The Role of Education Signaling in Explaining the Growth of College Wage Premium

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Introduction

- Well-known Facts: simultaneous increase in the supply of college graduates (i.e. skilled worker) and the price of skilled workers (i.e. skill premium) in the US since 1980.

  Explanations: Skill-biased technical change, capital-skill complementarity, imperfect substitutability across age groups, to name a few.
- I propose a new mechanism that contributes to the reconciliation of the above two facts.
- It is based on the idea of education signals (Spence, 1973, and Stiglitz, 1975).
- I show this channel is quantitatively significant in explaining the rise of college wage premium observed in the US since 1980.

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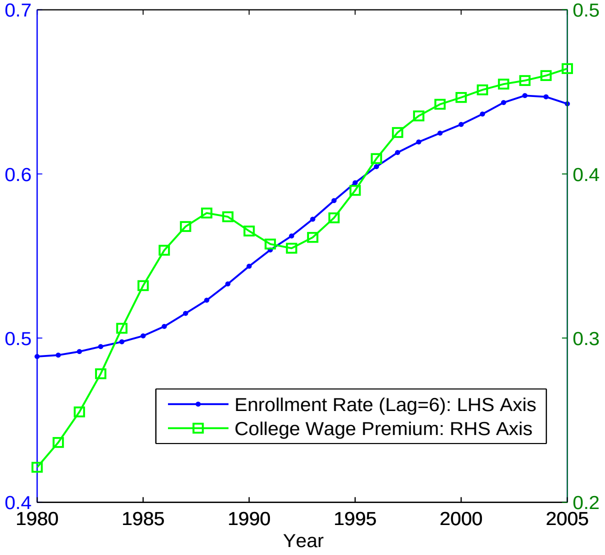
Facts: U.S. 1980-2005



Toy Model

Consider a static model.

- Population of size 1. All high school graduates.
- Talent is private info. Half high talent, $\overline{\theta}$. Half low talent, $\underline{\theta}$.
- Distribution of wealth in the population $F(k)$.
- College incurs a fixed cost Q. Fraction of college-goers $1 - F(Q)$.
- High talent completes college w.p. $\overline{p}$. Low talent complete college w.p. $\underline{p}$. Naturally, $\overline{p} > \underline{p}$.
- Wage offer is the expected talent conditional on the degree.

Toy Model

The wage offer to college graduates is

$$\overline{W} = \frac{\overline{p}}{\overline{p}+\underline{p}}\overline{\theta} + \frac{\underline{p}}{\overline{p}+\underline{p}}\underline{\theta}.$$

The wage offer to the high school graduates is

$$\overline{W} = \frac{1-\overline{p}(1-F(Q))}{2-(\overline{p}+\underline{p})(1-F(Q))}\overline{\theta} + \frac{1-\underline{p}(1-F(Q))}{2-(\overline{p}+\underline{p})(1-F(Q))}\underline{\theta}.$$

Note that $\underline{W}$ is decreasing in the college attendance $1-F(Q)$.

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Dynamic Model: Endowment and Preference

Consider a continuous time discrete choice problem.

- 1 unit measure of dynastic families.
- Each dynasty is characterized by (θ, k_0):
  - Talent θ is distributed as $G(\theta)$ over $[0, \overline{\theta}]$.
  - Initial capital endowment at time 0 is distributed as $F(k_0)$ over $[0, \overline{k}_0]$.
- Each agent in the dynasty is endowed with 1 unit of labor.
- Each agent is born a high school graduate.
- Each agent is risk neutral and maximizes:

$$U(t; \theta, k_0) = \int_t^{\infty} c(\tau; \theta, k_0) e^{-r\tau} d\tau.$$

Dynamic Model: Time-line

At each instant,

1. Agent i from dynasty (θ, k_0) chooses if to go college:
   - Yes: Pays Q. Completes college w.p. $p(\theta)$. Enter the labor market. Assume $p'(\theta) > 0$.
   - No: Enter the labor market.
2. Supply 1 unit of labor, get a wage (contingent on degree) and return on capital.
3. Save a fraction ϕ of total income for the next generation.
4. Exit.

