College, Childhood and Intergenerational Persistence

DEEQA Quantitative Macro

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Topics for Today

1. Roy Model
   - Self-selection model: sorting, comparative advantage
   - Individuals sort themselves into the jobs best for themselves
   - Used to explain college enrollment, occupation choice, etc.
2. Becker-Tomes Model
   - Intergenerational model
   - Contrasts with the reduced form "Goldberger Model": differentiates human capital from physical capital
   - Used in any structural model with correlations across multiple generations

References

1. Roy Model: Roy (1951); Willis and Rosen (1979); Heckman and Honoré (1990); French and Taber (2011); Taber and Vejlin (n.d.)

... Also many trade models with heterogeneous skills (Costinot and Vogel (2010) can be generalized either way)

2. Becker-Tomes Model: Becker and Tomes (1979, 1986); Lee and Seshadri (2017)

- *Most of the theoretical literature comes from classical labor economics. For macroeconomic roots, see Uzawa (1965); Lucas (1988)*

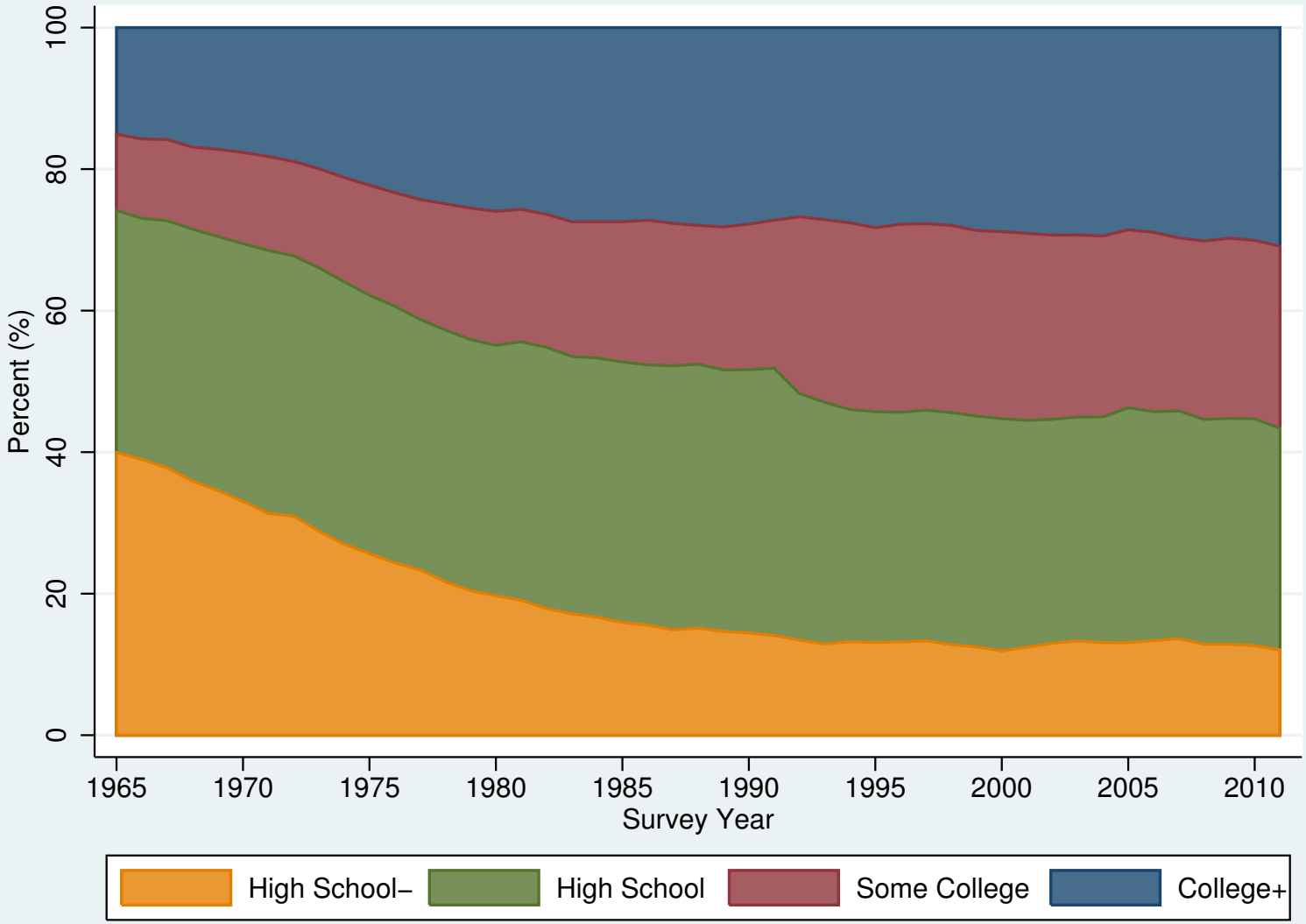
Some History (basically, Heckman's Career)

- Economic inequality fanning out over the life-cycle is confirmed in most data sets, countries, etc.
- **Big Question: selection or treatment?**
- Most studies conclude it's mostly selection (exact estimates vary from 65-90%)
- Hence, a lot of research focuses on college (*before* labor market entry)
- Turns out that at least in the U.S., college seems to be mostly selection too...even despite the recent surge in college costs (some evidence that this is not the case in France/Germany?)
- Recent research has focused on even earlier ages

Roy Model: Data and Questions

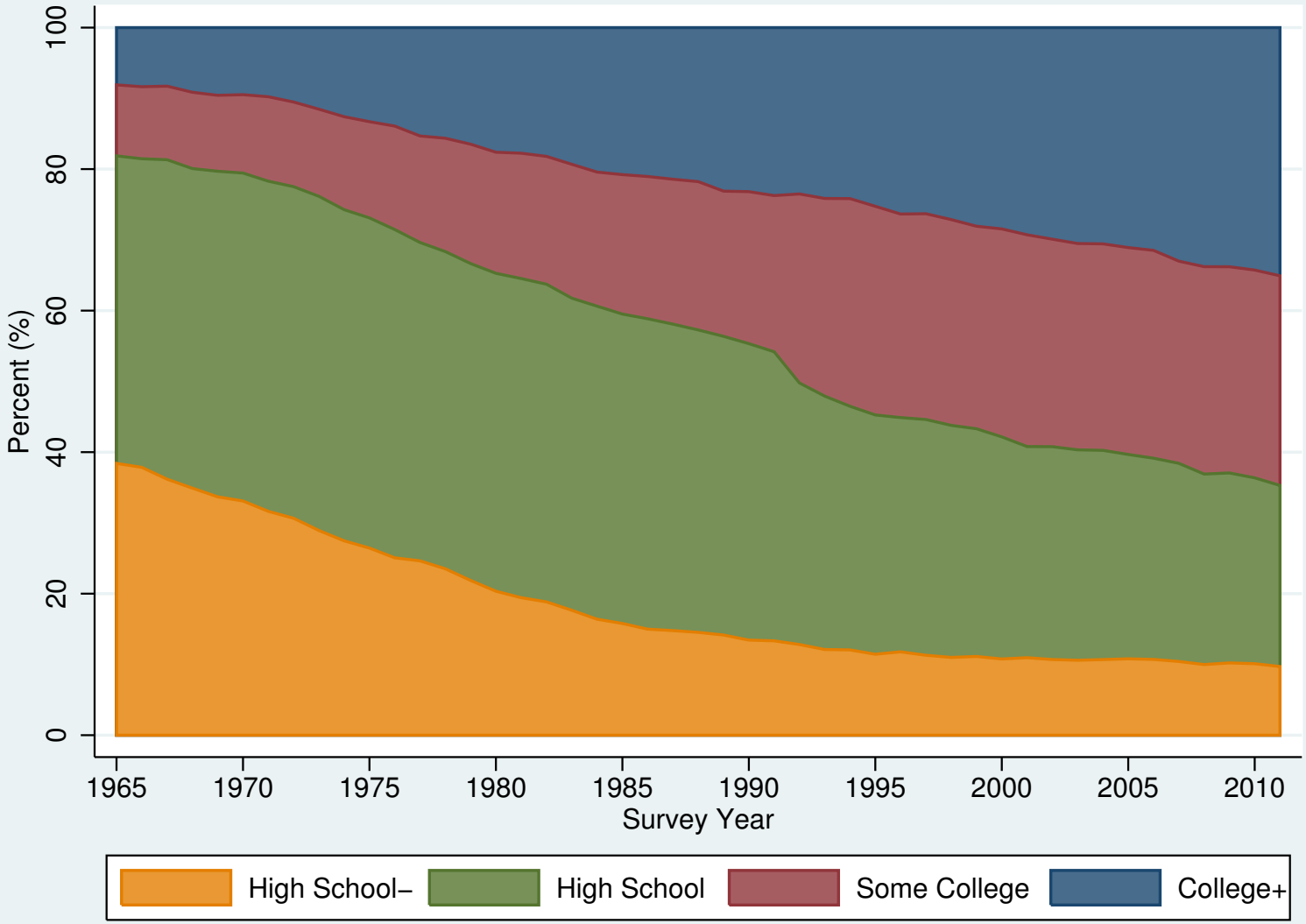
1. Trends in education choices and labor market outcomes (e.g., wages), for males in the United States between 1980 and 2005
   - College enrollment rate and dropout rate are up; graduation rate is flat.
   - College wage premium increased. Wage inequality increased, especially among college graduates.
2. How do expected future labor market outcomes affect education choices? Also, how do education choices affect future labor market outcomes?
3. Can higher education outcomes explain initial level of inequality?

