Education, Earnings Dynamics, and Life-Cycle Inequality

Kai Liu\textsuperscript{1}, Magne Mogstad\textsuperscript{2}, Kjell G. Salvanes\textsuperscript{3}

\textsuperscript{1}University of Cambridge

\textsuperscript{2}University of Chicago

\textsuperscript{3}Norwegian School of Economics

May 13, 2016
Trade-off between risk and return plays a central role in empirical work on investment in physical capital.

By way of comparison, this trade-off has received little attention in the empirical literature on investments in human capital.

To date, most research focuses on how additional schooling affects mean earnings, abstracting from other life-cycle factors such as:

- unemployment risk
- earnings volatility
- concavity of utility over consumption

(see review in Heckman et al., 2006)
College vs. high school: Mean and variance of earnings

![Graphs showing mean and variance of earnings over age, with lines for T=0 and T=1 separately.](image-url)
Introduction: Our objectives

We use a population panel data containing records for every Norwegian from 1967 to 2010 to:

1) Provide evidence on the causal impacts of additional schooling on life cycle profiles in the mean and variance of earnings
   - following individuals over their working lifespan
   - instrumenting schooling with an education reform

2) Examine how an exogenous increase in education affects the earnings dynamics over the life cycle
   - focusing on persistent vs. transitory components of earnings

3) Compute internal rates of return, obtaining informal bounds on how incentives to invest in education
   - is affected by earnings and employment risk
Introduction: Review of key findings

Over most of the life-cycle, additional schooling increases
  • both the mean and the variance of earnings

Schooling matters little for earnings dynamics over the life cycle
  • both in terms of permanent and transitory shocks

Internal rates of return are much higher than real interest rates if one abstracts from uncertainty
  • suggests investment in schooling was financially profitable

However, compared with the unadjusted returns, accounting for uncertainty generate
  • much lower rates of return, without credit market
  • similar rates of return, with access to credit market
Our paper builds bridges between two literatures

1) Returns to schooling:
   - Vast majority of studies look at mean earnings only (see review in Heckman et al., 2006)
   - A few studies consider earnings variability but assume schooling is exogenous (see e.g. Pistaferri, 2001; Cunha and Heckman, 2006)

2) How education affects the dynamics of earnings:
   - Distinguishing between persistent and transitory components
   - Assumes exogeneity of schooling (see e.g. Carroll and Samwick 1997; Meghir and Pistaferri 2004)
We link these literatures by estimating the causal impacts of additional schooling on the life cycle profiles in

- mean earnings,
- variance of earnings and its components,
- higher order moments, Skewness and kurtosis,
- and the implied internal rates of return

We also relax other strong assumptions typically invoked:

- Multiplicative separability between experience and schooling
- Stationary environment in age and time
- No earnings while in school
- Exogenous post-schooling employment
Plan of the Talk

- Data and sample
- Identifying moments of the potential earnings distribution
- Education reform and empirical implementation
- Preliminary findings
  - Education and life-cycle earnings
  - Education and inequality over the life cycle
  - Education and earnings dynamics
- Value of additional education and uncertainty
  - No credit market
  - Self-insurance through savings
Two data sources covering the entire Norwegian population over the period 1967-2009:

1) Administrative tax records with information on market income:
   - Labor income (includes wages and self-employment)
   - Work-related cash transfers (such as unemployment and short-term sickness benefits)

2) Administrative schooling records with information on highest completed education
Sample selection:
- Males born in 1943 – 1963
- In each year, we trim the earnings of the top 0.1 percent

Education margins:
- Mandatory 9 years vs. 9 years
- Lower secondary school vs. high school
- High school vs. college
Identification of potential outcome distributions

2SLS identifies the average causal effect for compliers
- But does not work for higher order moments
- Only identifies differences in potential outcomes, not levels.

Imbens and Rubin (1997) show how to identify the potential outcome distribution of compliers, with and without treatment.