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Technology

- Competitive firms hire skilled and unskilled labor and rent capital.
- Worker's talent is modeled as efficient units in a CES production function:

$$Y(k,u,s) = A\{\mu k^{\sigma} + (1-\mu)[\lambda u^{\rho} + (1-\lambda)s^{\rho}]^{\frac{\sigma}{\rho}}\}^{(1/\sigma)},$$

where

$$u = \Psi_u h_u = E[\theta | HSG] h_u;$$
$$s = \Psi_s h_s = E[\theta | CG] h_s.$$

- The skill premium has the familiar form:

$$\pi = \frac{1-\lambda}{\lambda}\left(\frac{h_u}{h_s}\right)^{1-\rho}\left(\frac{\Psi_s}{\Psi_u}\right)^{\rho}.$$

- The growth in skill premium can be decomposed as:

$$g_{\pi} = (1-\rho)(g_{h_u} - g_{h_s}) + \rho(g_{\Psi_s} - g_{\Psi_u}).$$

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Equilibrium

I construct a *wealth-separating* equilibrium in which the decision to go to college depends on the contemporaneous wealth level only.

In other words, the policy function, $e(k(t;\theta,k_0))$, has the following form:

$$e(k(t;\theta,k_0)) = \begin{cases} 1, & \text{if } k(t;\theta,k_0) \geq Q \\ 0, & \text{if } k(t;\theta,k_0) < Q \end{cases}.$$

Proposition

For sufficiently high ρ, sufficiently low λ and Q, there exists a wealth-separating equilibrium where the college enrollment rate increases together with the skill premium.

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Quantitative Assessment: US 1980-2003

I allow both the signaling mechanism and the skill-biased technical change (SBTC) to be at work (due to Proposition 2).

Recall the efficiency units of the two types of labor:

$$\Psi_s(t) = (1+\gamma_{SBTC})^t E_t[\theta|CG] = (1+\gamma_{SBTC})^t \frac{\int_0^{\overline{\theta}} \theta p(\theta) dG}{\int_0^{\overline{\theta}} p(\theta) dG},$$

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Strategy for the Quantitative Exercise

Step 1 Calibrate the model equilibrium characterized by a pair of differential equations. ▸ Formula

- ▷ Outer loop: Choose γ_{SBTC} to minimize the distance between the model skill premium and the data.
- ▷ Inner loop: Given γ_{SBTC}, choose the saving rate ϕ to minimize the distance between the model enrollment rate and the data.

Step 2 Simulate the skill premium in the calibrated model fixing the enrollment rate at the initial level. The difference between the growth of the counter-factual skill premium and that of the model skill premium is the measure of the contribution of the signaling story.

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Data and Parameters

Skill Premium
CPS March from 1980 to 2003. Age group 23-26. Ratio between the weekly wage of a CG and that of a HSG. HP filtered.

College Enrollment Rate
Digest of Education Statistics 2007 (NCES). Ratio between the total enrollment over the total number of high school completers.

College Completion Rate
Digest of Education Statistics 2007 (NCES). Ratio between the number of bachelor's degrees conferred in t and the total college enrollment in $t-4$.

Cost of College
Trends in College Pricing 2009 and *Trends in Student Aid 2009*. Difference between the sticker price of college and the total aid.

Initial Income Distribution in 1980
CPS March 1980. Age group 40-50. Normalized so the 51^{th} percentile is exactly Q.

Data and Parameters

Model	*Value*	*Interpretation*
ρ	0.4	It implies an elasticity of substitution between skilled and unskilled labor of 1.67 (Krusell et al., 2000).
μ	$1/3$	Income share of capital.
σ	-1	It implies an elasticity of substitution between capital and aggregated labor of 0.5 (Antras, 2004).
λ	0.6	Income share of unskilled labor out of total labor income.

