The Great Gatsby Goes to College:

Tuition, Inequality and Intergenerational Mobility

Damien Capelle (International Monetary Fund)

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Introduction

Motivation

How does higher education contribute to income inequality and intergenerational mobility?

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Partial Equilibrium view

Higher Education $\longrightarrow$ Income Inequality

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General Equilibrium view (this paper)

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- Sorting of financial resources across colleges
- Role of tuition fees (and governments policies)
- Sorting into colleges in turn shapes
  - Inequality at the next generation Mean Kid Inc. by Coll.
  - Intergenerational mobility

Approach

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  - Colleges choose students and educational expenditures
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- Build a tractable GE framework with
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- Use the model to
  - Develop intuitions using analytical solutions about linkages between
    - Sorting of heterogeneous stud. across heterogeneous coll.
    - Income inequality
    - Intergenerational mobility
  - Quantification based on micro-data in the U.S.

Preview of Findings

Finding 1: Higher ed. increases income inequality and intergenerational persistence, partially mitigated by gov. interventions.

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Finding 2: Increase in returns to education

- rationalizes increase in tuition and dispersion of expend./students across colleges Data
- worsens misallocation of students

Literature

Theoretical and structural literature

- Transmission of human capital, social mobility and inequality
  Loury (1981), Becker and Tomes (1986), Fernandez and Rogerson (1996), Benabou (2002), Caucutt and Lochner (2020)
- Pricing behavior of colleges and sorting
  Rothschild and White (1995), Epple et al.(2006, 2017), Cai and Heathcote (2019) More.
- Higher education in structural GE
  Restuccia and Urrutia (2004), Abbott et al. (2013), Krueger and Ludwig (2016), Lee and Seshadri (2019), Herrington, Hendricks and Schoellman (2020)

Empirical/micro literature

- Empirical studies on mobility, returns to higher education
  Dale and Krueger (2002, 2011), Long (2008, 2010), Zimmerman (2014,2019), Chetty et al. (2019)
- Effects of financial aid
  Hoxby et al. (2012), Dynarski et al. (2013), Autor et al. (2019)

The Model (analytical solution)

Timeline and Blocks of the Model

h

h: human capital

Timeline and Blocks of the Model

$$\overset{h}{\longmapsto} y$$

h: human capital   y: parental income

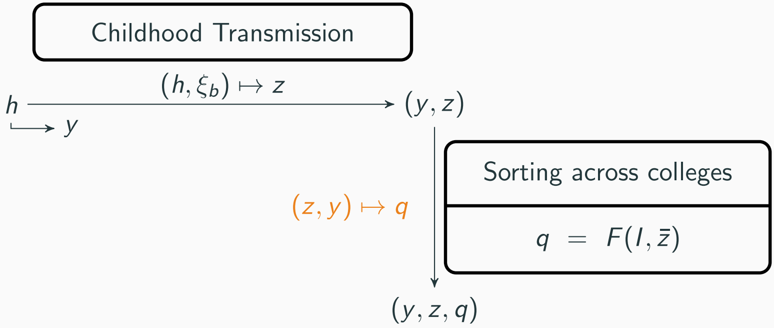
Timeline and Blocks of the Model

Childhood Transmission

$$
\begin{array}{l}
h \xrightarrow{\quad (h, \xi_b) \mapsto z \quad} (y, z) \\
\hookrightarrow y
\end{array}
$$

h: human capital y: parental income ξ_b: birth shock z: child ability

Timeline and Blocks of the Model



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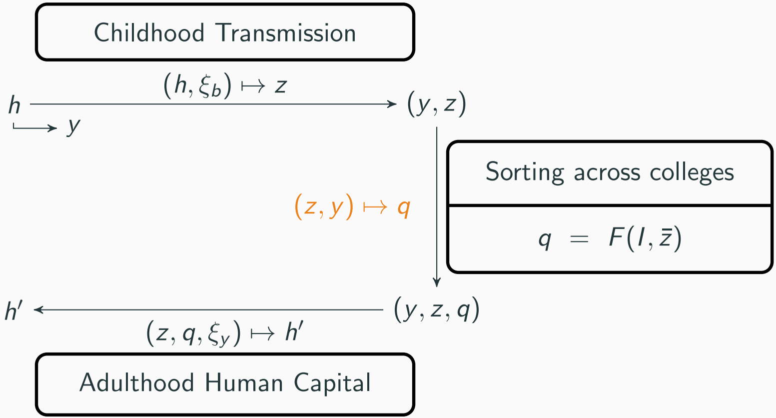

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The Model (analytical solution)

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A dynasty solves:

$$\mathcal{U}(h,z) = \max_{c,\ell,q} \left\{ \ln c - \ell^{\eta} + \beta E \left[\mathcal{U}(h',z') \right] \right\}$$

$$y = c + \underbrace{e(q,z,y)}_{\text{Tuition Payment}} \qquad \underbrace{\text{Life-time Budget Constraint}}_{\blacktriangleright \text{ Intergenerational Borrowing Constraint}}$$

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$$\xi_b, \xi_y \sim \text{Log-normal} \qquad \text{Birth and Labor Market Shocks}$$

Model with Government · Borrowing Constraint

The Model (analytical solution)

Colleges

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Technology: A college delivers a quality to its students

$$q = I^{\omega_1} \left(\bar{z}\right)^{\omega_2} \qquad \text{Production Func. of Quality}$$

with two inputs

$$p_I I = E_{\phi(.)}[e(q, z, y)] \qquad \text{Educational Services/Budget Constraint}$$

$$\ln \bar{z} = E_{\phi(.)}[\ln(z)] \qquad \text{Average Student Ability}$$

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Objective: Taking tuition schedule $e(q,z,y)$ and p_I as given, college chooses

- density $\phi(z,y)$ = composition of student body
- educational services I

to solve $\max_{I,\bar{z},\phi(.)} q$

s.t. sequential positioning rule + size constraint Positioning

The Model (analytical solution)