We build on their two step procedure:
1) Estimate population shares compliance types:
   - Always takers, never takers, compliers

2) Combining estimates of compliance types with observed outcomes (Y) when
   - instrument (Z) and/or treatment (T) are switched on and off
The reform increased compulsory schooling from 7 to 9 years implemented 1959-1974 in different municipalities over time

Use the spatial & temporal variation in exposure to schooling laws by controlling for cohort dummies and municipality FEs

We find significant reduced form and first-stage robust to differential time trends by municipality timing of is implementation uncorrelated with key baseline characteristics

For more details, see Black, Devereux and Salvanes (2005) and Bhuller, Mogstad and Salvanes (2016)
Education and Life-cycle Earnings: OLS Estimates

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Education and Life-cycle Earnings: IV Estimates

- Earnings (in 1000 USD)
  - Mean earnings
  - Variance of earnings

- Age

- IV estimate
- 90% C.I

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Education and Life-cycle Employment

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Education, Earnings Dynamics, and Life-Cycle Inequality
Education and Life-cycle Employment: college vs. high school

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Education, Earnings Dynamics, and Life-Cycle Inequality
Education and Distribution of Earnings: college vs. high school

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high school vs. less than high school

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Education, Earnings Dynamics, and Life-Cycle Inequality
Education and Life-cycle Employment: high school vs. less than high school

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Education, Earnings Dynamics, and Life-Cycle Inequality
Potential earnings process for $T = 0, 1$:

$$y_{it}^T = m^T(X_{it}) + u_{it}^T + v_{it}^T$$

$$u_{it}^T = u_{it-1}^T + \zeta_{it}^T$$

where $m^T(X_{it})$ is the mean potential log earnings at age $t$ for individuals with characteristics $X$ and transitory shocks are i.i.d.

We estimate separate intercept for each cohort-municipality-treatment cell and obtain residual earnings $r_t$

$$r_t = r_t^0 + (r_t^1 - r_t^0)T$$
We can identify the variance of the potential earnings shocks:

\[
\begin{align*}
\text{var}(\zeta^T_t | T^1 > T^0) &= E(\Delta r^T_t (\Delta r^T_{t-1} + \Delta r^T_t + \Delta r^T_{t+1}) | T^1 > T^0) \\
\text{var}(\nu^T_t | T^1 > T^0) &= -E(\Delta r^T_t \Delta r^T_{t+1} | T^1 > T^0)
\end{align*}
\]

by combining estimates of compliance types with observed variance and covariance matrix when

- instrument (Z) and/or treatment (T) are switched on and off

The causal impact of additional schooling on earnings risk is:

- \( \text{var}(\zeta^1_t | T^1 > T^0) - \text{var}(\zeta^0_t | T^1 > T^0) \)
- \( \text{var}(\nu^1_t | T^1 > T^0) - \text{var}(\nu^0_t | T^1 > T^0) \)
Education and Earnings Dynamics: Permanent Shocks

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Education, Earnings Dynamics, and Life-Cycle Inequality
Education and Earnings Dynamics: Transitory Shocks

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Education, Earnings Dynamics, and Life-Cycle Inequality
college vs. high school

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Education, Earnings Dynamics, and Life-Cycle Inequality
high school or upper secondary

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Education, Earnings Dynamics, and Life-Cycle Inequality
No uncertainty and internal rates of return

Discount rate $\rho$ giving indifference between schooling level $s$ and $s'$:

$$
\sum_{t=t_0}^{T} (1 + \rho)^{t_0-t} \frac{E_{t_0}(Y_{it}(s)^{1-\gamma})}{1-\gamma} = \sum_{t=t_0}^{T} (1 + \rho)^{t_0-t} \frac{E_{t_0}(Y_{it}(s')^{1-\gamma})}{1-\gamma}
$$

