The Demand for and Return to Education When Education Outcomes are Uncertain


Presentation for the Macro Reading Group
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Motivation

- In most of the literature education outcomes are certain
- No role for uncertainty
- However education choices are sequential in their nature
- Uncertainty may be important
Motivation
Why modeling uncertainty is important

- Many people who plan to complete college, drop out
  - Students change their college major
- Ex-post returns to one year of college are non-linear in the years of education
  - Hence ex-ante returns may be different from ex-post returns
  - The effect of different characteristics on ex-ante returns may be understated
Aim of the paper

- Develop a simple model of education choices under uncertainty
  - Students differ in ability, preferences and other characteristics
  - When enrolled in college students receive new information
- Use the theoretical model to setup an empirical framework to estimate ex-ante returns to one year of college
Main empirical results

- Ex-post returns to one year of college for men are slightly negative
- Ex-ante returns are 2.8%
- For women returns are 8.5% and 7.4%
- If we allow for returns to experience, the ex-ante returns increase substantially
- Ability and other characteristics increase ex-ante returns
The Model

- Two-period model: \( s \in \{0, 1, 2\} \)
- In period 0 students choose to enroll in college or not, and their major \( c \in \{m, h\} \)
- Their state is knowledge: \( K_0 = \{K_{m0}, K_{h0}\} \)
  - and ability \( A = \{A_m, A_h\} \)
At the end of first period they may drop out or change their field of study.

\[ K_{s+1} = f(K_s, A)_c + \nu_{s+1} \]

\( g_{2c} \) is the probability of graduating in field c

\( F_{hm}(g_{2m}, g_{2h} | K_0, A, c_1) \) is the joint distribution of graduation probabilities.
The Model
(Earnings)

- High school graduate: $Y_0$
- College drop-out after one year: $Y_1 = \frac{Y_0(1+r_1)}{1+R}$
- College drop-out after two years: $Y_2 = \frac{Y_0(1+r_1)}{(1+R)^2}$
- College graduate: $Y_c = \frac{Y_0(1+r_c)}{(1+R)^2}$
- $Y_c > Y_1, Y_0$
The Model
(Preferences)

- $U(Y_c, j) = Y_c - u_j^c$, $j \in \{0, 1, 2\}$, $c \in \{0, 1, 2, h, m\}$
The Model
(Preferences)

- $U(Y_c, j) = Y_c - u_j^c \quad j \in \{0, 1, 2\} \quad c \in \{0, 1, 2, h, m\}$
- $U(Y_0, 0) > U(Y_c, 0), U(Y_1, 0)$ does not enroll in college
The Model
(Preferences)

\[ U(Y_c, j) = Y_c - u_j^c \quad j \in \{0, 1, 2\} \quad c \in \{0, 1, 2, h, m\} \]

\[ U(Y_0, 0) > U(Y_c, 0), U(Y_1, 0) \quad \text{does not enroll in college} \]
\[ U(Y_h, 1) > U(Y_m, 1) \quad \text{does not change his major to m} \]
The Model
(Preferences)

- \( U(Y_c, j) = Y_c - \bar{u}_j \) \( j \in \{0, 1, 2\} \), \( c \in \{0, 1, 2, h, m\} \)
- \( U(Y_0, 0) > U(Y_c, 0), U(Y_1, 0) \) does not enroll in college
- \( U(Y_h, 1) > U(Y_m, 1) \) does not change his major to m
- \( U(Y_h, 2) = U(Y_m, 2) > U(Y_0, 2) \) may change his major
The Model
(Preferences)

\[ U(Y_c, j) = Y_c - \bar{u}_j^c \quad j \in \{0, 1, 2\} \quad , \quad c \in \{0, 1, 2, h, m\} \]

- \( U(Y_0, 0) > U(Y_c, 0), \ U(Y_1, 0) \) does not enroll in college
- \( U(Y_h, 1) > U(Y_m, 1) \) does not change his major to m
- \( U(Y_h, 2) = U(Y_m, 2) > U(Y_0, 2) \) may change his major
- Students do not know their type in period zero
Demand for college

\[ V_1(K_0, A, \theta, c_1) = \sum_{j=0}^{2} \theta_j E_{g_2}[V_2(g_2, j)|K_0, A, c_1] \]
Demand for college

\[ V_1(K_0, A, \theta, c_1) = \sum_{j=0}^{2} \theta_j E_{g_2}[V_2(g_2, j) | K_0, A, c_1] \]

for type 0: \[ V_2(g_2, 0) = Y_1 \]
Demand for college

- $V_1(K_0, A, \theta, c_1) = \sum_{j=0}^{2} \theta_j E_{g_2}[V_2(g_2, j)|K_0, A, c_1]$
- for type 0: $V_2(g_2, 0) = Y_1$
- for type 1: $V_2(g_2, 1) = \max\{g_{2h}Y_h + \frac{(1-g_{2h})Y_1}{1+R}, Y_1\}$
Demand for college

\[ V_1(K_0, A, \theta, c_1) = \sum_{j=0}^{2} \theta_j E_{g_2}[V_2(g_2, j)|K_0, A, c_1] \]