Male Education



CPS, ages 26-50

Female Education



CPS, ages 26-50

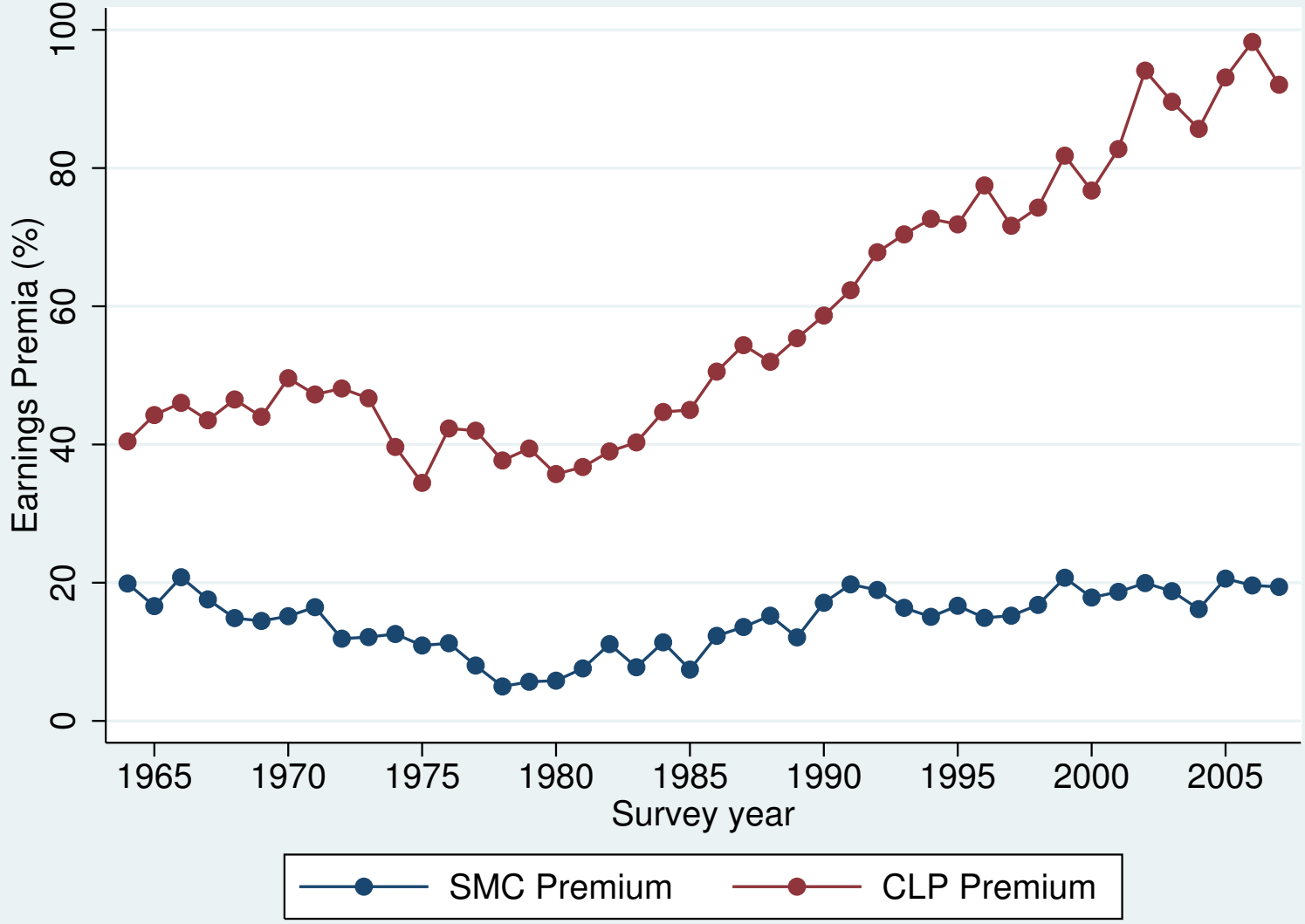
Time Effects

- Consider the regression

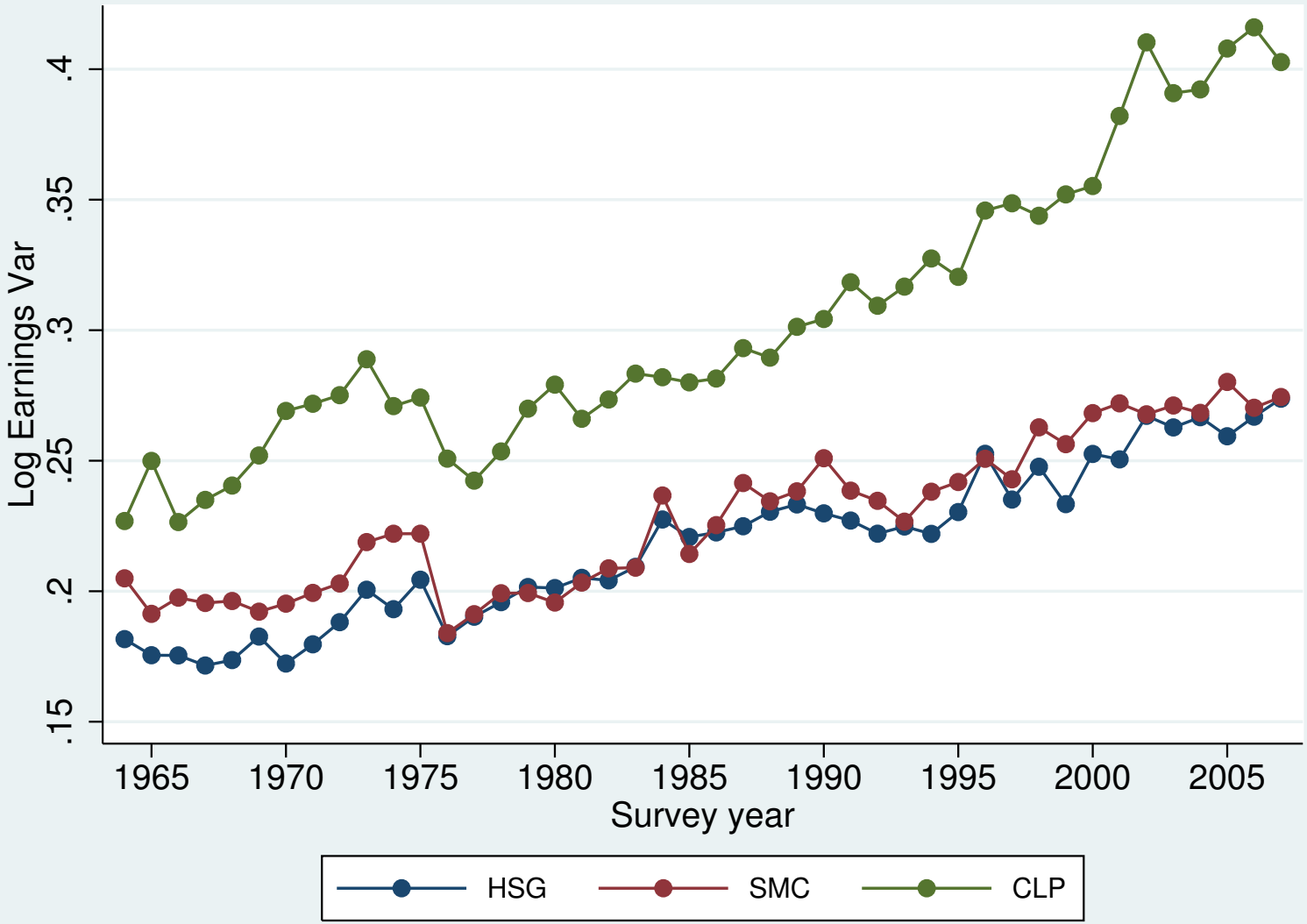
$$\log e_{i,t} = E_e + A_{e,a} + T_{e,t} + \epsilon_{i,t}$$

- Plot $T_{e,t}$ and residual earnings inequality over *time*, using CPS
- CPS: annual data for representative sample, going back to 1960s

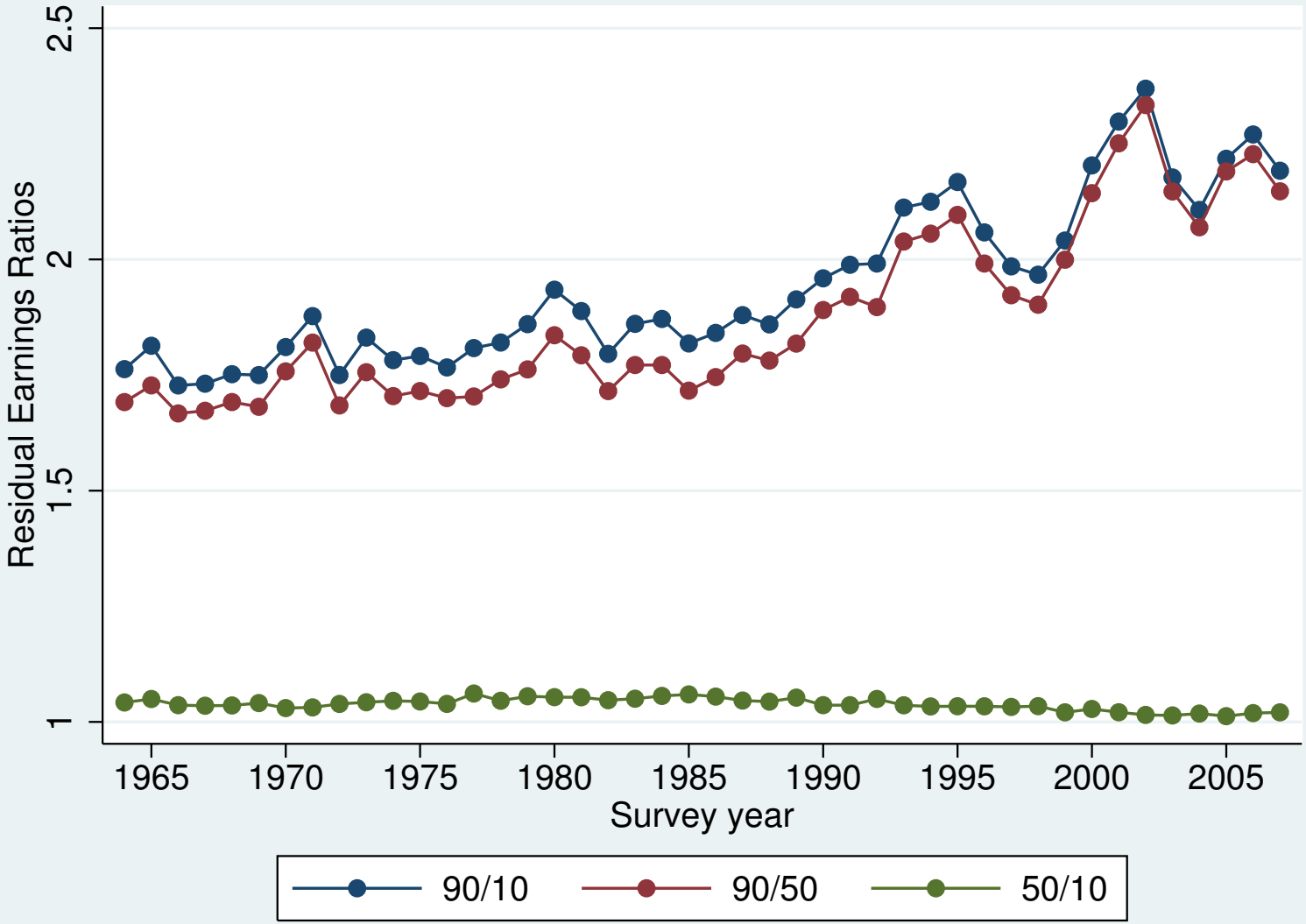
College Premium (Males 26-50)



