Human capital investment, Signaling, and Wage differentials

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For several decades, many countries have experienced expanded access to higher education. What is the major purpose of receiving higher education — learning or credentialing?

- Jaeger and Page (1996) and Park (1999) find the size of diploma effects on wages:
  - 9 – 10% with high school graduates
  - 11% with associate’s degrees
  - 20 – 30% with bachelor’s degrees

- Shortcoming of human capital theory
  - There are a couple of benefits to receiving higher education:
    - human capital accumulation
    - diploma
Figure 1.—Total Returns to Completed Years of Education for White Men

- Without Diploma Effects

Jaeger and Page (1996), pp. 736, Figure 1

Diploma effect of college degree

Diploma effect of high school degree
Educational investment models with signaling theory

- focus not on *learning* but on *credentialing* of students and/or their parents
- However, these models rely on an unrealistic assumption: firms cannot observe workers’ individual productivities
  - Workers’ wages are largely insensitive to their performances
Motivation

- Credentials may be becoming the major purpose rather than the byproduct of educational achievements
  - How big are households’ credentialing actions compared with their learning actions?

Model

- This model introduces two kinds of educational investment: Human capital investment and Signaling investment
- Households (with income heterogeneity) invest in the two types of education for their children

Contribution

- The ratio of human capital investment to signaling investment captures the degree of credentialing
Introduction < Results >

- **Static analysis**
  - The ratio of human capital to signaling investment becomes a U-shaped function of the wage differentials between rich and poor

- **Dynamic analysis**
  - Three patterns of stable steady states exist w.r.t. the wage differentials
    - No-inequality
    - High-inequality
    - Multiple steady states
  - An increase in skill-biased technology may switch the economy from no-inequality to high-inequality steady state
  - This causes an increase in the ratio of signaling investment
The Model < 3 Periods OLG >

There are two agents in each generation

Young agents
  - are born with same ability
  - receive educational investments from parents
  - Under uncertainty, either young agent obtains a signal

Middle-aged agents
  - give birth to one child, work, consume, and invest in two types of education for their children (no savings)
  - Firms cannot observe the individual productivity of each worker

Old agents
  - work and consume
  - Firms can observe the individual productivity of each worker
The Model < Lifetimes of Two Agents >

- Period $t$
  - Young: born to rich parent
  - Young: born to poor parent

- Period $t+1$
  - Rich Middle: with signal
  - Poor Middle: with no signal

- Period $t+2$
  - Rich Old
  - Poor Old

- Either the rich young or the poor young obtains a signal with uncertainty:
  - with prob. $\theta$
  - with prob. $1 - \theta$

- Firms cannot observe the individual productivity of each middle:
  - Middle with (no) signal becomes rich (poor)

- Firms can observe the individual productivity of each old:
  - Wages of old workers are paid according to their productivities
Production technologies

- Firms produce final goods using linear technologies of labor inputs

\[ f(h_H) = \phi h_H \]

\[ f(h_L) = h_L \]

- High skilled workers work with the superior technology \( \phi > 1 \)

\( \rightarrow \) \( \phi \) represents the level of skill-biased technologies
Wages of middle-aged workers

As firms cannot observe the individual productivity of each middle-aged worker, the wages are paid according to whether they have the signal

→ The wages are consistent with the expected productivity of each worker

\[
\hat{w}_{H,t+1} = \hat{\theta}_{t+1} \phi \hat{h}_{H,t+1} + (1 - \hat{\theta}_{t+1}) \hat{h}_{L,t+1}
\]

\[
\hat{w}_{L,t+1} = \hat{\theta}_{t+1} \hat{h}_{L,t+1} + (1 - \hat{\theta}_{t+1}) \phi \hat{h}_{H,t+1}
\]

Wages of old workers

As firms can observe the individual productivity of each old worker, the wages are paid according to their productivities

\[
w_{H,t+1}^o = \phi h_{H,t}
\]

\[
w_{L,t+1}^o = h_{L,t}
\]
The Model 〈 Educational Investment 〉

- **Human capital investment**
  \[
  h_{i,t+1} = B(e_{i,t})^\mu
  \]
  - \( e_{i,t} \): the human capital investment
  - \( h_{i,t+1} \): human capital level
  - \( \mu \in (0, 1) \) and \( B > 0 \)

- **Signaling investment**
  \[
  S'_{i,t+1} = B'(s_{i,t})^\nu
  \]
  - \( s_{i,t} \): the signaling investment
  - \( S'_{i,t+1} \): signaling ability
  - \( \nu \in (0, 1) \) and \( B' > 0 \)
The Model < Uncertainty of the Signal >

- The uncertainty of the signal

\[ \theta_{t+1} = \Theta(\tilde{h}_{t+1}, \tilde{S}_{t+1}) \]

- \( \tilde{h}_{t+1} = h_{H,t+1}/h_{L,t+1} \): human capital gap

- \( \tilde{S}_{t+1} = S_{H,t+1}/S_{L,t+1} \): signaling ability gap

\[ \Theta(\tilde{h}_{t+1}, \tilde{S}_{t+1}) \]

\[ \Theta \in [\frac{1}{2}, 1], \Theta_\tilde{h} > 0, \Theta_{\tilde{h}\tilde{h}} < 0, \Theta_\tilde{S} > 0, \Theta_{\tilde{S}\tilde{S}} < 0, \Theta_{\tilde{h}\tilde{S}} < 0, \Theta(1, 1) = \frac{1}{2}, \text{ and } \lim_{\tilde{h} \to \infty, \tilde{S} \to \infty} \Theta = 1. \]
The Model < Uncertainty of the Signal >

- The interpretation of $\theta_{t+1}$

  - As the educational gaps between two young, $\tilde{h}_{t+1}$ and $\tilde{S}_{t+1}$, increase, highly educated young can obtain the signal more easily, whereas poorly educated young finds it more difficult to obtain the signal.
The Model < Household >

The lifetime utilities of middle-aged agents are defined over consumption and the expected wage of their offspring.