Equilibrium: Tuition Schedule, Sorting Rule and Law of Motion

Tuition Schedule and Sorting Rule

Proposition

In equilibrium, the tuition schedule is given by

$$e(q, z) = p_{I,t} q^{\frac{1}{\omega_1}} z^{-\frac{\omega_2}{\omega_1}}$$

and the sorting rule by

$$q = K_t y^{\omega_1} z^{\omega_2}$$

with C, K *aggregate variables.* Epple HH K

Sorting Rule: Illustration

Proposition

The sorting rule is given by $q = \tilde{K}_t h^{\omega_1 \lambda} z^{\omega_2}$

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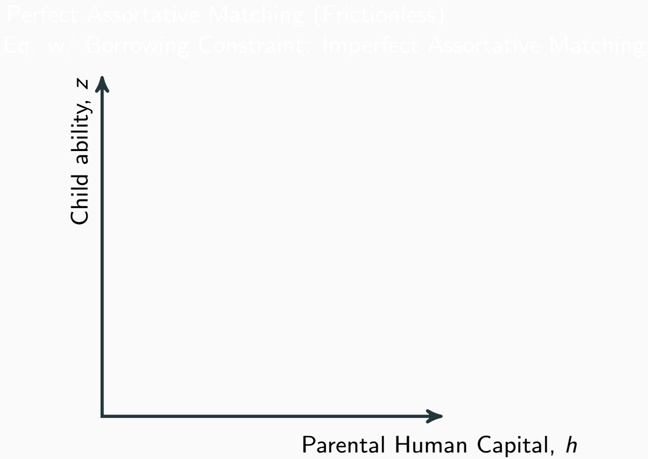

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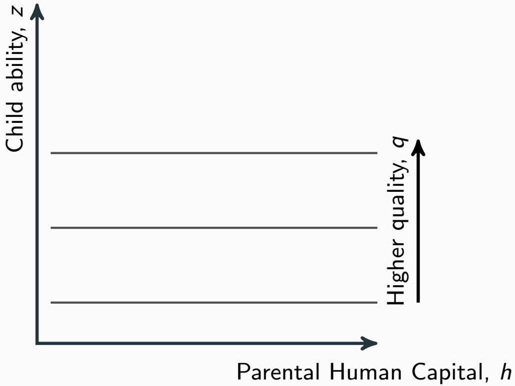
Perfect Assortative Matching (Frictionless)

Eq. w/ Borrowing Constraint: Imperfect Assortative Matching



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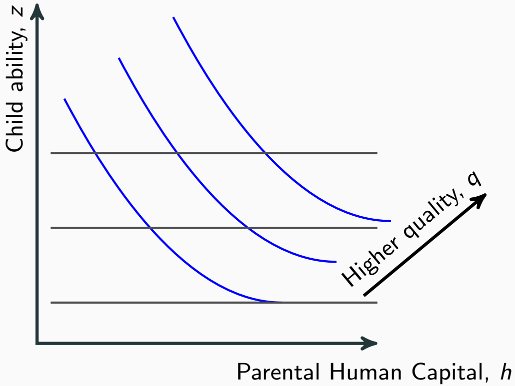

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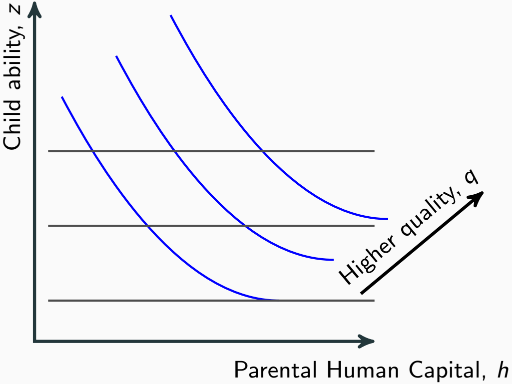

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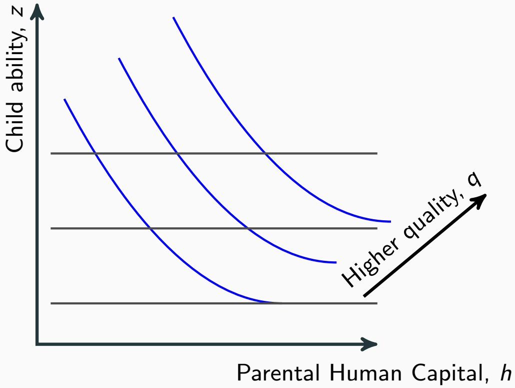

Law of Motion of Human Capital and the Great Gatsby Curve

Intergenerational Transmission of Status

$$h' = \xi_y \underbrace{(\xi_b h)^{\alpha_1}}_{z} \left(\underbrace{\tilde{K}_t h^{\omega_1 \lambda} z^{\omega_2}}_{q} \right)^{\alpha_2}$$

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with α_h the intergenerational elasticity (IGE)

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Income Inequality

Steady-state variance of (log) labor earnings GGC

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Steady-state variance of (log) labor earnings GGC

$$V[\ln y] = \lambda^2 V[\ln h] = \lambda^2 \frac{\sigma_y^2 + [\alpha_1 (1 + \alpha_2 \omega_2)]^2 \sigma_b^2}{1 - \alpha_h^2}$$

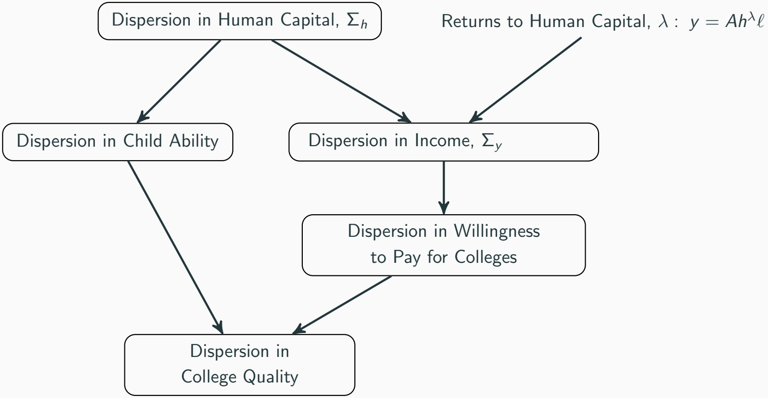
Rationalizing Trends in Higher Education

Comparative Static: Increase in Returns to Human Capital, $\uparrow \lambda$

Proposition

Assume the economy starts from a steady-state at $t = 0$. Consider a weakly increasing sequence $\{\lambda_t\}_0^{+\infty}$.

