start at age 38; 15-year averages start at age 36; 20-year averages start at age 33; and 25-year averages start at age 31. Men and women in final generation

Time difference		Age starting from...						
obs. - instr.		39	40	41	42	43	44	45
1 years	F	0.126	0.121	0.109	0.124	0.103	0.109	0.097
		(0.015)	(0.017)	(0.015)	(0.016)	(0.014)	(0.016)	(0.015)
	G	0.089	0.090	0.092	0.085	0.092	0.095	0.093
		(0.032)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
2 years	F	0.143	0.129	0.154	0.129	0.135	0.117	0.135
		(0.019)	(0.017)	(0.020)	(0.017)	(0.019)	(0.018)	(0.018)
	G	0.085	0.089	0.082	0.084	0.085	0.093	0.078
		(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.032)
3 years	F	0.145	0.170	0.145	0.159	0.128	0.156	0.146
		(0.020)	(0.022)	(0.020)	(0.023)	(0.019)	(0.020)	(0.022)
	G	0.085	0.080	0.084	0.077	0.085	0.078	0.077
		(0.033)	(0.032)	(0.033)	(0.033)	(0.033)	(0.032)	(0.032)
4 years	F	0.190	0.156	0.176	0.142	0.167	0.169	0.138
		(0.024)	(0.022)	(0.025)	(0.022)	(0.022)	(0.025)	(0.019)
	G	0.075	0.083	0.077	0.080	0.070	0.078	0.076
		(0.033)	(0.033)	(0.033)	(0.033)	(0.032)	(0.032)	(0.032)
5 years	F	0.172	0.185	0.158	0.187	0.179	0.158	0.173
		(0.024)	(0.026)	(0.024)	(0.024)	(0.026)	(0.022)	(0.020)
	G	0.079	0.077	0.081	0.062	0.070	0.078	0.067
		(0.033)	(0.033)	(0.033)	(0.032)	(0.033)	(0.032)	(0.032)
6 years	F	0.198	0.167	0.205	0.186	0.168	0.194	0.185
		(0.028)	(0.025)	(0.026)	(0.027)	(0.023)	(0.023)	(0.024)
	G	0.073	0.079	0.061	0.063	0.070	0.069	0.059
		(0.033)	(0.033)	(0.032)	(0.033)	(0.032)	(0.032)	(0.032)
10 years	F	0.208	0.252	0.266	0.222	0.235	0.219	0.184
		(0.029)	(0.029)	(0.034)	(0.032)	(0.032)	(0.032)	(0.026)
	G	0.063	0.054	0.043	0.046	0.054	0.064	0.076
		(0.032)	(0.032)	(0.033)	(0.033)	(0.033)	(0.033)	(0.035)

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