Inequality by Educ Group



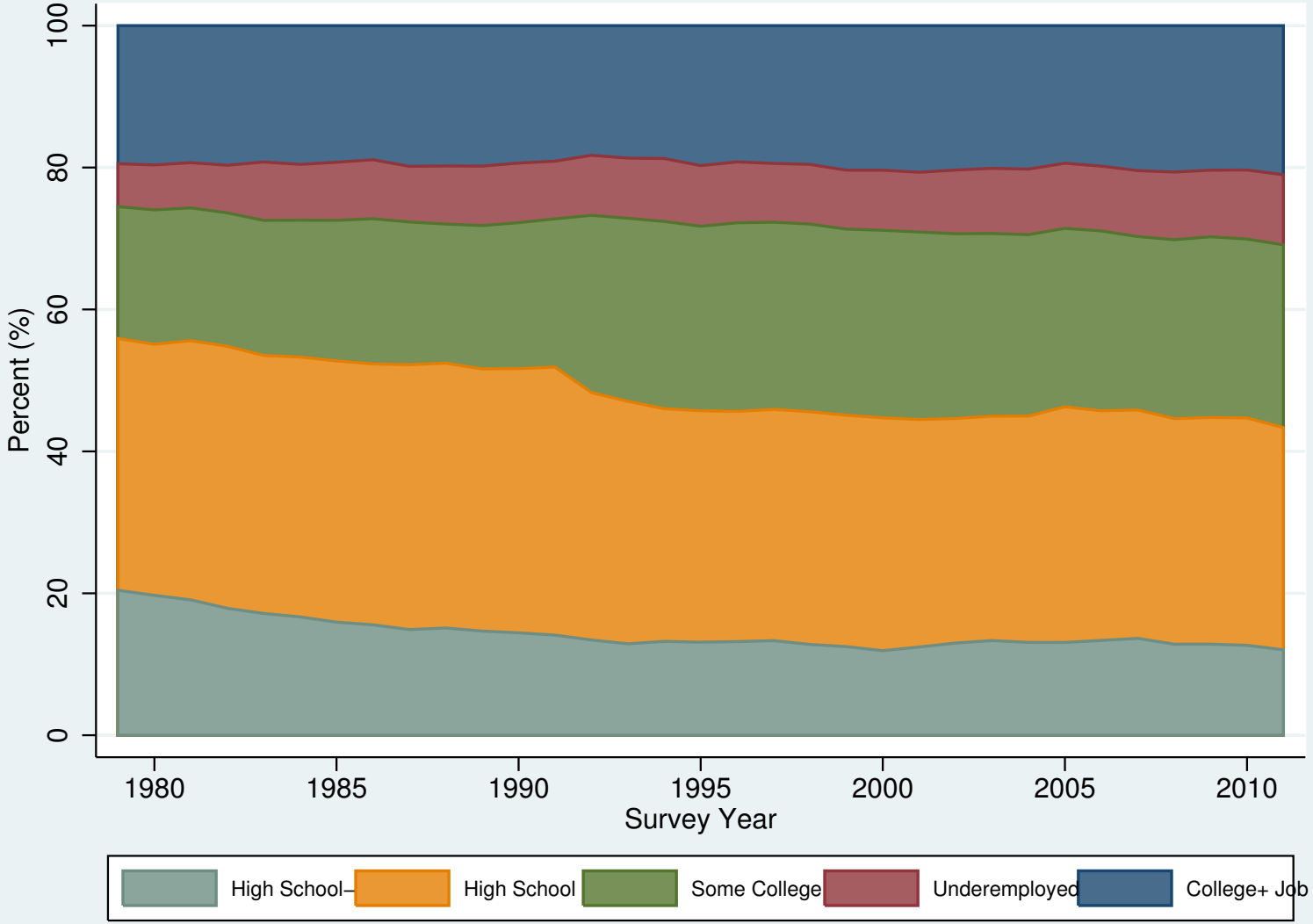
Residual Inequality



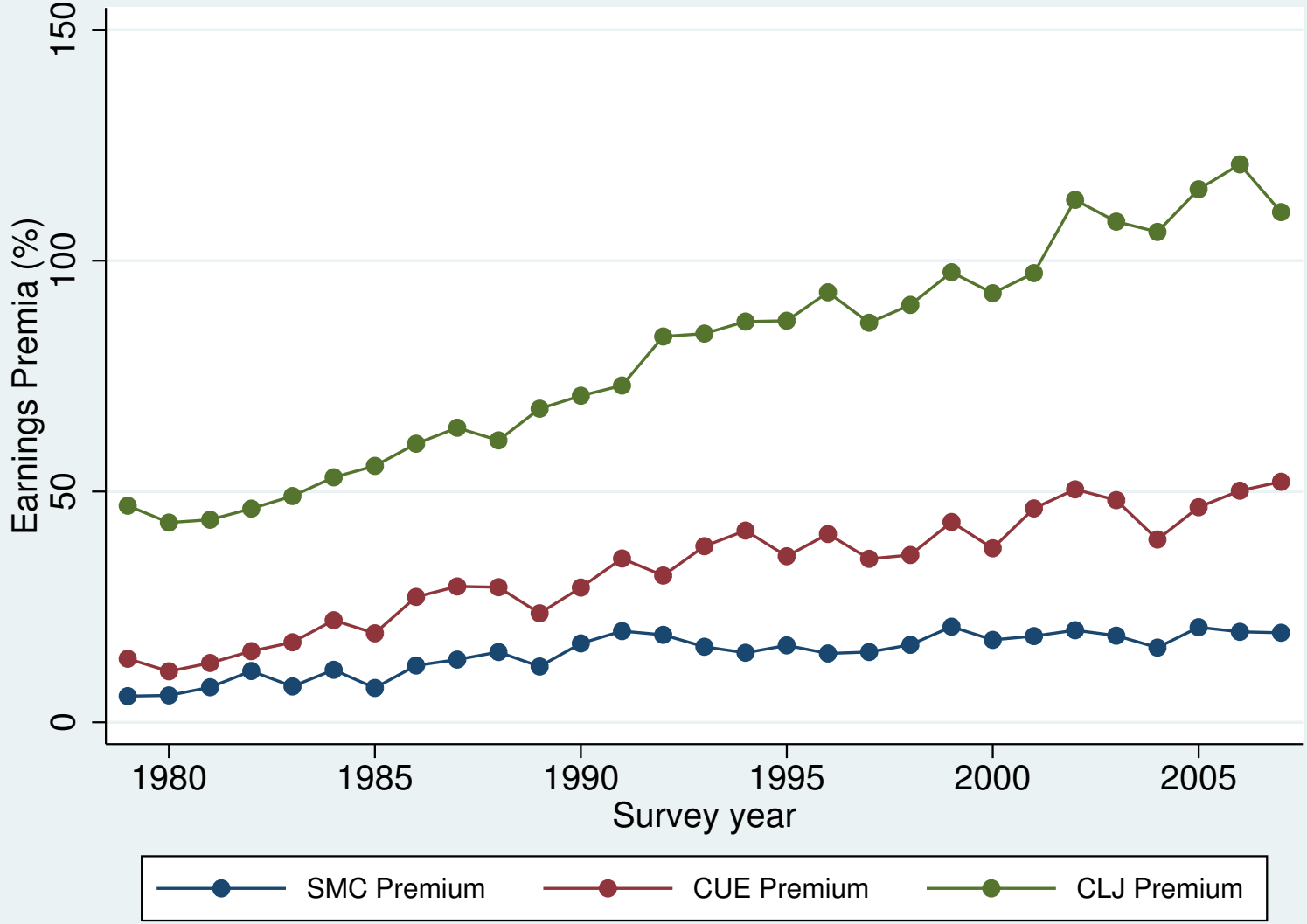
Some More Data

- This means even among higher education groups, it's only the top that has gained
- We already kind of knew this from previous lectures...education doesn't always get you a good job
- In the middle, some guys may be overqualified, or underemployed

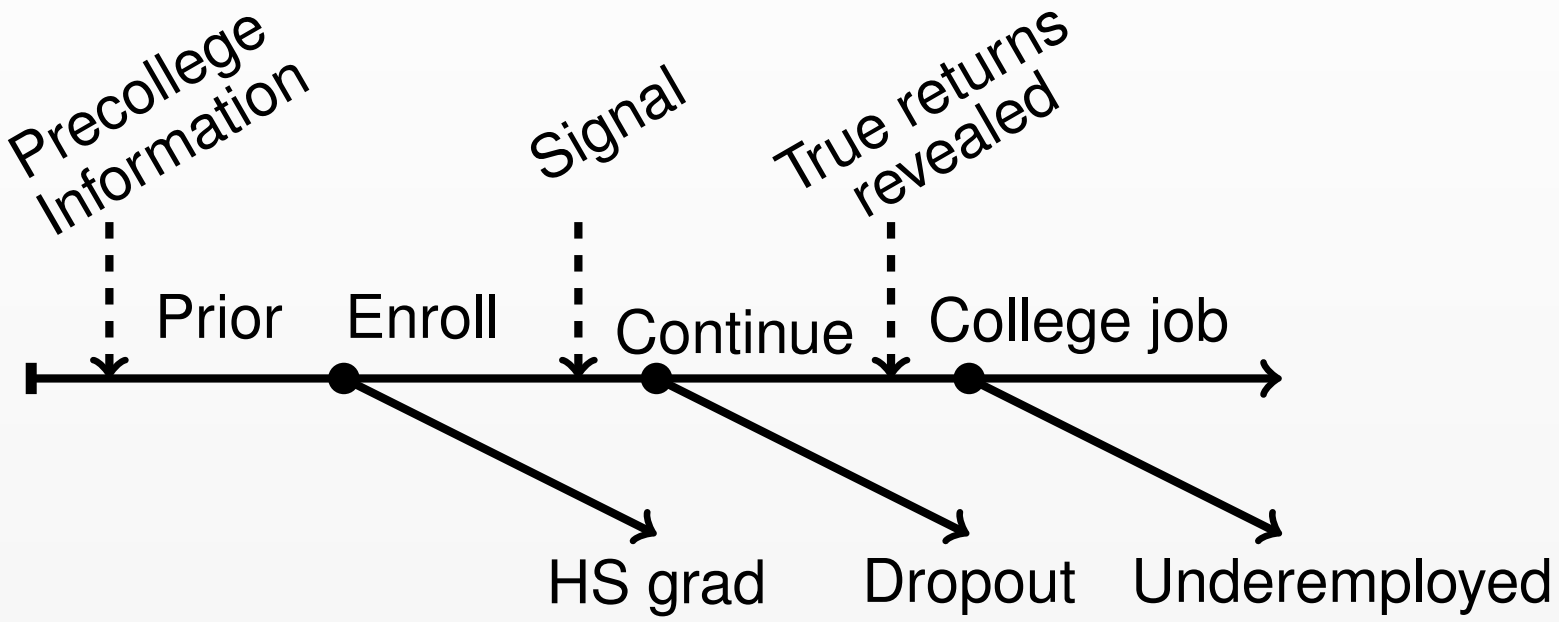
Underemployment



Education Premia Again (Males)

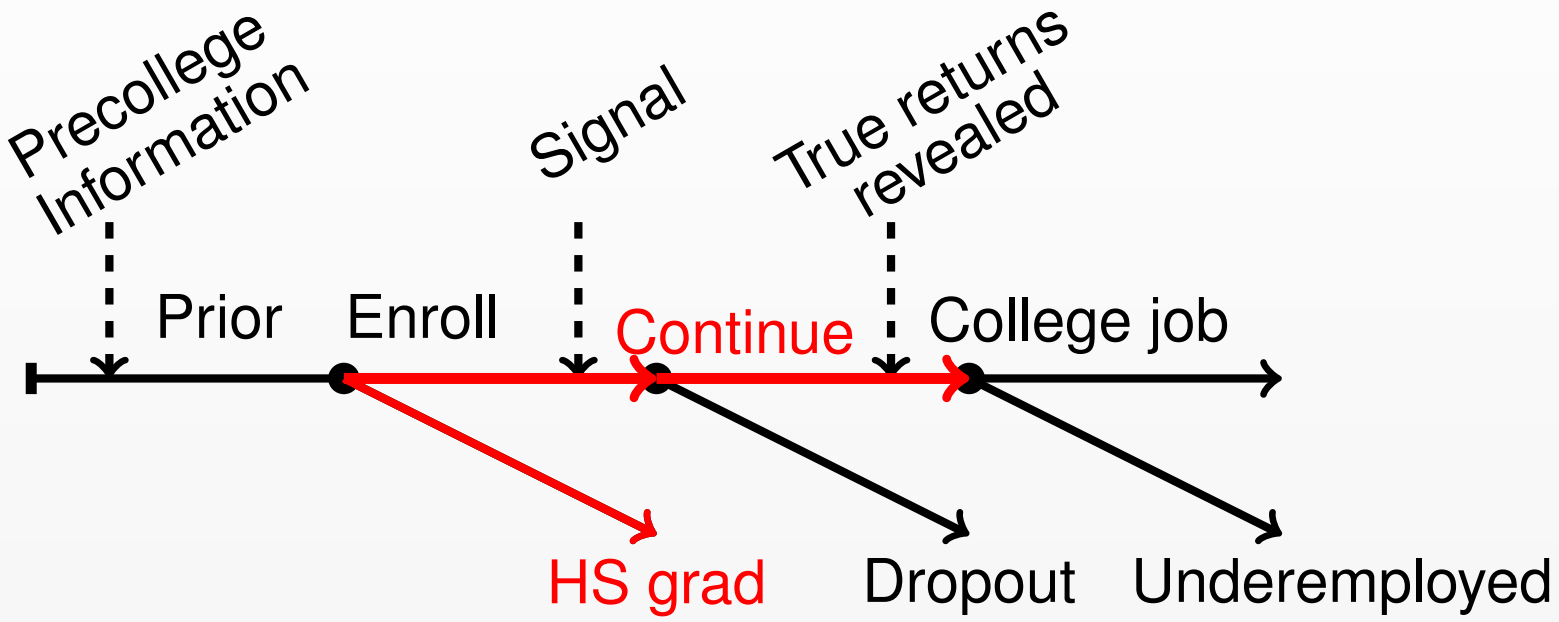


Simple Formulation of College Enrollment



1. Option to continue
2. Value of making decision after observing more information
3. Limited downside risk

Simple Formulation of College Enrollment



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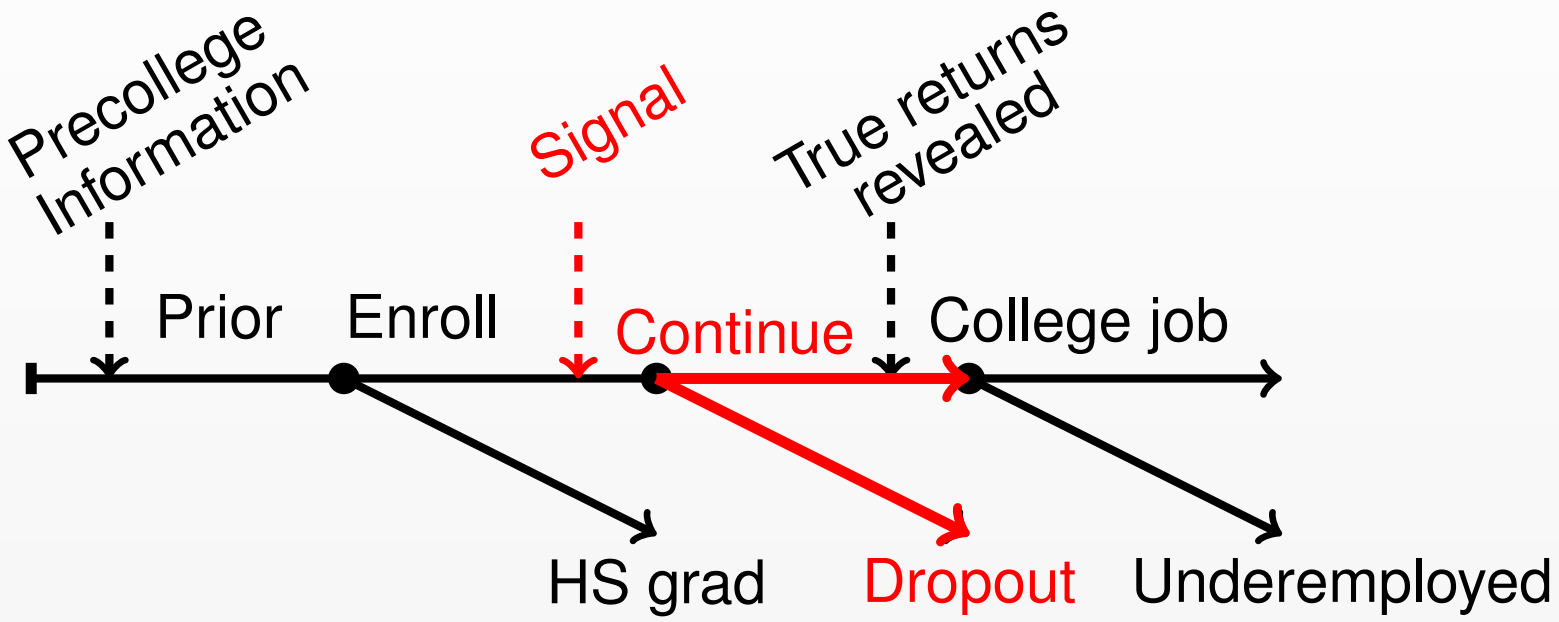