a) *The Gini coefficient of human capital and income increase.*
b) *The Gini coefficient of colleges' (log) expenditures per student and quality increase.*
c) *The average expenditure for college as a share of income increases.*
d) *The ratio of variance of (log) income within a college over variance of (log) income in economy decreases.*
e) *The intergenerational elasticity increases.*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Returns to Human Capital, $\lambda: \; y = Ah^{\lambda}\ell$
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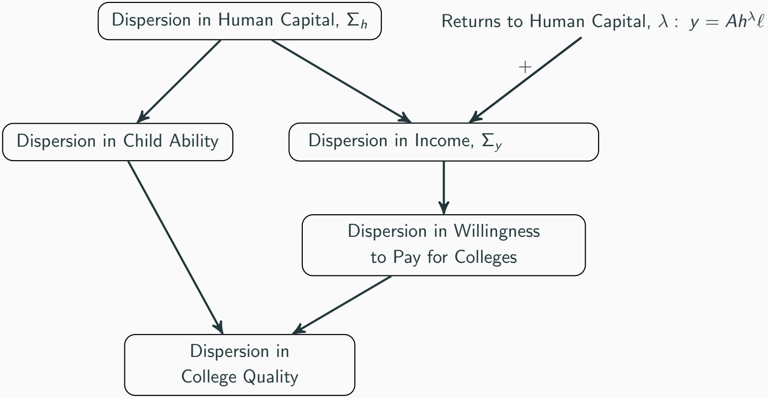
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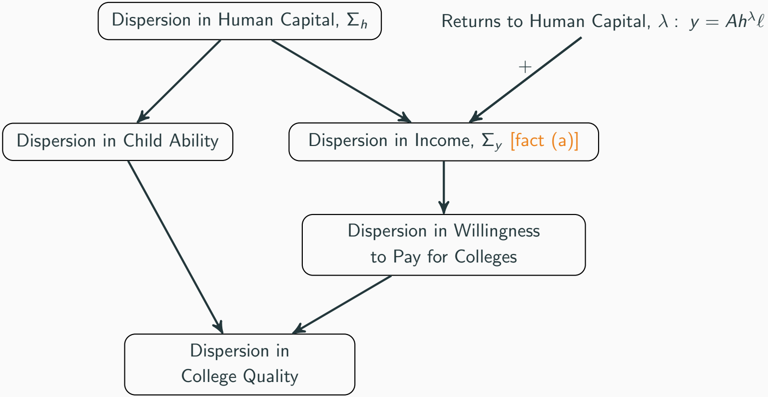

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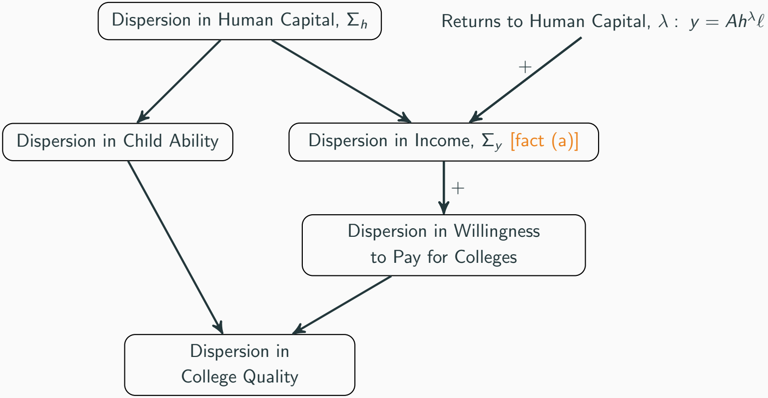
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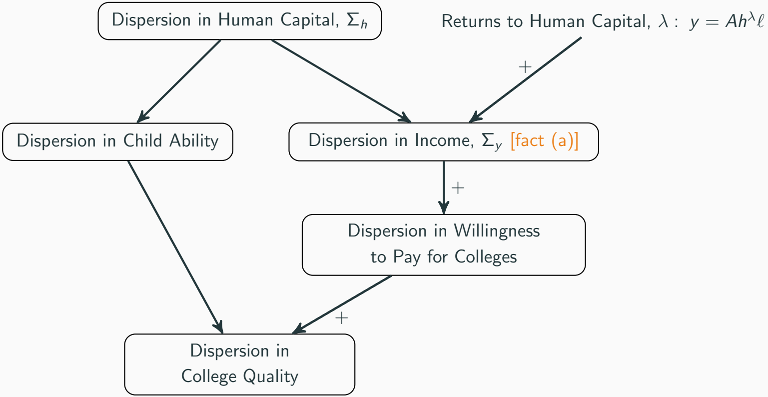

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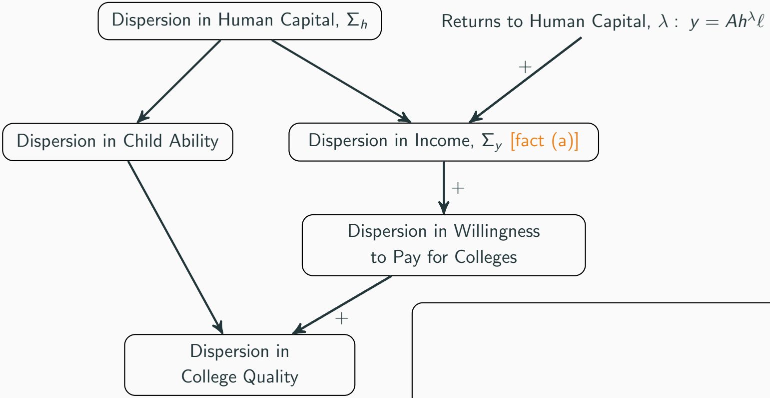
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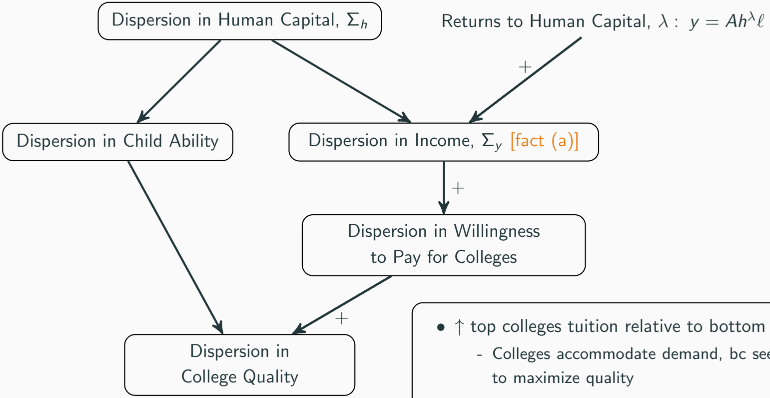
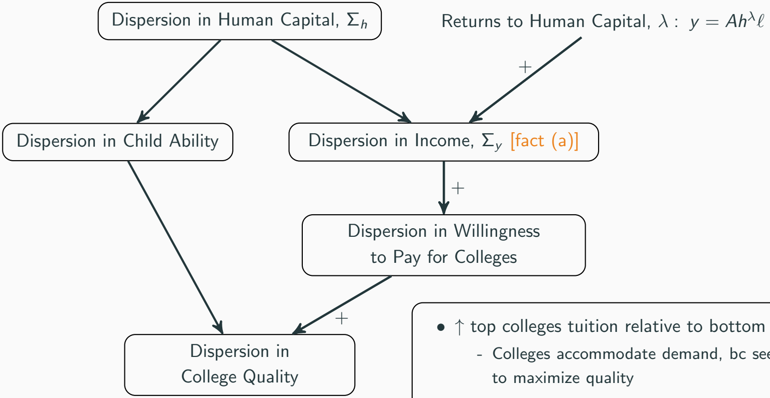