- for type 0: \( V_2(g_2, 0) = Y_1 \)
- for type 1: \( V_2(g_2, 1) = \max\{g_{2h}Y_h + \frac{(1-g_{2h})Y_1}{1+R}, Y_1\} \)
- for type 2:
  \[ V_2(g_2, 2) = \max\{(g_{2h}Y_h + \frac{(1-g_{2h})Y_1}{1+R}), (g_{2m}Y_m + \frac{(1-g_{2m})Y_1}{1+R}), Y_1\} \]
Demand for college

- Students start college if:

$$\max f_{V_1}(K_0, A, \theta, m_1), V_1(K_0, A, \theta, h_1) \geq Y_0$$

$$V_1(K_0, A, \theta, m_1) > V_1(K_0, A, \theta, h_1)$$
Demand for college

- Students start college if:
- \( \max \{ V_1(K_0, A, \theta, m_1), V_1(K_0, A, \theta, h_1) \} > Y_0 \)
Demand for college

- Students start college if:
  \[
  \max \{ V_1(K_0, A, \theta, m_1), V_1(K_0, A, \theta, h_1) \} > Y_0
  \]
- Students choose field \( m \) if:
Demand for college

- Students start college if:
  \[ \max \{ V_1(K_0, A, \theta, m_1), V_1(K_0, A, \theta, h_1) \} > Y_0 \]
- Students choose field \( m \) if:
  \[ V_1(K_0, A, \theta, m_1) > V_1(K_0, A, \theta, h_1) \]
Ex-ante returns to starting college

\[ Y_0 = \frac{P_{1c1} Y_0 (1 + r_1)}{1 + \rho} + \frac{P_{1c2} Y_0 (1 + r_1)}{(1 + \rho)^2} + \frac{P_{1c2h} Y_0 (1 + r_h)}{(1 + \rho)^2} + \frac{P_{1c2m} Y_0 (1 + r_m)}{(1 + \rho)^2} \]

- Ex-ante return \( \rho \) is increasing in: \( r_1, r_{2h}, r_{2m}, A, K_0 \) and \( \frac{\theta_2}{\theta_2 + \theta_1} \)
- It is decreasing in \( \theta_0 \)
Ex-ante returns to starting college

\[ Y_0 = \sum_{s=1}^{\infty} \sum_c P(X, Z)_{1,sc} Y(X, Z, \rho)_{sc} + P(X, Z)_{1,1} Y_0(X, Z, \rho) \]

- Estimate \( P(X, Z)_{1,sc} \) and \( P(X, Z)_{1,sc} \) from data with a probit model
- Estimate \( Y(X, Z, \rho)_{sc} \) and \( Y_0(X, Z, \rho) \) from data with a Mincer regression
- Find \( \rho \) that solves the equation
Wage equation

\[ \ln w_t = XB_1 + ZB_2 + r_{sc} + a_{st} + \Psi_t \]

\[ Y(X, Z, \rho)_{sc} = Y_0(X, Z) \exp^{rs-\rho} \]
Data

- Panel: NLS72
- Data on education outcome
  - College major
  - Aptitude and achievement measures (Z)
  - Family characteristics (X)
  - Hourly wage rates
Empirical Results

Ex-post returns

<table>
<thead>
<tr>
<th>Education outcome</th>
<th>Pooled</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>College less than 2</td>
<td>0.037</td>
<td>−0.0076</td>
<td>0.085</td>
</tr>
<tr>
<td>College 2</td>
<td>0.129</td>
<td>0.057</td>
<td>0.194</td>
</tr>
<tr>
<td>College nontechnical</td>
<td>0.238</td>
<td>0.298</td>
<td>0.152</td>
</tr>
<tr>
<td>College technical</td>
<td>0.441</td>
<td>0.404</td>
<td>0.394</td>
</tr>
</tbody>
</table>
## Empirical Results

**Ex-ante returns**

<table>
<thead>
<tr>
<th>Returns to experience</th>
<th>Pooled</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a = 0$</td>
<td>5.1</td>
<td>2.8</td>
<td>7.4</td>
</tr>
<tr>
<td>$a = 0.001$</td>
<td>6.2</td>
<td>4.1</td>
<td>8.4</td>
</tr>
<tr>
<td>$a = 0.05$</td>
<td>9.0</td>
<td>7.3</td>
<td>10.8</td>
</tr>
</tbody>
</table>
## Empirical Results

### Ex-ante returns

<table>
<thead>
<tr>
<th>Ability</th>
<th>Pooled</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>6.4</td>
<td>4.2</td>
<td>8.8</td>
</tr>
<tr>
<td>Low</td>
<td>3.6</td>
<td>0.5</td>
<td>5.9</td>
</tr>
</tbody>
</table>
Empirical Results

Ex-ante returns

<table>
<thead>
<tr>
<th>Family background</th>
<th>Pooled</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorable</td>
<td>5.4</td>
<td>3.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Unfavorable</td>
<td>4.8</td>
<td>1.9</td>
<td>7.6</td>
</tr>
</tbody>
</table>

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Conclusions

- Develop a theoretical model of college enrollment under uncertainty
- Set up an empirical framework to estimate ex-ante returns to education
- Ex-ante returns to one year of college for men are substantially higher than ex-post returns
- The effect of ability and family background on returns to education is understated if we only consider ex-post returns