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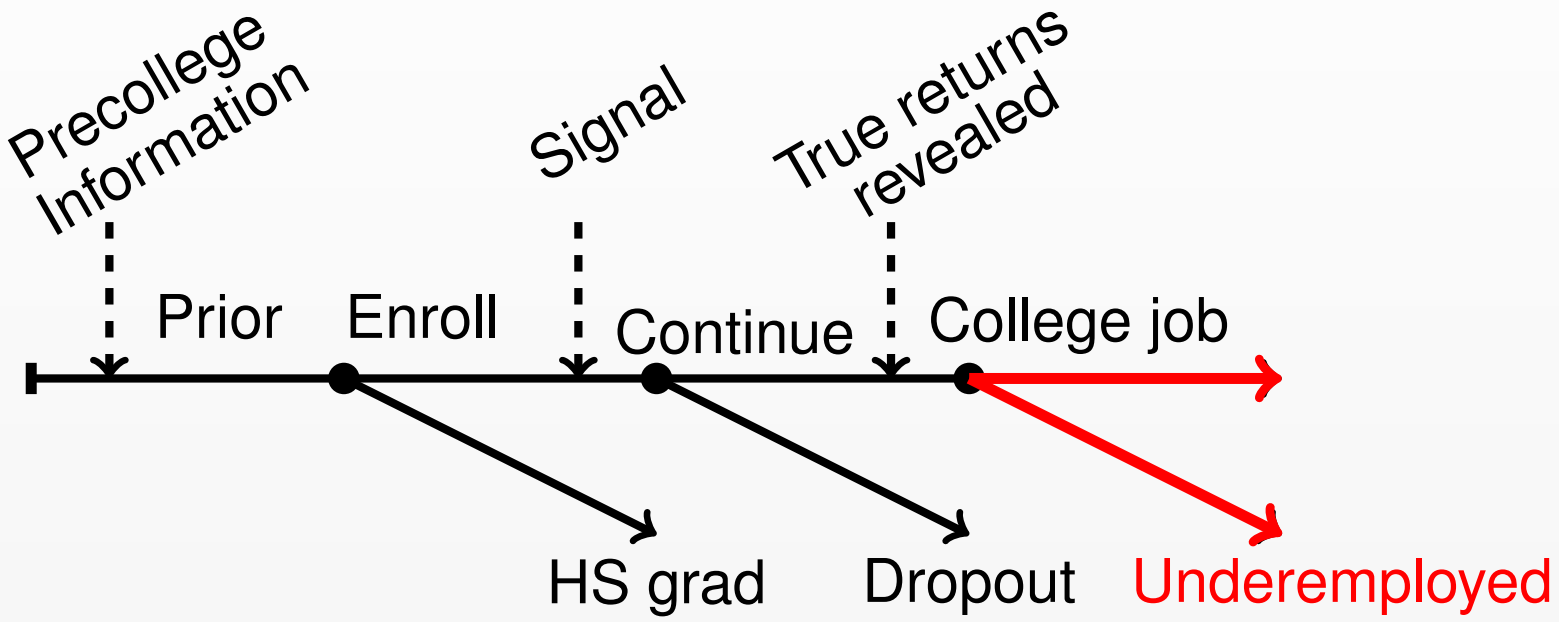


1. Option to continue
2. Value of making decision after observing more information
3. Limited downside risk

Roy Model (thanks to Chris Taber)

Let's work with an example

- There are 2 occupations, hunter and fisher
  - I.e., college or no-college, two types of jobs, etc.
- Fish and Rabbits are homogeneous
- No uncertainty in number you catch
- Individuals have different proficiencies in hunting and fishing

Roy Model (thanks to Chris Taber) cont.

- Let
  - π_F be the price of fish
  - π_R the price of rabbits
  - F number of fish an individual can catch
  - R number of rabbits an individual can catch
- Earnings are then

$$W_F = \pi_F F$$
$$W_R = \pi_R R$$

- Each individual chooses occupation that gives higher wage

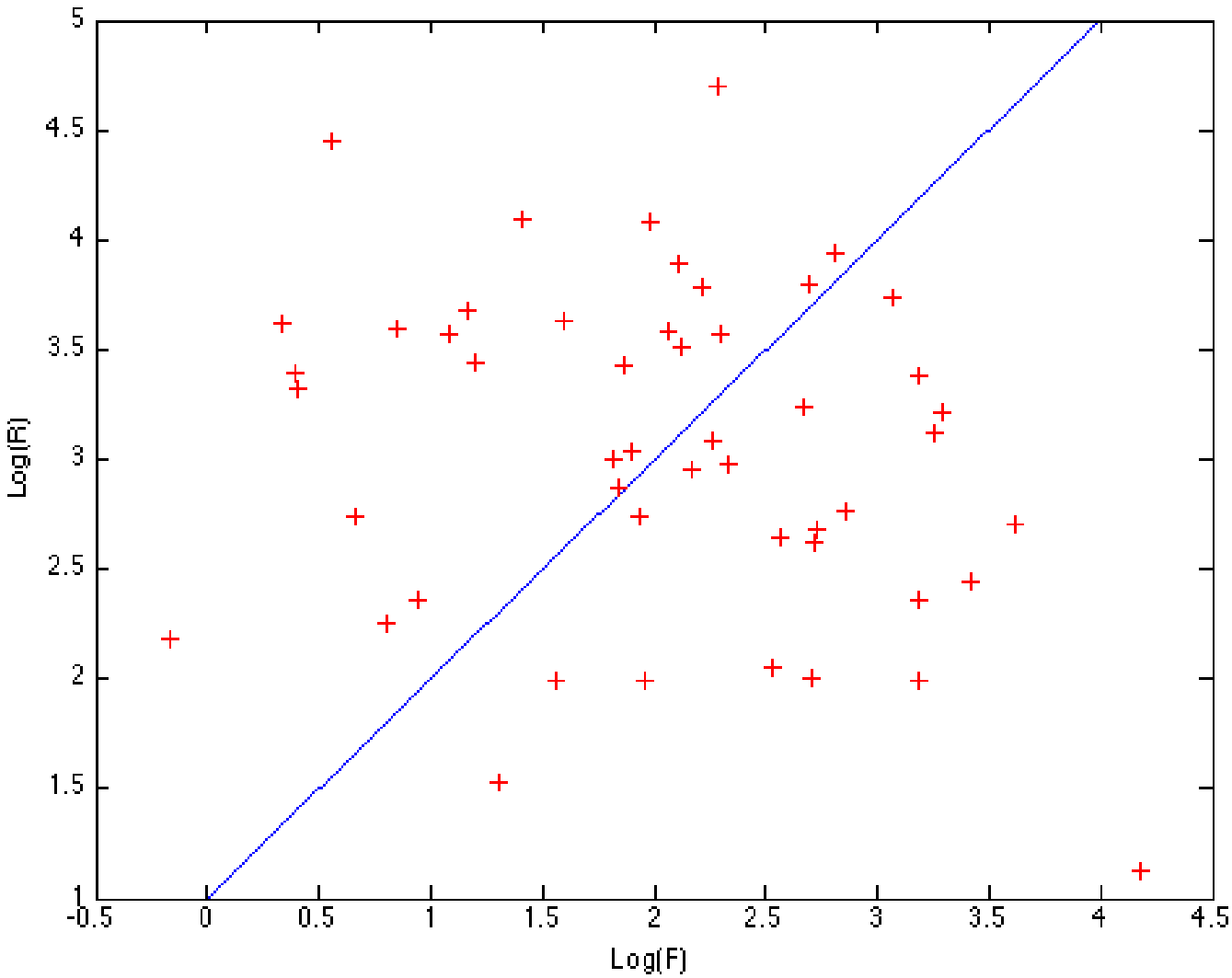
That's the celebrated "Roy Model."

Implications

- The optimal threshold is defined by

$$\log \pi_R + \log R = \log \pi_F + \log F$$

- If $>$, hunt. If $<$, fish.
- It turns out that whichever with the larger variance has more sorting


Log(F)
Log(F)
5
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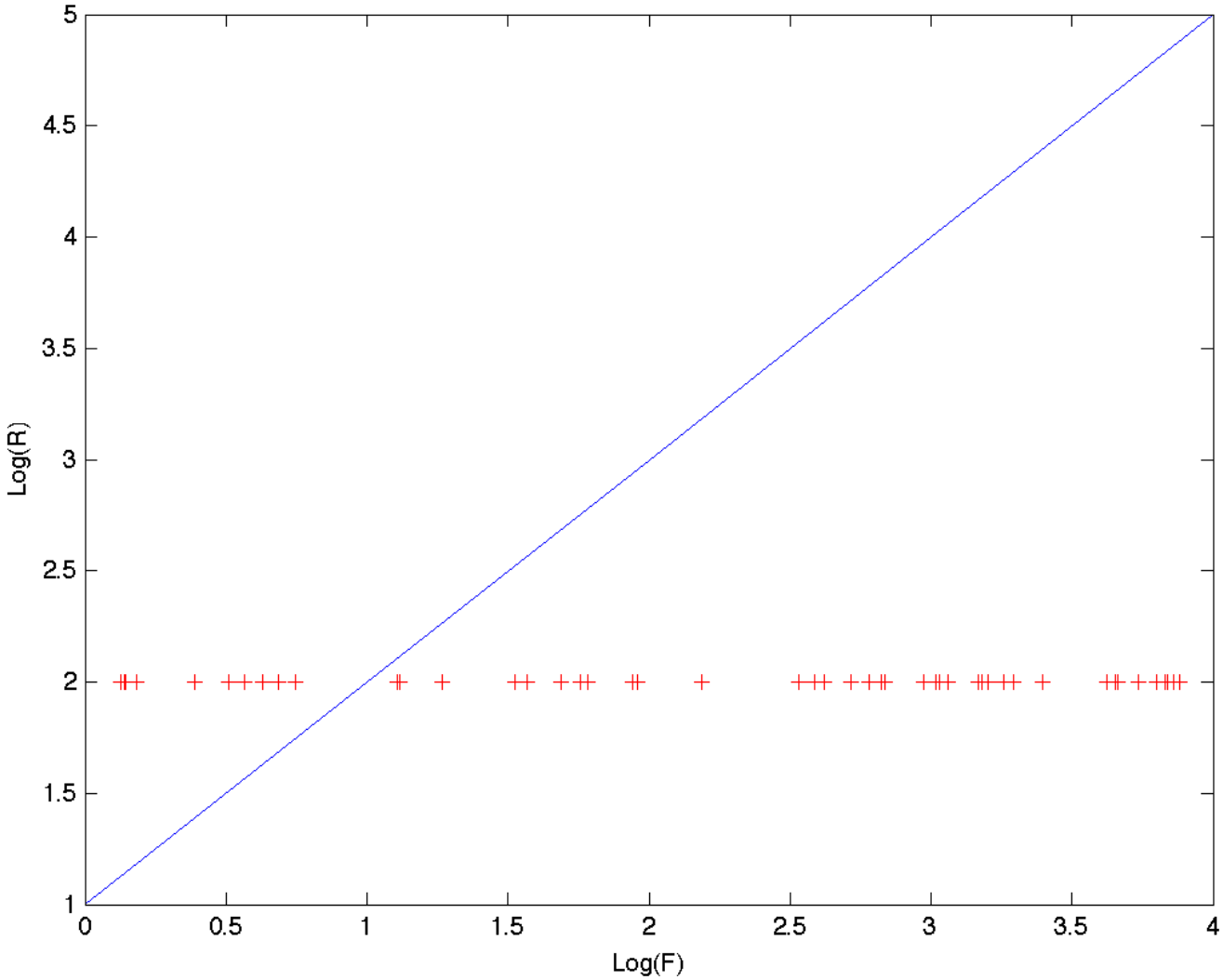
Case 1: No variance in Rabbits