- ↑ top colleges tuition relative to bottom
  - Colleges accommodate demand, bc seek to maximize quality



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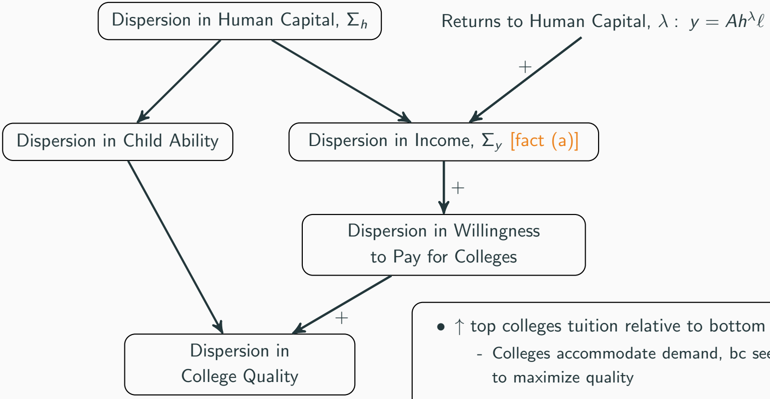
- $\uparrow$ inequality of revenues and spending across colleges [fact (b)]



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  1. ↑ relative tuition at top colleges
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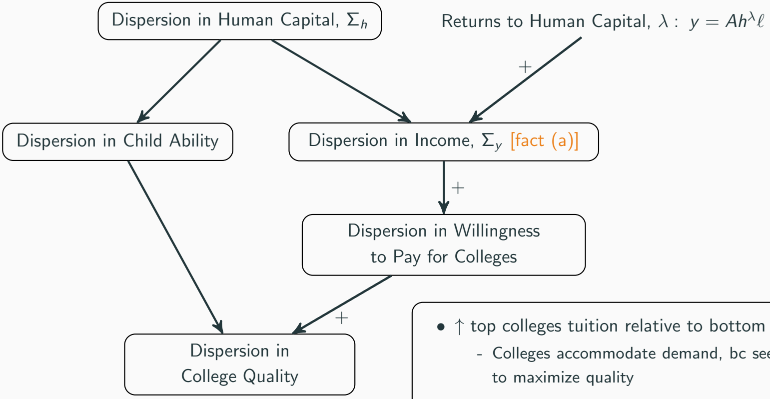

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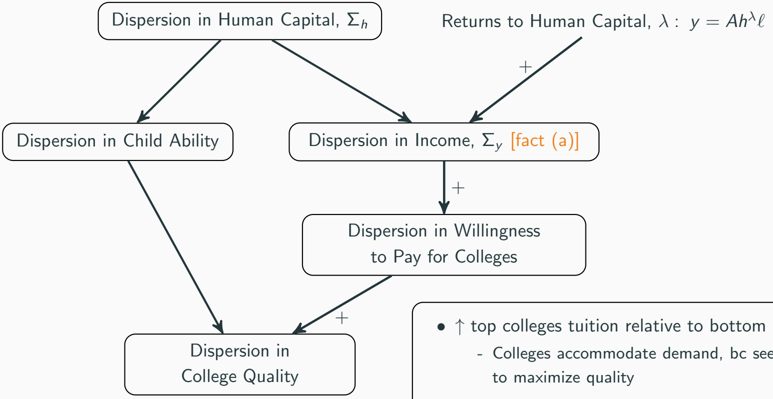

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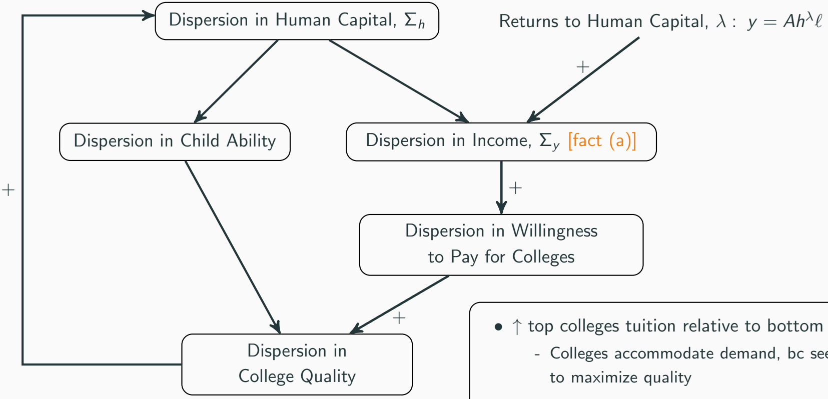
- $\downarrow$ mobility as parental income increasingly determinant [fact (e)]



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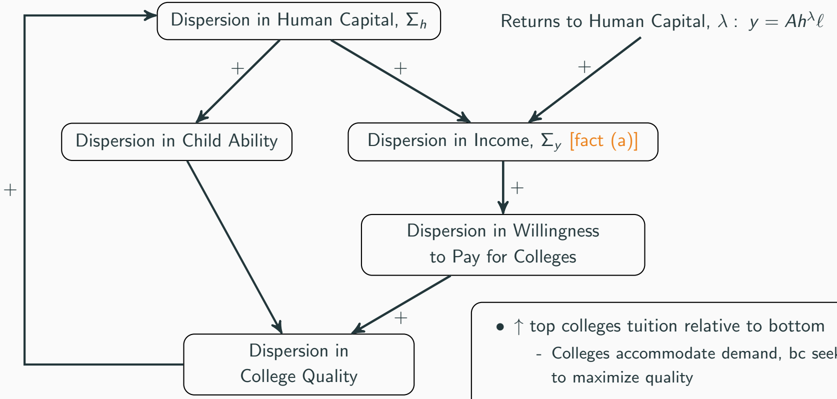