With risk neutrality ($\gamma = 0$), internal rate of return given by:

$$
\sum_{t=t_0}^{T} \frac{\beta_t}{(1 + \rho)^{t-t_0}} = 0
$$

where

$$\beta_t = E_{t_0}(Y_{it}(s) - Y_{it}(s'))$$
Using second-order Taylor approximation

\[
\frac{E_t[(Y_{it}(s))^{1-\gamma}]}{1-\gamma} = \frac{[E_t(Y_{it}(s))]^{1-\gamma}}{1-\gamma} - \frac{\gamma}{2} \text{Var}_t(Y_{it}(s))[E_t(y_{it}(s))]^{-1-\gamma}
\]

With risk aversion (\(\gamma > 0\)), internal rate of return given by:

\[
\sum_{t=t_0}^{T} \frac{\beta_t}{(1+\rho)^{t-t_0}} = 0
\]

where

\[
\beta_t = \frac{1}{1-\gamma} \left\{ \frac{[E_t(Y_{it}(s))]^{1-\gamma} - (E_t(Y_{it}(s')))^{1-\gamma}}{1-\gamma} \right\} - \frac{\gamma}{2} \text{Var}_t(Y_{it}(s))[E_t(y_{it}(s))]^{-1-\gamma} - \text{Var}_t(Y_{it}(s'))[E_t(y_{it}(s'))]^{-1-\gamma}
\]
Internal rates of return

Exogenous education

Endogenous education

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External validity: Internal rates of return

High school vs. less than HS

College vs. High school

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Education, Earnings Dynamics, and Life-Cycle Inequality
Allowing for savings

An individual contemplating potential education level $T$ maximizes the expected discounted flow of utility subject to a dynamic budget constraint:

$$\max \sum_{t=t_0}^{t=85} (1 + \rho)^{t-t_0}(\prod_{j=t_0}^{t} S_j)E_{t_0}\left(\frac{(C_{it})^{1-\gamma}}{1-\gamma}\right)$$  \hfill (1)

$$s.t. \ A_{it+1}^T = (1 + r)(A_{it}^T + Y_{it}^T - C_{it}^T)$$  \hfill (2)

Potential log income is based on the same process estimated in the previous section for the working years:

$$y_{it}^T = m^T(X_{it}) + u_{it}^T + v_{it}^T$$  \hfill (3)

$$u_{it}^T = u_{it-1}^T + \zeta_{it}^T$$  \hfill (4)
# Table: Calibrated Earnings Risks

<table>
<thead>
<tr>
<th></th>
<th>&lt; 9 (IV)</th>
<th>9 (IV)</th>
<th>&lt; 9 (OLS)</th>
<th>9 (OLS)</th>
<th>Less than HS</th>
<th>High school</th>
<th>College</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perm. shock</td>
<td>0.026</td>
<td>0.025</td>
<td>0.027</td>
<td>0.026</td>
<td>0.025</td>
<td>0.020</td>
<td>0.022</td>
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<tr>
<td>Tran. shock</td>
<td>0.017</td>
<td>0.015</td>
<td>0.018</td>
<td>0.017</td>
<td>0.016</td>
<td>0.011</td>
<td>0.011</td>
</tr>
</tbody>
</table>
Allowing for savings

Colleges vs. High School: $\gamma = 1, \rho = 0.023$

Colleges vs. High School: $\gamma = 1, \rho = 0.05$

Colleges vs. High School: $\gamma = 4, \rho = 0.023$

Colleges vs. High School: $\gamma = 4, \rho = 0.05$
<table>
<thead>
<tr>
<th>Education choice</th>
<th>Coeff. Of relative risk aversion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Less than 9 vs. 9 (endogenous education)</td>
<td>0.221</td>
</tr>
<tr>
<td>Less than 9 vs. 9 (exogenous education)</td>
<td>0.166</td>
</tr>
<tr>
<td>Less than high school vs. HS</td>
<td>0.121</td>
</tr>
<tr>
<td>High school vs. college</td>
<td>0.315</td>
</tr>
</tbody>
</table>
Conclusion: Our contributions

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