- Suppose everyone catches R^*
- If you hunt you receive $W^* = \pi_R R^*$
- Fish if $F > \frac{W^*}{\pi_F}$
- Hunt if $F \leq \frac{W^*}{\pi_F}$

Then

- The best fishers fish
- All who fish make more than all who hunt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Log(F)

Case 2: Perfect correlation

Suppose that

$$\log(R) = \alpha_0 + \alpha_1 \log(F)$$

with $\alpha_1 > 0$

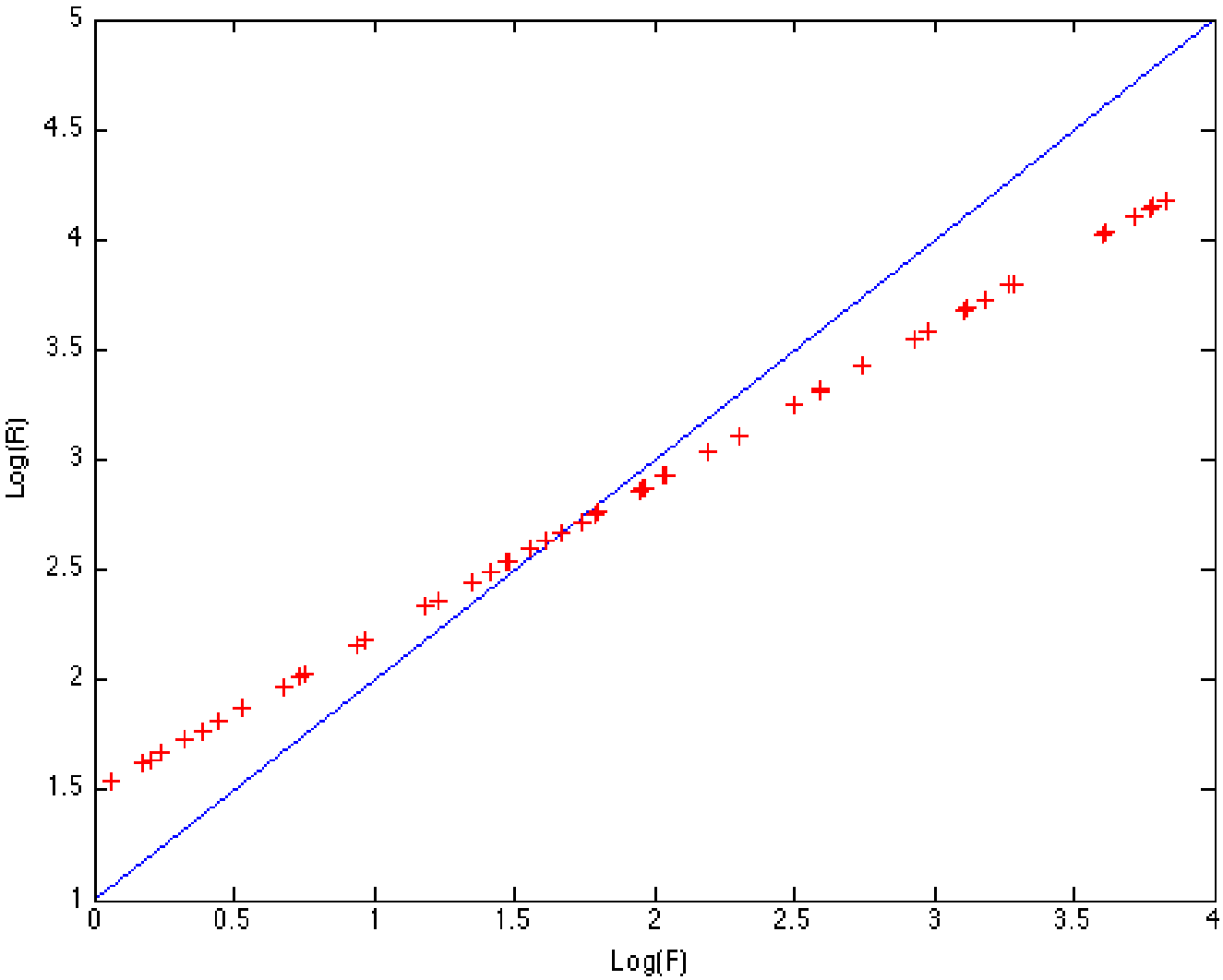
$$var(\log(R)) = \alpha_1^2 var(\log(F))$$

Fish if

$$\begin{aligned}
\log(W_F) &\geq \log(W_r) \\
\log(\pi_F) + \log(F) &\geq \log(\pi_R) + \log(R) \\
\log(\pi_F) + \log(F) &\geq \log(\pi_R) + \alpha_0 + \alpha_1 \log(F) \\
(1 - \alpha_1) \log(F) &\geq \log(\pi_R) + \alpha_0 - \log(\pi_F)
\end{aligned}$$

- If $\alpha_1 < 1$ then left hand side is increaing in $\log(F)$ meaning that better fishers are more likely to fish
- This also means that the best hunters fish
- Sorting into fishing, hunters are crappy
- If $\alpha_1 > 1$ pattern reverses itself

$\Rightarrow$ **P**ositive **A**ssortative **M**atching, or positive sorting (between workers and jobs), that we studied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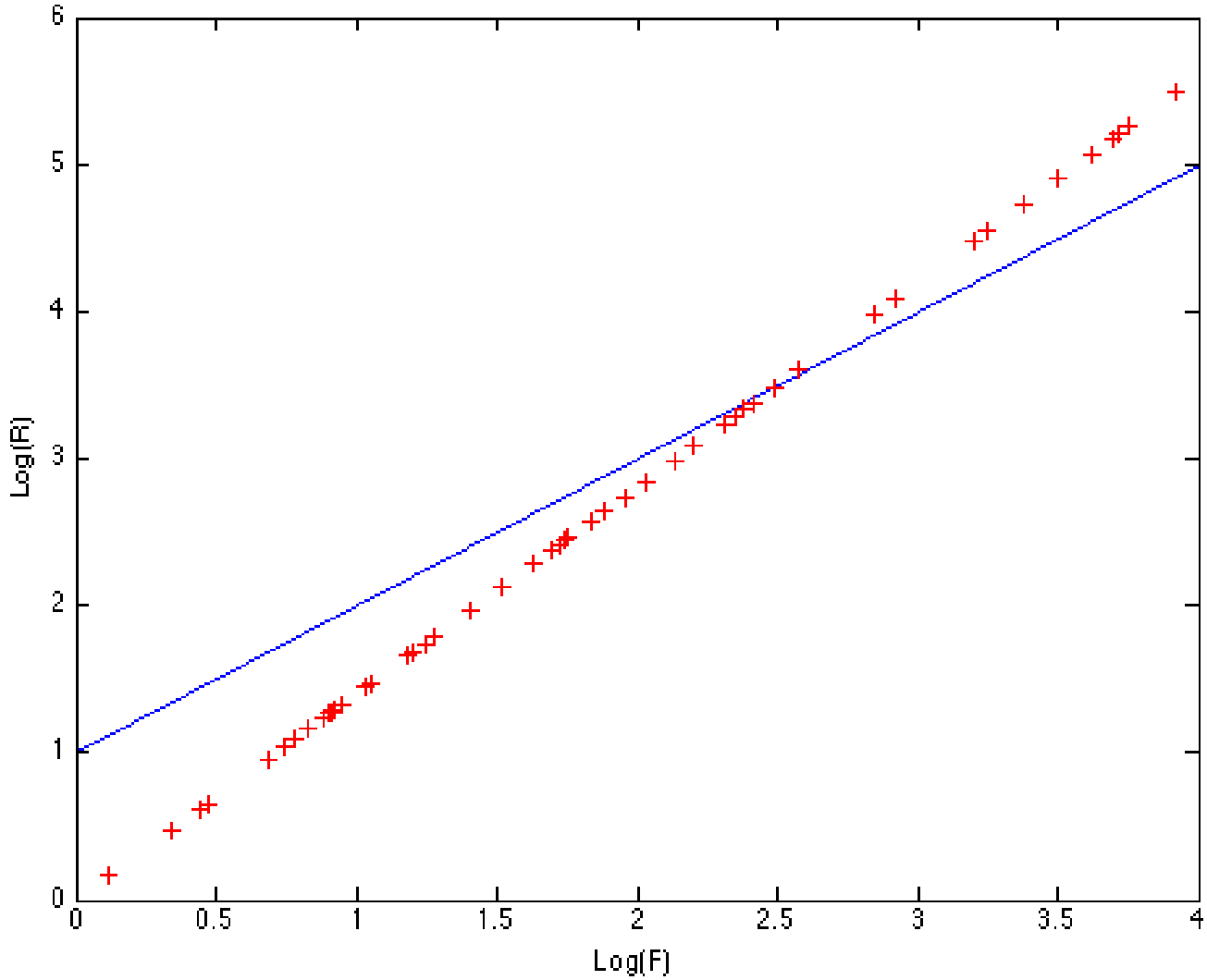
Log(R)
Log(F)


Log(R)
Log(F)
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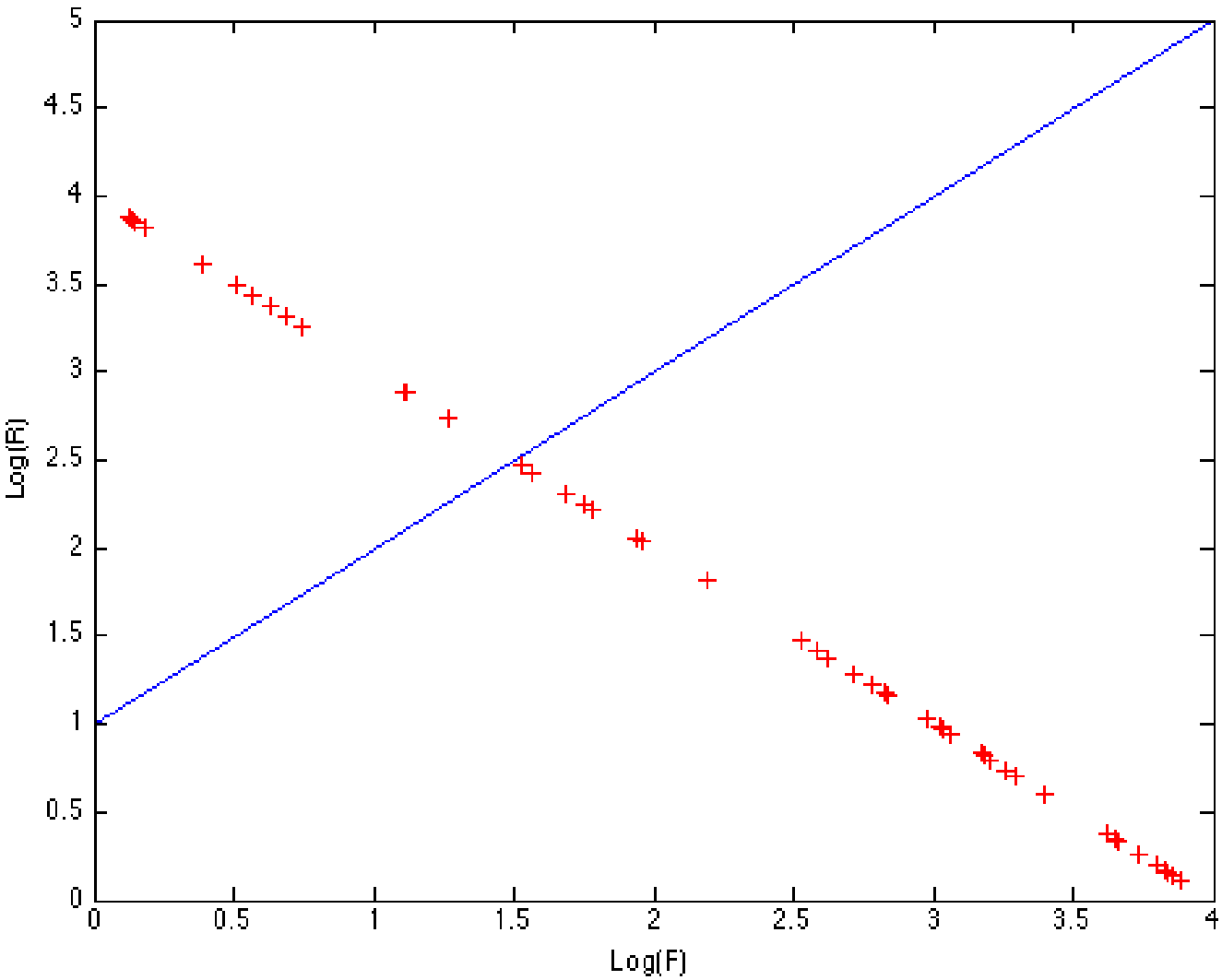
3
3.5
4