- ↑ top colleges tuition relative to bottom
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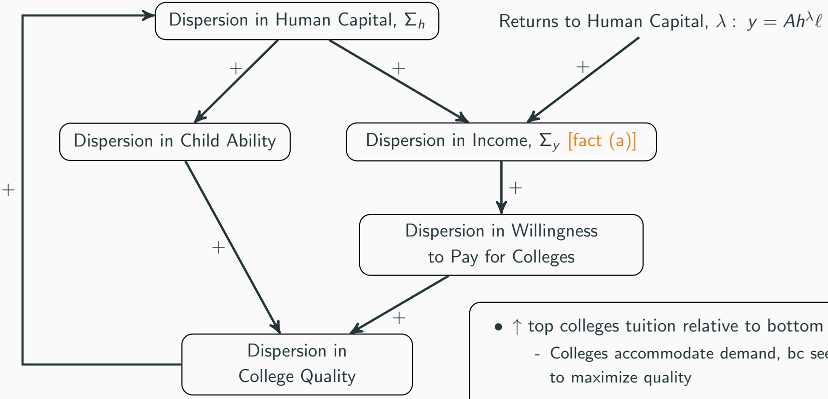

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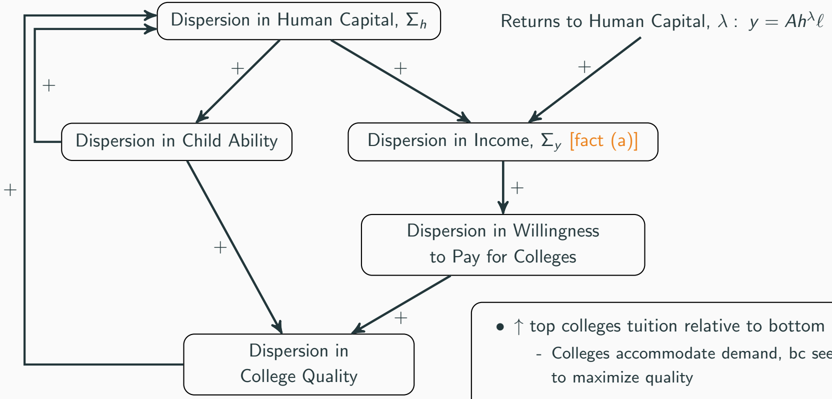

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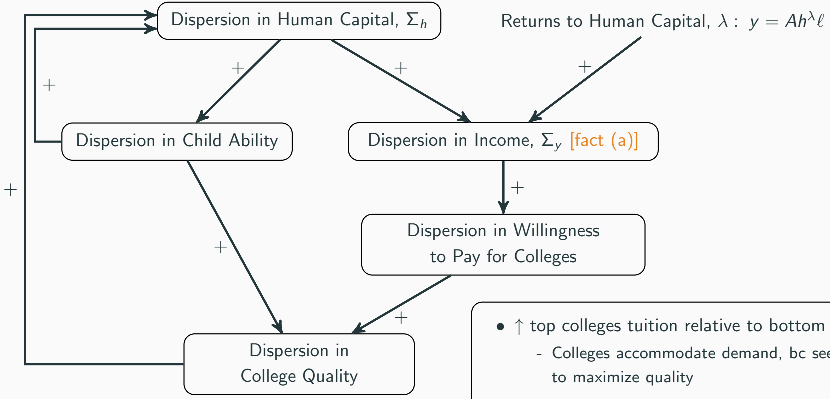

1. Mitigating effect of lower concentration of able students at top colleges

- $\uparrow$ top colleges tuition relative to bottom
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- $\uparrow$ inequality of revenues and spending across colleges [fact (b)]
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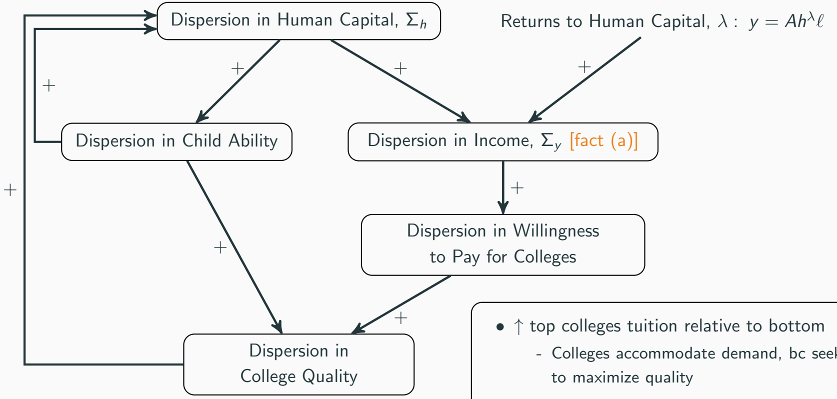

1. Mitigating effect of lower concentration of able students at top colleges
2. ↑ average tuition fees because overall demand for education ↑ [fact (c)]

- ↑ top colleges tuition relative to bottom
  - Colleges accommodate demand, bc seek to maximize quality
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Quantitative Analysis: Policy Experiments

Extension - Data - Strategy

- Extension More
  - tax and transfers
    1. Progressive income tax
    2. Government need and merit-based student aid
    3. Progressive subsidies to university
    4. Need-based aid by colleges (social objective)
  - allows for some intergenerational transfers of wealth
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- Data used in calibration More
  - NLSY97
  - NCES-NPSAS (student-level tuition and financial aid),
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- Method of moments: combine cross sectional and aggregate moments. More

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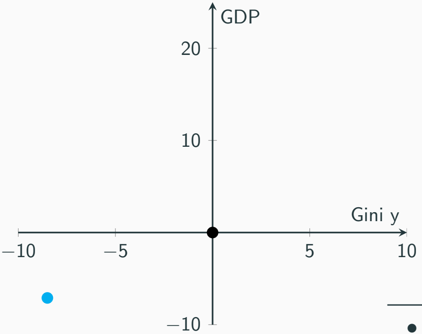
Policy Experiments: GDP and Inequality

IGE-Gini   Coll for All   More

	Peers	Spending
• *Status-Quo*		
Policy		
Random Admission		
Equal Resources		
Laissez-faire		

P-PAM=Perfect Positive Assortative Matching

Policy Experiments: GDP and Inequality



IGE-Gini | Coll for All | More

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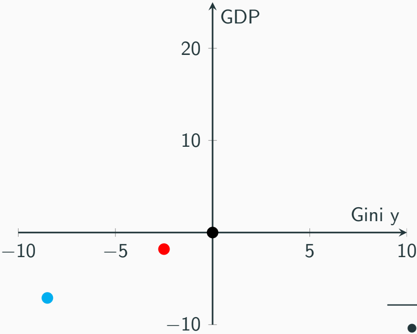