- Rich middle (with the signal) in period $t$

$$U_R = \alpha \ln c_{H,t} + (1-\alpha) \left[ \Theta(\tilde{h}_{t+1}, \tilde{S}_{t+1}) \ln \hat{w}_{H,t+1} + (1 - \Theta(\tilde{h}_{t+1}, \tilde{S}_{t+1})) \ln \hat{w}_{L,t+1} \right] + \beta \left[ \alpha \ln c_{i,t+1} + (1 - \alpha) \ln \phi h_{H,t+1} \right]$$

Budget constraint of middle

$$c_{H,t} + e_{H,t} + s_{H,t} = w_{H,t}$$

Budget constraint of old

$$c_{i,t+1} = \begin{cases} \phi h_{H,t} \\ h_{L,t} \end{cases}$$
The Model < Household >

- Poor middle (with no signal) in period $t$

$$U_P = \alpha \ln c_{L,t}$$
$$+ (1-\alpha) \left[ \Theta(\tilde{h}_{t+1}, \tilde{S}_{t+1}) \ln \hat{w}_{L,t+1} + \left(1 - \Theta(\tilde{h}_{t+1}, \tilde{S}_{t+1}) \right) \ln \hat{w}_{H,t+1} \right]$$
$$+ \beta \left[ \alpha \ln c_{j,t+1} + (1 - \alpha) \ln h_{L,t+1} \right]$$

Budget constraint of the rich middle

$$c_{L,t} + e_{L,t} + s_{L,t} = w_{L,t}$$

Budget constraint of old

$$c_{j,t+1} = \begin{cases} h_{L,t} \\ \phi h_{H,t} \end{cases}$$
The Model < Equilibrium >

- Equilibrium property 1

\[
\frac{e_{H,t}}{e_{L,t}} = \frac{s_{H,t}}{s_{L,t}} = \frac{w_{H,t}}{w_{L,t}} \equiv \tilde{w}_t
\]

- Human capital investment and signaling investment of the rich are always greater than those of the poor

- The uncertainty of the signal decreases as the parental wage differential increases

- Equilibrium property 2

\[
\frac{e_{H,t}}{s_{H,t}} = \frac{e_{L,t}}{s_{L,t}}
\]

- The rich and poor choose the same educational investment ratio
U-shaped relationship between $e_t/s_t$ and $\tilde{w}_t$ (shown analytically)

In equilibrium, the ratio of human capital investment to signal investment is a U-shaped function of the wage differentials of middle-aged generation.
Result 1 < Mechanism >

- Two opposite effects of wage differentials on educational investment: the uncertainty of the signal and the value of the signal.
Three patterns of stable steady states (shown analytically)

Three patterns of stable steady states exist with respect to the wage differentials: a unique steady state with no inequality, a unique steady state with high-inequality, and multiple steady states. These alternative steady states can be distinguished by the level of skill-biased technology $\phi$. 

<table>
<thead>
<tr>
<th>no-inequality</th>
<th>multiple steady states</th>
<th>high-inequality</th>
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<tbody>
<tr>
<td>$\tilde{w}_{t+1}$</td>
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<tr>
<td>$\tilde{w}_t$</td>
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<td>$\tilde{w}_t$</td>
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<tr>
<td>0</td>
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</tbody>
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- small $\phi$
- size of $\phi$
- large $\phi$
Suppose
- the economy is initially in the neighborhood of the no-inequality steady state
- a rapid increase in skill-biased technology ($\phi \uparrow$) switches the economy from the no-inequality steady state to the high-inequality steady state

Then
- the signaling investment ratio increases at least a couple of periods
- the economy may experience a U-shaped change of $e/s$ during the transition to the new steady state
Result 3 << Combining the Static and the Dynamic Results >>

\[ e_t / s_t \]

\[ \tilde{w}_{t+1} \]

\[ 45\text{-degree} \]

\[ \tilde{w}_t \]
Conclusions and Remarks

† Skill-biased technical change (SBTC) and wage inequality †

- The literature on wage inequality by emphasizing SBTC show
  - SBTC $\Rightarrow$ wage inequality $\uparrow$
  - SBTC $\Rightarrow$ demand for skilled labor $\uparrow \Rightarrow$ educational investment $\uparrow$

- This model shows
  - SBTC $\Rightarrow$ credentialing $\uparrow$

† Contribution of this study †

- The ratio of human capital to signaling investment well describes whether households’ primary objectives for educational attainment are learning or credentialing

- Because private decisions between learning and credentialing are less observable, this theoretical analysis makes a contribution to explaining households’ educational decisions