Case 3: Perfect Negative Correlation

- Exactly as before

$$(1 - \alpha_1) \log(F) \geq \log(\pi_R) + \alpha_0 - \log(\pi_F)$$

- Best fishers still fish
- Best hunters hunt


Log(F)
Log(F)
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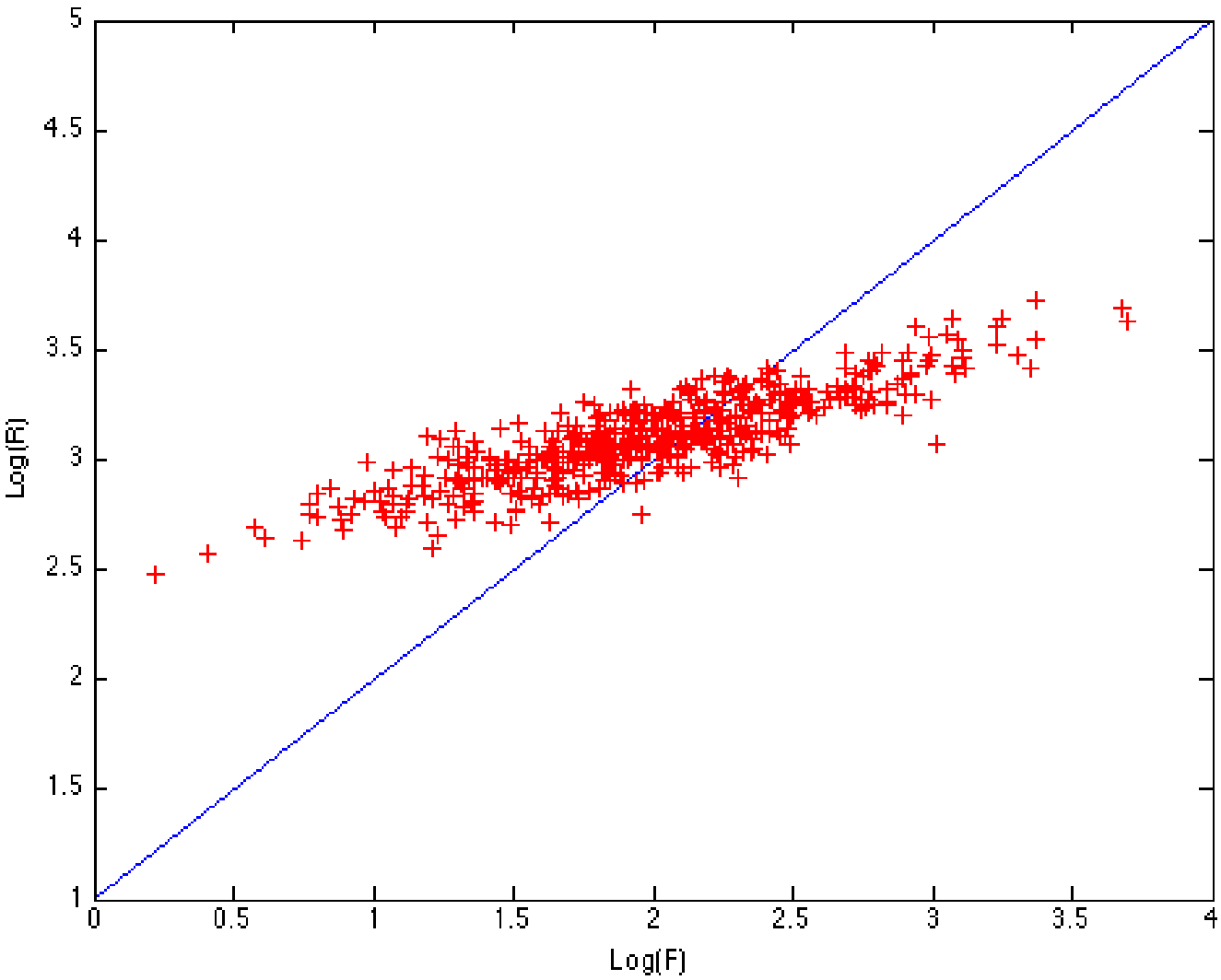
Implications

1. Easy to formally derive, with Gaussian assumptions, that
   - Occupation with larger spread (variance) $\Rightarrow$ more positive selection
   - Smaller correlation $\Rightarrow$ positive selection into both occupations
   - Larger correlation $\Rightarrow$ negative selection into smaller variance occupation
2. Identification issues without Gaussian assumption...won't deal with that here (Heckman and Honoré, 1990; French and Taber, 2011)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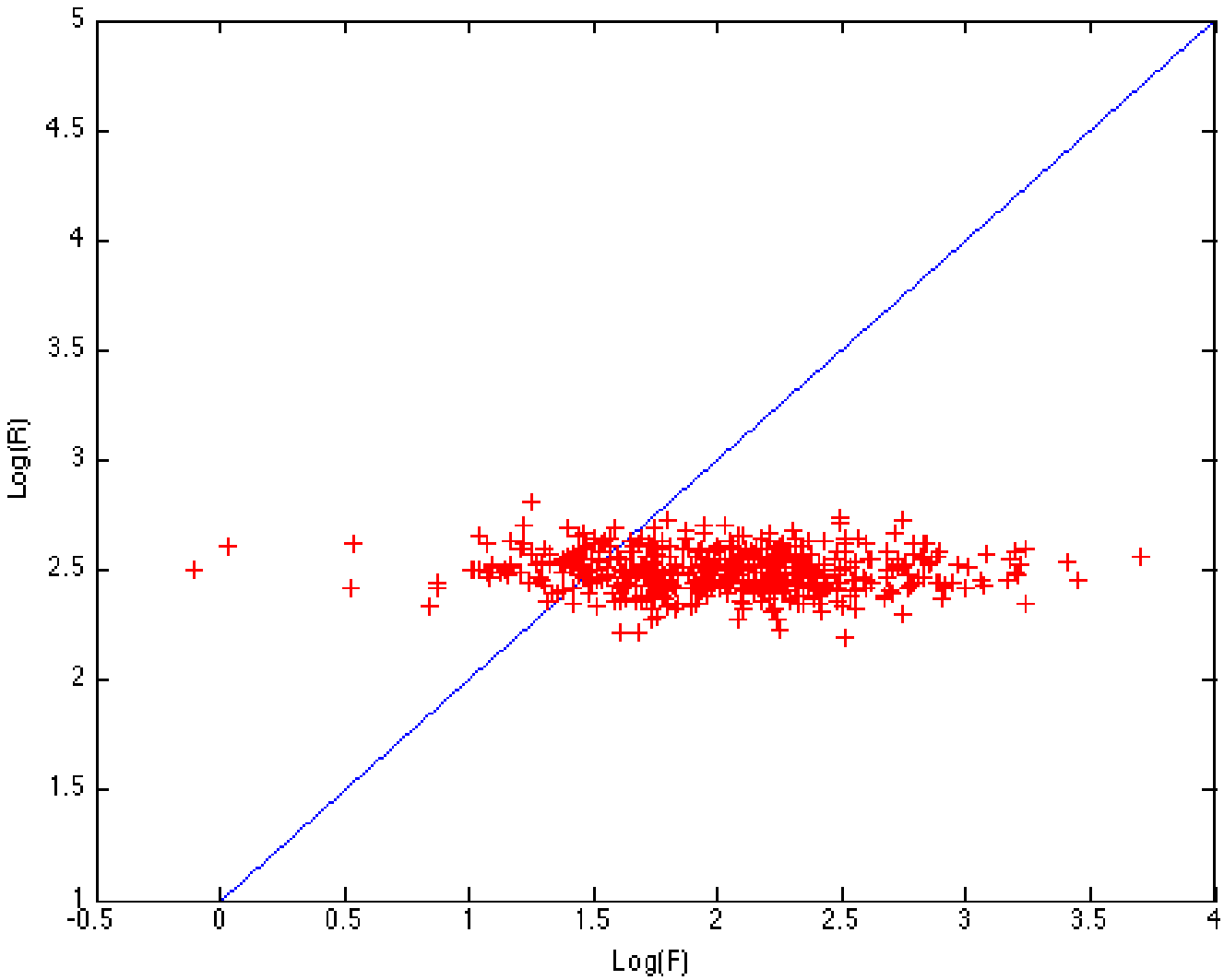
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Implications

1. Evidence in the data about correlation
   - College enrollment displays some selection, but confounded by college treatment effect
   - Different jobs display selection, but confounded by learning
2. But turns out that college seems to be mostly selection too (Heckman et al., 1998; Carneiro and Heckman, 2002; Carneiro et al., 2011)

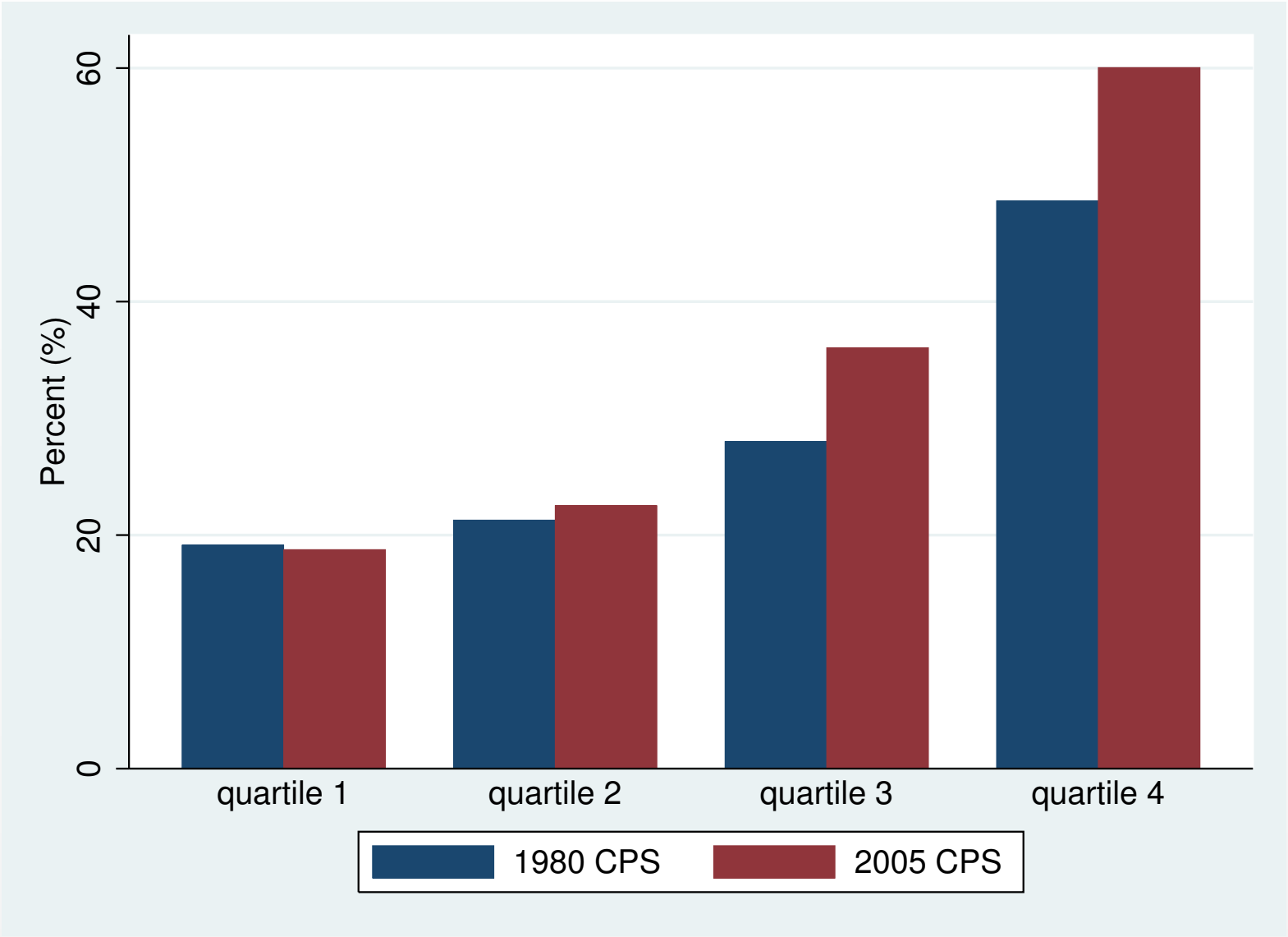
c.f. Some micro-level evidence that treatment effect is larger than we thought (Zimmerman, 2014)

But seems localized; need much more data (major, occupation, etc.)