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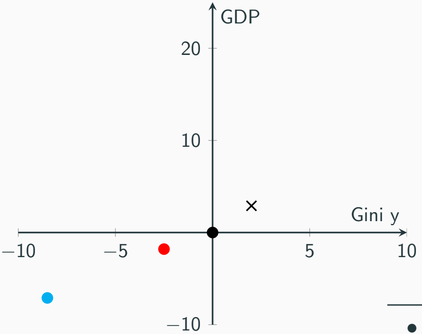

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Conclusion

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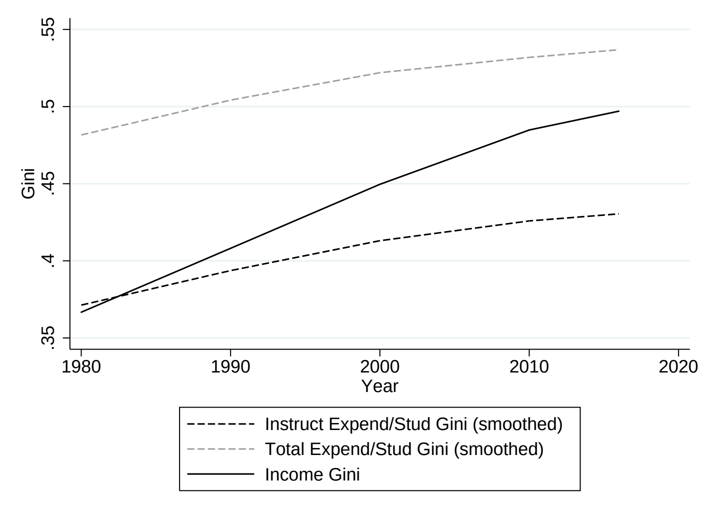
Future

- Donations and endowments income
- University research

Thank you very much!

Gini of Annual Income and Expend. per Students



Back

Households

A dynasty solves:

$$\mathcal{U}(h, z) = \max_{c,\ell,q} \left\{ \ln c - \ell^{\eta} + \beta E\left[\mathcal{U}(h', z')\right] \right\}$$

$$y = c(1 + a_c) + \underbrace{e(q, z, y)}_{\text{Tuition Payment}} \qquad \underbrace{\text{Life-time Budget Constraint}}$$

- Intergenerational Borrowing Constraint

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$$y_m = Ah^{\lambda}\ell \qquad \text{Market Income}$$

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After College Child's Human Capital

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$$\xi_b, \xi_y \sim \text{Log-normal} \qquad \text{Birth and Labor Market Shocks}$$

Back

Borrowing Constraints

1. Evidence borrowing constraints
   - Evidence that borrowing constraints matter for college choices (extensive & intensive margins) Carneiro and Heckman [2002], Belley and Lochner [2007], Lochner and Monge-Naranjo [2011], Brown et al. [2012] and Johnson [2012]
   - Disagreement in the exact number of students at the constraint, studies are hard to compare
2. In this model: an exogenous borrowing constraint
   - Closed-form model rules out net financial transfers across generations
   - Quanti. version partially relaxes: an exogenous debt limit
   - No Default ($\sim 5, 10\%$ but true default much lower)
3. Discussion of assumption Back
   - Government Student Loans have upper limit (but also function of college costs, making an exogenous constraint not stringent enough)
   - Private Loans (20% of all dollar loans) is function of collateral, including expected earnings (which respond endogenously)

Constant saving rate

Quintile population	1st	2nd	3rd	4th	5th
Share in consumption	4.3	1.76	1.62	1.90	3.1
Share in income	4.3	1.76	1.44	1.57	2.38

Table 1: Share of Education Spending

Note: Cleveland Fed, CPS and Dynan et al. (2004) for saving rates by quintiles and author's calculations.

Imperfect vs perfect competition tuitions

1. Epple (2015)
   - Technology $q = I^{\omega_1} \bar{z}^{\omega_2}$
   - Taste shocks create imperfect substituability across colleges
   - Market Power creates rents that are increasing in household income

$$e(I, z, y) = (1-\mu)\left[p^I I + \frac{\omega_2 I}{\omega_1 \bar{z}}(\bar{z} - z)\right] + \mu y$$

   with μ increasing in degree of market power.

2. This paper
   - Technology $q = I^{\omega_1} \bar{z}^{\omega_2}$
   - Social objective, $\ln \mathcal{V} = \ln q - \omega_3 \ln \bar{Y}$

$$e(I, z, y) = p^I I \left(\frac{z}{\bar{z}}\right)^{-\frac{\omega_2}{\omega_1}} \left(\frac{y}{\bar{Y}}\right)^{\frac{\omega_3}{\omega_1}}$$

   - If $\omega_3 = 0 \Rightarrow$ tuition indep. of y (as in Cai et Heathcote, 2019).

Back e(.) w/o Gov. Back e(.) w/ Gov.

What is K in $q = K_t y^{\omega_1} z^{\omega_2}$?

$$q = K_t y^{\omega_1} z^{\omega_2}$$
$$\text{with} \quad K_t = \left(\frac{s_t}{p_{I,t}}\right)^{\omega_1}$$

Back More on s

What is K in $q = \tilde{K}_t h^{\lambda\omega_1} z^{\omega_2}$?

$$q = \tilde{K}_t h^{\lambda\omega_1} z^{\omega_2}$$

$$\text{with} \quad \tilde{K}_t = \left(A\ell_t \frac{s_t}{p_{I,t}} \right)^{\omega_1}$$

Back More on s

Tuition Schedule in General

Proposition

Denoting by Σ_h the equilibrium standard deviation of (log) human capital in the economy, the equilibrium before-financial-aid tuition schedule is given by

$$e_{u,t}(q,z,y) = \left(\frac{p_{I,t}}{(1+a_{u,t})T_{u,t}} q^{\frac{1}{\epsilon_{1,t}}} z^{-\frac{\epsilon_{2,t}}{\epsilon_{1,t}}} \left(\frac{y}{\kappa_{2,t}}\right)^{\frac{\epsilon_{3,t}}{\epsilon_{1,t}}} \right)^{\frac{1}{1-\tau_{u,t}}}$$

$$\textit{where} \quad \epsilon_{k,t} = \frac{\omega_k}{1-\nu_t(\Sigma_{h,t})\omega_3} \quad \forall\, k = 1,2,3$$

with $\nu_t(\Sigma_t)$ the elasticity of within-college mean income to q

$$\bar{Y}(q) = \kappa_{2,t} q^{\nu_t(\Sigma_{h,t})}$$

$$\nu_t = \frac{1}{\left[\Sigma_{h,t}^{-2}\left(\frac{\omega_2}{\omega_h+\omega_2}\right)^2 \sigma_y^2 f + 1\right]\left[(\omega_1(1-\tau^s)-\omega_3) + \frac{\omega_2}{(1-\tau_y)\lambda}\right] + \omega_3}$$

and all colleges are indifferent between all types.