Data and Parameters

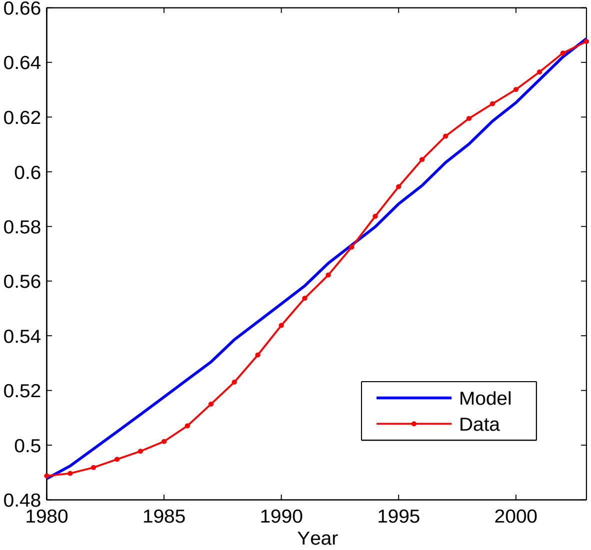
Motivated by Carneiro and Lee (2011), I further allow the expected talent of CG to decline over time:

$$\int_0^{\overline{\theta}} \theta p_0(\theta) dG \cdot (1+\omega)^t.$$

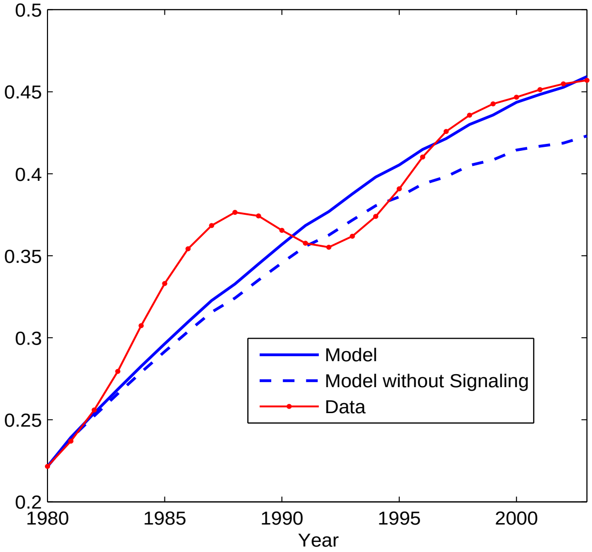
The rate of decline ω is calibrated so that the skill premium predicted by a model with $\omega = 0$ and the skill premium predicted by a model with the quality decline is roughly 17.25%.

Graph

Result: Enrollment Rates, Model vs. Data



Result: Model Skill Premium with and without Signaling



Conclusion

- I examine the hypothesis that increasing access to college in the US since 1980 has sharpened the signaling content of a high school degree (as a signal of low ability) and hence contributed towards the rising college wage premium.
- Quantitatively, this particular signaling story accounts for about 15% of the increase in the college wage premium over the sample period.

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Characterization of the Equilibrium

Let $K(t)$ be the aggregate capital at t and $\hat{k}_0(t)$ be the cut-off wealth level at which agents start to attend college at t.

$$\begin{cases} \dot{K}(t) = \phi Y(K(t) - x(t)Q, 1 - x(t)\int_0^{\overline{\theta}} p(\theta)dG, x(t)\int_0^{\overline{\theta}} p(\theta)dG) \\ \dot{\widehat{k}}_0(t) = -\phi[R(t)Q + \underline{W}_t] \end{cases}$$

where $x(t) = 1 - F(\widehat{k}_0(t))$, and $\widehat{k}_0(t) \geq 0$, with $K(0) = \int_0^{\overline{k}_0} k_0 dF(k_0)$ and $k_0(0) = Q$.

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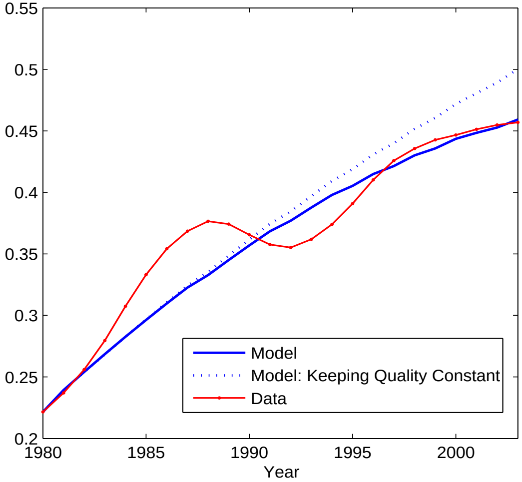
Skill Premium with Constant Quality of College



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