Is Everything Selection?

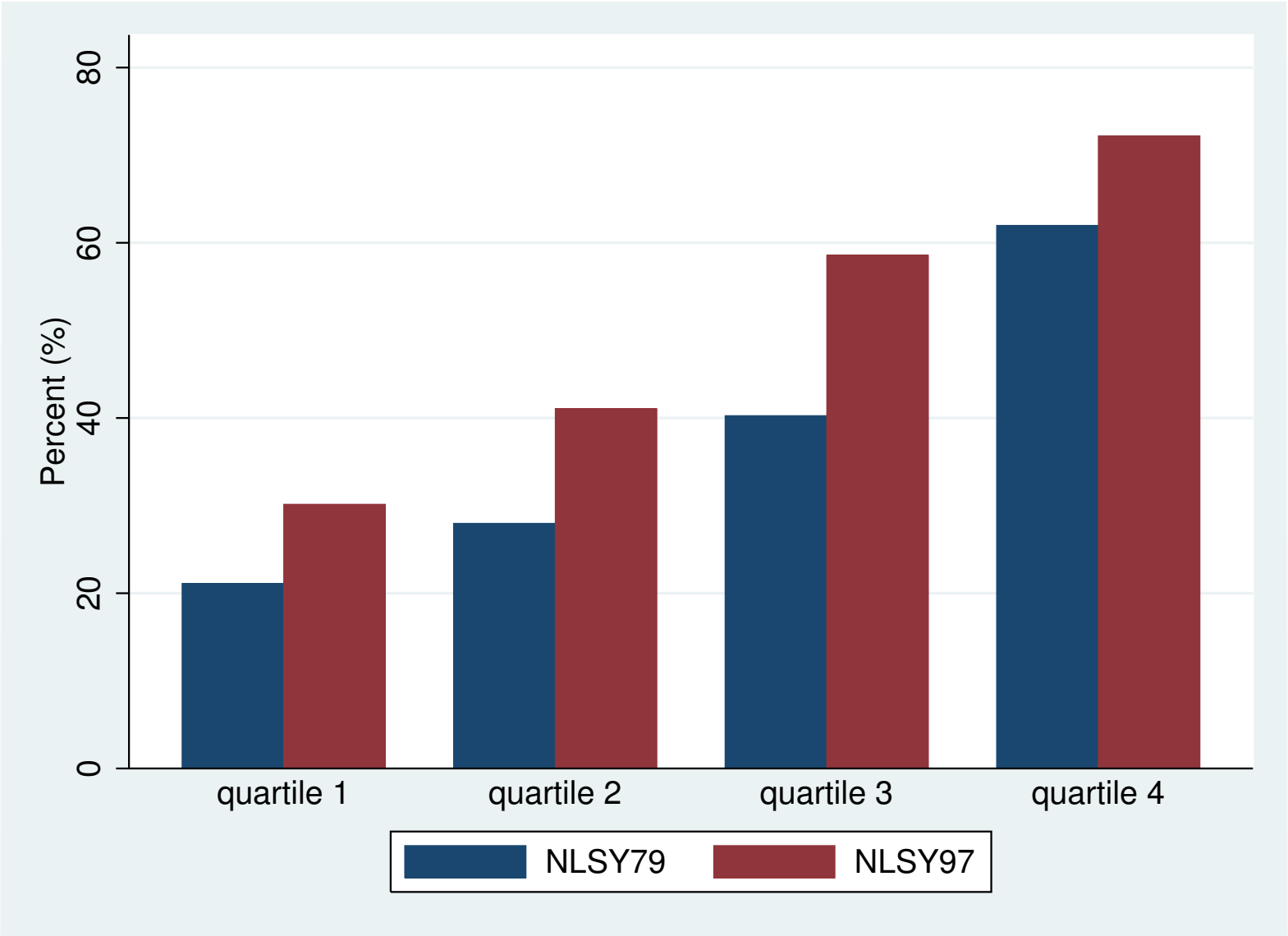
1. Empirically, increase in variance within-education groups seems to be due to increase in variance, not volatility (Cunha et al., 2005)
2. It could be that the life-cycle is too simplified (e.g. Belzil et al. (2012) models OJT, learning etc. more elaborately)
3. But my own view is that this is unlikely, at least in the U.S.
4. Leads us to even earlier periods

College Graduation by Ex-Post Income Quartiles



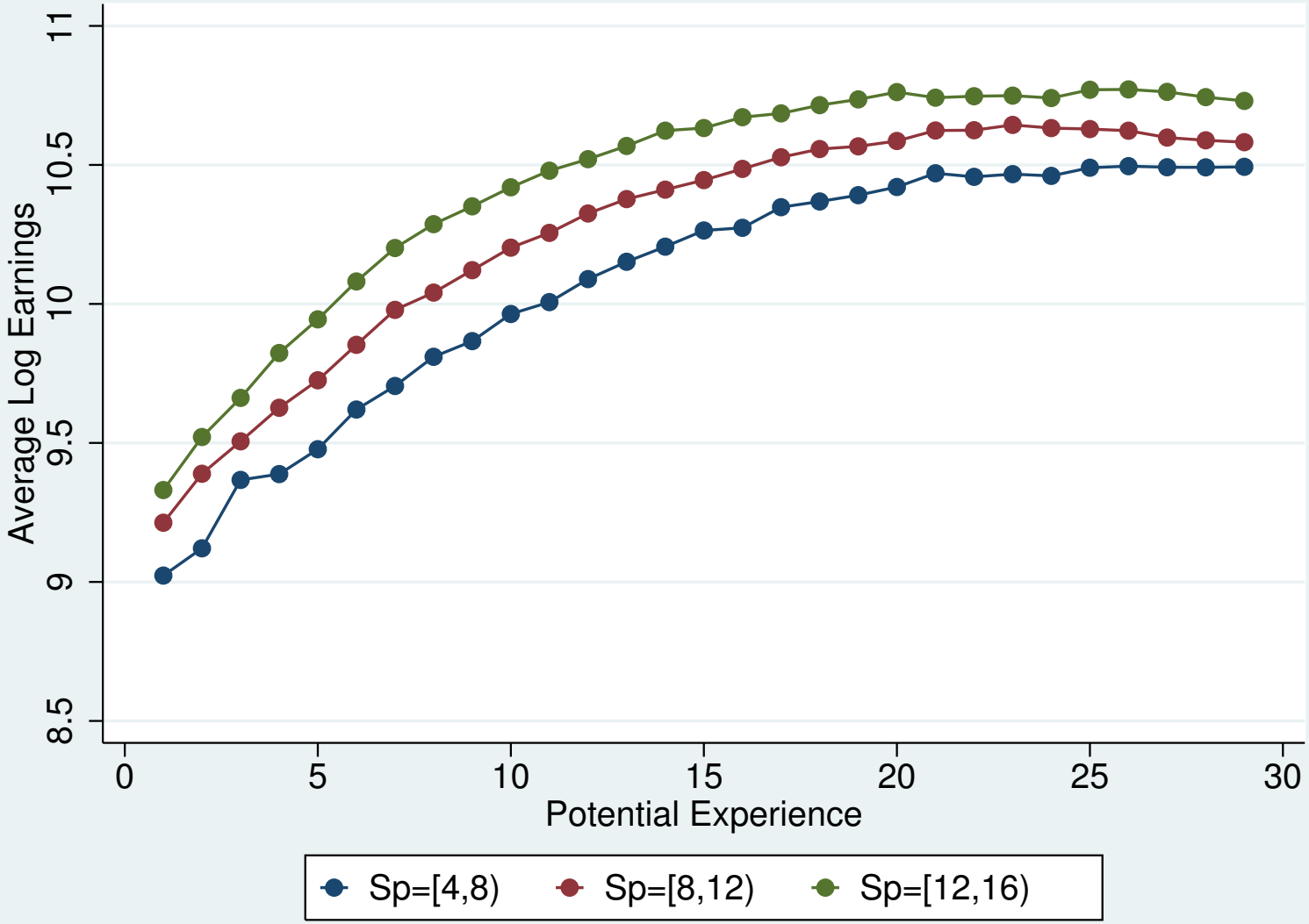
CPS, Males 26-50

College Enrollment by Family Income Quartiles



NLSY79 vs. NLSY97

Log Earnings by Mom's Years of Schooling



HRS, social security earnings

Motivating Data for Becker-Tomes

- Intergenerational persistence of earnings is quite high:

$\Rightarrow$ Intergenerational elasticity (IGE) of earnings:

  - 0.4 for 2-5 year horizons (Solon (2004))
  - up to 0.6 for 15 years? (Mazumder (2005))
  - 0.34 in tax returns data (Chetty et al., 2014)
  - Last estimate is definitive and robust to life-cycle attenuation, unlike previous studies

- Natural endowments and parental spillovers are important

$\Rightarrow$ each can explain approximately half of differences in educational attainment

  - twin studies: e.g. Behrman and Rosenzweig (2002)
  - biological vs adopted children: e.g. Plug and Vijverberg (2003)

IGE of Other Variables

- IGE is defined as the regression coefficient when

$$\log e_k = \alpha + \beta \log e + \omega$$

- Persistence in other variables
  1. Consumption of old parents and young children: 0.68 (Mulligan (1999), PSID)
  2. Wealth of old parents and young children: 0.37 (Charles and Hurst (2003), PSID)
  3. Educational attainment: 0.31-0.37 for non-black males (Hauser (1998), SIPP)

Plain Vanilla Becker-Tomes Model

- Two period OLG; child and parent: subscript k for child variables
- Only parents earn wages. Parents make decisions for children.
- Wages determined by level of human capital (h)
- Human capital is a function of natural endowments (a) and investments (m)
- Human capital formation takes place only for children
- Parents also make bequest (b) decisions (physical capital)

Becker-Tomes Model

- Children do nothing. Parent's maximize joint utility:

$$\max_{c,c_k,m_k,b_k} \left\{ u(c) + \theta \int_{\epsilon_k} u(c_k) dF(\epsilon_k) \right\}$$

$$\text{s.t.} \quad c = [h + (1+r)b]\,\epsilon - m_k - b_k$$

$$c_k = [h_k + (1+r)b_k]\,\epsilon_k$$

$$h_k = a_k m_k^{\gamma}$$

- Returns to human capital investment $\gamma \in (0,1)$
- Satisfies Inada conditions

Becker-Tomes Model - Assumptions

- Abilities are revealed when child is born. Transmitted across generations according to

$$\log a_k = (1-\rho)\mu + \rho \log a + \eta, \qquad \eta \sim \mathcal{N}(0, \sigma_a^2).$$

- Innate IGE $\rho < 1$
- "Market luck shock" ϵ revealed when adult, $\log \mathcal{N}(0, \sigma_\epsilon^2)$.

Becker-Tomes Model - F.O.C.'s

- First order conditions are straightforward:

$$u'(c) \leq \theta \int_{\epsilon_k} u'(c_k)\epsilon_k dF(\epsilon_k) \cdot \frac{\gamma a_k m_k^{\gamma}}{m_k} \quad \text{with equality if } m_k > 0$$

$$u'(c) \leq \theta \int_{\epsilon_k} u'(c_k)\epsilon_k dF(\epsilon_k) \cdot (1+r) \quad \text{with equality if } b_k > 0$$

- Unconstrained optimum is when marginal returns from physical and human capital investments are equalized:
  1. invest only in human capital up to the point where marginal returns equal market interest rate
  2. after that, leave everything in bequests

No Borrowing Constraint - Earnings

- Without any constraints, h_k is fixed at

$$\log \gamma + \frac{\log a_k}{\gamma} = \log(1+r) + \frac{1-\gamma}{\gamma} \log h_k$$

- In a steady state, earnings across generations simply reflects the ability process
- Hence IGE$= \rho$.

No Borrowing Constraint - Consumption

- Now assume $u(c) = \dfrac{c^{1-\sigma}}{1-\sigma}$
- Then it's just Friedman's PIH, but across generations!

$$\log c_k = \frac{\log \theta(1+r)}{\sigma} + \frac{(1-\sigma)^2\sigma_\epsilon^2}{2\sigma} + \log c + \log \epsilon_k,$$

- Consumption does **NOT** regress to the mean - whenever a generation is hit with a good luck shock,
  1. Increases own consumption
  2. Also increases next generation's consumption!