Back Gov. HHwPol Epple

Sorting Rule in General

Proposition

In equilibrium, the sorting rule is given by

$$q_t = \left(\frac{s_t y_t^{1-\tau_{n,t}} h_{s,t}^{\tau_{m,t}} (1 + a_{h,t})}{T_{e,t}} \right)^{\epsilon_{1,t}(1-\tau_{u,t})} \left(\frac{(1 + a_{u,t}) T_{u,t}}{p_{I,t}} \right)^{\epsilon_{1,t}} h_{s,t}^{\epsilon_{2,t}} \left(\frac{y_t}{\kappa_{2,t}} \right)^{-\epsilon_{3,t}}$$

In the special case without government policy, it writes

$$q_t = y_t^{\epsilon_{1,t} - \epsilon_{3,t}} h_{s,t}^{\epsilon_{2,t}} \left(\frac{s_t}{p_{I,t}} \right)^{\epsilon_{1,t}} \kappa_{2,t}^{\epsilon_{3,t}}$$

Back Gov. HHwPol

Households Policy Functions in General

Proposition

Defining $U = \frac{\partial \ln \mathcal{U}}{\partial \ln h}$*, the elasticity of the value function to human capital, one has that, in equilibrium, for all* i*, the households' saving rate, labor supply and marginal value of human capital* U *are given by:*

$$s_t = \frac{\beta \alpha_2 \epsilon_{1,t}(1-\tau_{u,t})U_{t+1}}{1-\beta+\beta\alpha_2\epsilon_{1,t}(1-\tau_{u,t})U_{t+1}} \tag{1}$$

$$\ell_t = \left[(1-\tau_{y,t})\frac{\mu}{\eta}\left(1+\frac{\beta}{1-\beta}\alpha_2\left(\epsilon_{1,t}(1-\tau_{u,t})(1-\tau_{n,t})-\epsilon_{3,t}\right)U_{t+1}\right)\right] \tag{2}$$

$$\textit{with} \quad U_t = (1-\beta)\sum_{k=0}^{\infty}\beta^k(1-\tau_{y,t+k})\lambda_{t+k}\prod_{m=0}^{k-1}\alpha_{h,t+m}\left(\Sigma_{h,t+m}\right) \tag{3}$$

$$\textit{and} \quad \alpha_{h,t} = \alpha_1+\alpha_3+\alpha_2\left[\epsilon_{A,t}\left(\Sigma_{h,t}\right)+\epsilon_{I,t}\left(\Sigma_{h,t}\right)\right]$$

Back Back Gov.

Households policy functions

Proposition

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$$\ell_t = \left[\frac{1}{\eta} \left(1 + \frac{\beta}{1-\beta} \alpha_2 \omega_1 U_{t+1} \right) \right]^{\frac{1}{\eta}} \tag{5}$$

$$\textit{with} \quad U_t = (1-\beta) \sum_{k=0}^{\infty} \beta^k \lambda_{t+k} \prod_{m=0}^{k-1} \alpha_{h,t+m} \tag{6}$$

$$\textit{and} \quad \alpha_{h,t} = \alpha_1 + \alpha_2 \left[\omega_2 + \omega_1 \lambda_t \right]$$

Back Back Graph

Government Budget Constraints

$$\int_0^1 (y)^{1-\tau_y} (\tilde{Y})^{\tau_y} dF(y) = \int y dF(y)$$

$$\int \left(\frac{y}{\tilde{\tilde{Y}}_t} \right)^{\tau_t^s} e(q, y, z) dF(y, z) = \int e(q, y, z) dF(y, z)$$

$$\int [a_y y + a^c c + e(q, y, z)] dF(y, z)$$

$$= \int e(q, y, z)(1 + a_u)(1 + a_h) dF(y, z)$$

Back

Positioning Game

- Colleges play a positioning game on the line of qualities
  - Taking the position of all other colleges as given and distribution of demand over qualities by students
  - They sequentially choose which quality to offer
  - Order is arbitrary and inconsequential
  - Size constraint: cardinality of set of students no less than $\aleph_1$
  - Payoff for operating a given quality is q, non-operating is 0
- SPNE: mapping from set of colleges to set of qualities s.t. given positioning of other colleges, no college wants to change position
- Ensures that all positive qualities are offered in equilibrium
  - Non-operating payoff 0 implies lowest qualities offered is $q = 0$
  - Size assumption $c = 1 > 0$ ensures that colleges do not agglomerate at the highest quality level
  - Otherwise would operate with an infinitely small mass of students
- Positioning game + quality-max $\iff$ free-entry + profit-max
- Difference: non-equalization of payoffs Back Back eq.

Equilibrium

1. An equilibrium
   - Given prices, HH choose college quality, consumption and labor
   - Given prices, colleges choose composition of students body ϕ, expenditures I, and location on the line of qualities Positioning
   - Higher education markets and goods' market clear

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     - Colleges are indifferent between all student types (interior F.O.C.)

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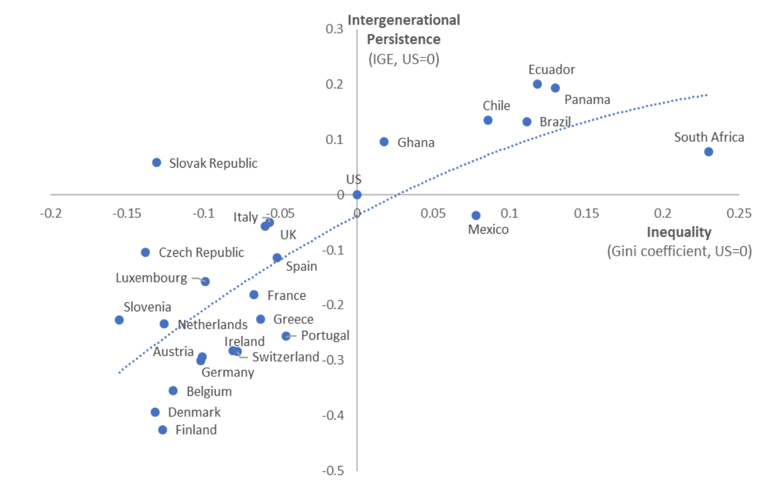
     - Initial distribution of human capital is log-normal
     - Colleges are indifferent between all student types (interior F.O.C.)
   - Steady-state is globally stable