Borrowing Constraint - Earnings

- Now assume $b_k \geq 0$ (no reverse transfers) and $\sigma = 1$ (log utility)
- Further assume that *everyone* is constrained. Then

$$\log h_k = \gamma \log \left[\frac{\theta\gamma}{1+\theta\gamma} \right] + \gamma \log h + \log a_k + \gamma \log \epsilon$$

- Note that a_k is correlated with both (h_k, h). Assume $\sigma_\epsilon = 0$ and subtract $\rho \log h$ from both sides to get

$$\begin{aligned} \log h_k =& (\gamma + \rho) \log h - \gamma\rho \log h_{-1} \\ &+ \gamma(1-\rho) \log \left[\frac{\theta\gamma}{1+\theta\gamma} \right] + \eta \end{aligned}$$

Borrowing Constraint - Earnings

$$\log h_k = \alpha + (\gamma + \rho) \log h - \gamma\rho \log h_{-1} + \eta_t$$

- If use both parent and grandparent, classical OLS—somewhat absurd implication that grandparents have *negative* effect, conditional on parents
- One-step ahead IGE, assuming stationarity is

$$\text{IGE} = \frac{\gamma + \rho}{1 + \gamma\rho} \quad \text{and} \quad \text{IGE} = \gamma \quad \text{if} \quad \rho = 0$$

- IGE increasing in education efficiency!

Digression on AR(1)

- Assume y_t is stationary in

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + u_t \tag{1}$$

  and u_t i.i.d.
- Let $\sigma_k \equiv \mathrm{Cov}(y_t, y_{t-k})$
- OLS of y_t on y_{t-1} is asymptotically $\tilde{\beta} = \sigma_1/\sigma_0$
- From (1),

$$\sigma_1 = \beta_1\sigma_0 + \beta_2\sigma_1 \quad \Rightarrow \quad \tilde{\beta} = \sigma_1/\sigma_0 = \beta_1/(1-\beta_2)$$

- In our application, $\beta_1 = \gamma + \rho$ and $\beta_2 = -\gamma\rho$

Borrowing Constraint - Taxes and Transfers

- Assume that everyone is still constrained (equivalent to assuming no bequests) and

$$
\begin{aligned}
c &= (1-\tau)h\epsilon - m_k \\
c_k &= (1-\tau)h_k\epsilon_k \\
h_k &= a_k\left(m_k + d\right)^{\gamma}
\end{aligned}
$$

  i.e. τ earnings tax and d education subsidies
- Using the AR(1) result, and assuming that $d = \tilde{d}\bar{h}\epsilon$ (fixed fraction of earnings for education budget), easy to show that IGE$= \dfrac{(\gamma+\rho)(1-\tau)+\rho\tilde{d}}{(1+\gamma\rho)(1-\tau)+\tilde{d}}$ when $\sigma_\epsilon = 0$.
- Decreasing in τ and $\tilde{d}$!

Empirical Implications

- Mulligan (1999):
  1. Consumption regresses slower to the mean than earnings
  2. Without constraints, consumption inequality would explode over time - IG constraints guarantee stability
- Solon (2004); Holter (2012):
  1. Education can *increase* persistence
  2. Tax/transfers may alleviate them
- Schooling displays similar or more persistence than earnings at short time horizons (because of luck shocks)

Toward Dynamic Complementarity

1. IGE may also be selection, impossible to separate exogenous persistence from borrowing constraints? (Goldberger, 1989; Mulligan, 1999; Han and Mulligan, 2001)
2. Not possible to identify without more structure, but:
   - Becker-Tomes setup simplifies childhood effect
   - Macro models lump pre-labor market entry into one big period
3. Undermines role for childhood; dynamic complementarity recovers this
4. Also important to have life-cycle element since we observe parents' life-cycle will affect investment in children, and hence their outcomes (Lee and Seshadri, 2017)

Dynamic Complementarity

Recent literature emphasizes that, investments in different periods are complements rather than substitutes (Cunha et al. (2010); Caucutt and Lochner (2012)):

- e.g., if primary education is crappy, it also affects tertiary education
- If I know tertiary education is crappy, less incentive for primary education as well
- If $h' = f(x, h)$ where x is investment, $\frac{\delta^2 f}{\delta h \delta x} > 0$ implies **D**ynamic **C**omplementarity, i.e. early accumulation helps today's production.

Simple Dynamic Complementarity

A very simple version of Cunha et al. (2010):

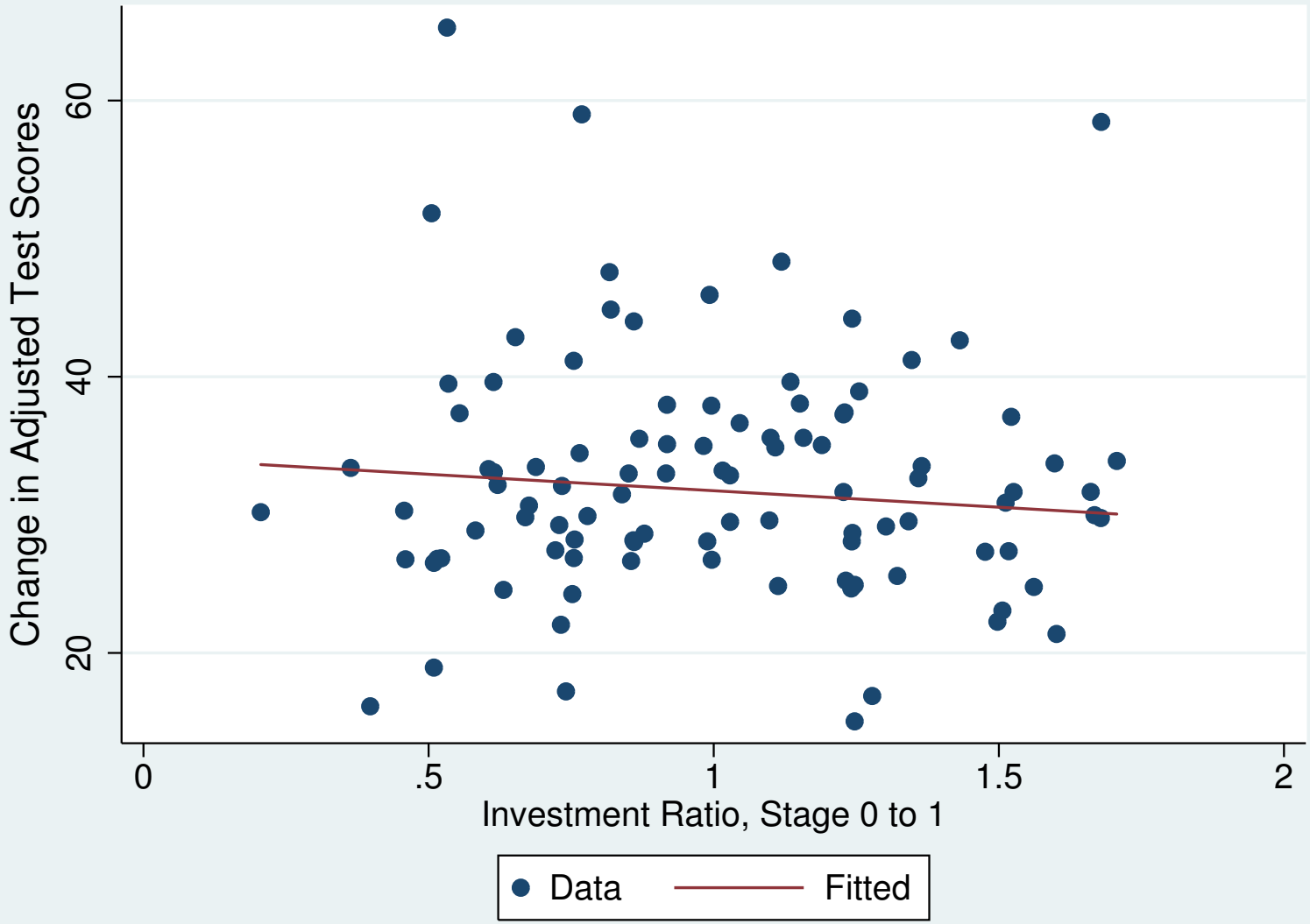
$$h' = \left[\omega x^{\phi} + (1-\omega)h^{\phi}\right]^{\frac{1}{\phi}}$$

where

- h': next period human capital
- ω: this period's relative productivity
- x: this period investment
- h: this period human capital
- ϕ: CES parameter, measures DC

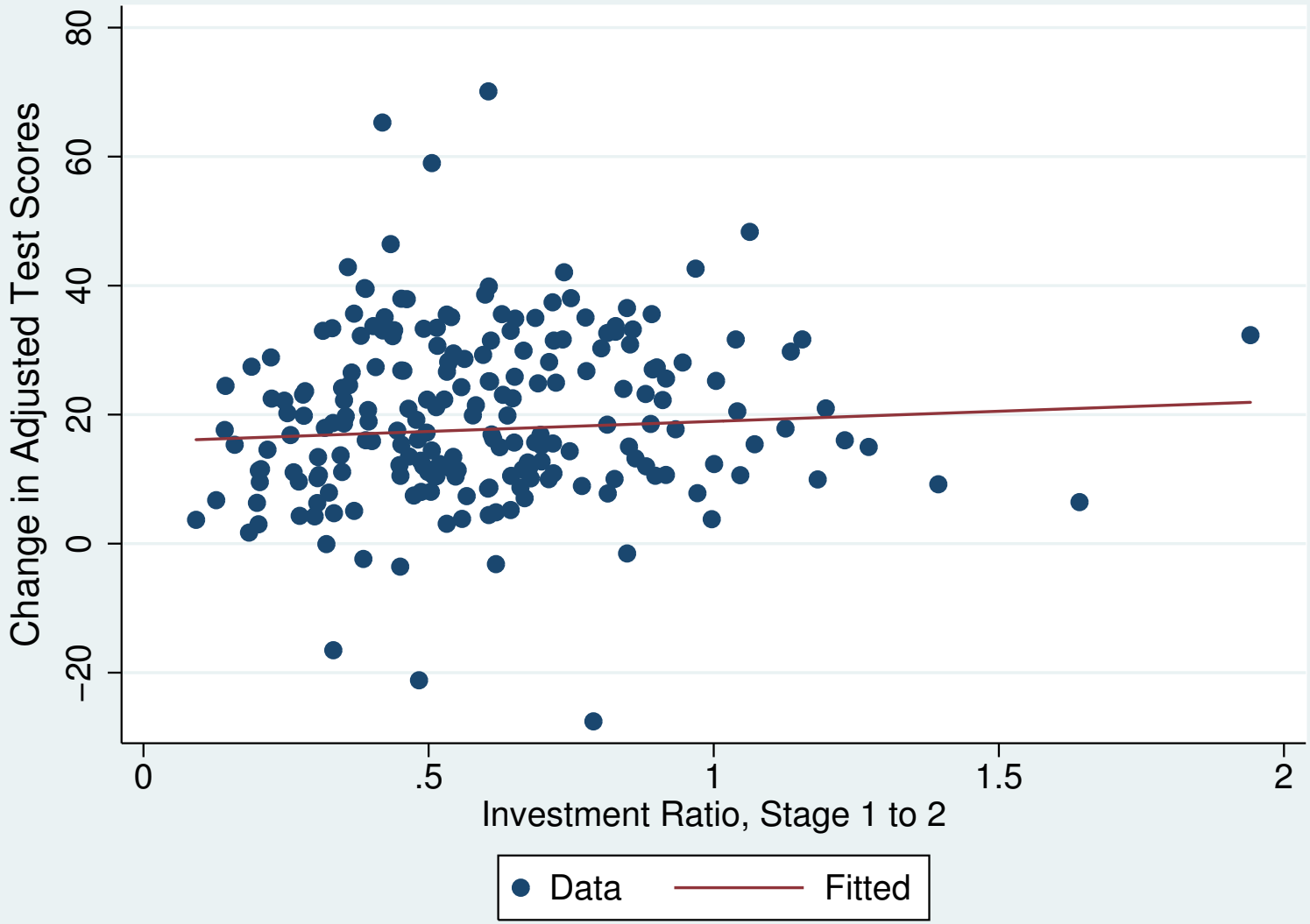
Becker-Tomes and most macro models implicitly assume $\phi = 1$ (perfect substitution)...but using test scores for h,

DC estimate ϕ_1, below and after age 6



PSID, Child Development Supplement

DC estimate ϕ_2, below and after age 12



PSID, Child Development Supplement

Summary

- Pre-labor market inequality is important
- Education explains some, but even that seems to be selection
- Even then, it could still be intergenerational selection Mulligan (1999); Black et al. (2005)
- But recent literature, with more data and new mechanisms, are finding roles for early interventions Björklund et al. (2006); Heckman et al. (2013)
- More data and new mechanisms on education and work also reveal more roles other than just selection

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