Back

The Great Gatsby Curve



Source: Equalchances.org, own calculations Back LoM Back Preview Findings

Extension with Student Debt and Enrollment Decision

- Allow for intergenerational transfers a' (student loan if $a' < 0$)

Discussion

$$y + (1+r)a = c(1 + a^c) + e(q, y, z) + a'$$
$$a' \geq \underline{a}$$

Extension with Student Debt and Enrollment Decision

- Allow for intergenerational transfers a' (student loan if $a' < 0$)

Discussion

$$y + (1+r)a = c(1 + a^c) + e(q, y, z) + a'$$
$$a' \geq \underline{a}$$

- Allow for outside option of not going to college $\underline{q}$

$$e(\underline{q}, y, z) = 0 \quad \forall\, (z, y)$$

Back

Data - Parameters - Strategy

1. Data
   - NLSY97: panel of 12-17yo in 1997, followed up to now
   - NCES-NPSAS: student-level tuition and financial aid data
   - NCES-IPEDS: college-year-level data (universe)

Data - Parameters - Strategy

1. Data
   - NLSY97: panel of 12-17yo in 1997, followed up to now
   - NCES-NPSAS: student-level tuition and financial aid data
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2. Parameters
   - Human Capital production function $\alpha_1, \alpha_2, \alpha_3$
   - Production function of college quality: $\omega_1, \omega_2, \omega_3$
   - Government policy parameters: $\tau_y, \tau_u, \tau_n, \tau_m, a_u, a_h, a_y$
   - Variance of birth and labor market shocks: σ_b^2, σ_y^2
   - Return to human capital and misc. parameters: $\lambda, \eta, A, \kappa, r, \underline{q}, \underline{a}$

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Estimation - Identification

1. External Parameters, $\eta = 6, \tau_y = .23$

Param.	Description	Value	Sources
η	(Inv.) elast. labor	6	**??**
τ_y	Inc. Tax Slope	.23	Gouveia et al. (1994), Heathcote et al. (2016), own comp.

More on η

Estimation - Identification

1. External Parameters, $\eta = 6, \tau_y = .23$

Param.	Description	Value	Sources
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τ_y	Inc. Tax Slope	.23	Gouveia et al. (1994), Heathcote et al. (2016), own comp.

$$\log(\text{Disp. Income}_i) = c + (1 - \underbrace{\tau_y}_{=.23})\log(\text{Pre-government Income}_i)$$

Plot from Heathcote et al.

Estimation - Identification

1. External Parameters, $\eta = 6, \tau_y = .23$
2. Subsidies to Colleges, $\tau_u = .35$

$$\log\left[\text{College Revenue}_j\right] = c + (1 - \underbrace{\tau_u}_{=.35}) \log\left[\text{College Revenue Before Subs}_j\right]$$

Figure 1: (log) Revenues Before & After Government Subsidies

Estimation - Identification

1. External Parameters, $\eta = 6, \tau_y = .23$
2. Subsidies to Colleges, $\tau_u = .35$
3. Fin. Aid and Tuition Schedule, $\tau_m = .07, \tau_n = .197, \omega_3 = 0$

- Government Financial Aid Parameters

$$\log\left[\frac{\text{After Gov. Aid Tuition}_{i,j}}{\text{Before Gov. Aid Tuition}_{i,j}}\right] = \underbrace{\tau_n}_{=.197} \log y_i - \underbrace{\tau_m}_{.07} \log h_{s,i} + c_0$$

- Social Objective Parameter/Need-based Institutional Aid

$$\log\left[\text{Before Gov. Aid Tuition}_{i,j}\right] = \gamma_j + \ldots$$
$$\left(\underbrace{\frac{\omega_3}{\omega_1}}_{=0}(1-\tau_u) + \tau_n\right)\log y_i - \left(\frac{\omega_2}{\omega_1(1-\tau_u)} + \tau_m\right)\log h_{s,i}$$

- γ_j are college fixed effects, $R^2 = 80\%$

Estimation - Identification

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3. Fin. Aid and Tuition Schedule, $\tau_m = .07, \tau_n = .197, \omega_3 = 0$
4. Sorting Rule, $\omega_2 = .84$

$$\log q_i = c + \beta_1 \log y + \beta_2 \log z + \epsilon_i$$

- In closed-form model

$$\log q_i = c + h(\Sigma_h)\left[\left((1-\tau_u)(1-\tau_n) - \frac{\omega_3}{\omega_1} \right) \log y_i + \left(\underbrace{\frac{\omega_2}{\omega_1}}_{=.84} + \tau_m(1-\tau_u) \right) \log h_{s,i} \right]$$

- Construct college quality, q_i, from IPEDS (and a guess on $\frac{\omega_2}{\omega_1}$).
  - IPEDS gives expend./student and median student ability
- $R^2 = 23\%$ (No residual in the model)

Estimation - Identification

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2. Subsidies to Colleges, $\tau_u = .35$
3. Fin. Aid and Tuition Schedule, $\tau_m = .07, \tau_n = .197, \omega_3 = 0$
4. Sorting Rule, $\omega_2 = .84$
5. Human Capital Production Function, $\alpha_2 = .3, \alpha_3 = .2, \lambda = .5$

    - α_2 is set to match micro-estimates of returns to quality
        - Black and Smith (2004), Zimmerman (2014), Bleemer (2019) Details
    - λ and α_3 are estimated with constrained-OLS

$$\ln y'_{m,i} = c + \underbrace{\lambda}_{.5} \ln h_{s,i} + \underbrace{\alpha_2}_{.3} \omega_1 \lambda \ln q_i + \underbrace{\alpha_3}_{.2} \ln y_{m,i} + \ln \xi_{y,i}$$

Alter. for λ

Estimation - Identification

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4. Sorting Rule, $\omega_2 = .84$
5. Human Capital Production Function, $\alpha_2 = .3, \alpha_3 = .2, \lambda = .5$
6. InterGenerational Elasticity, $\alpha_1 = .2$

$$\ln y'_{m,i} = c + \alpha_h \ln y_{m,i} + \epsilon_i$$

- In closed-form version model

$$\alpha_h = \underbrace{\alpha_1}_{=.2} + \alpha_3 + \alpha_2 \left(\epsilon_A + \epsilon_I\right)$$

- Disagreement in literature about IGE: $\alpha_h \in [.37, .55]$ [??]
  - Life-cycle bias in NLSY, $\alpha_h = .35$
  - Target $\alpha_h = .4$

Estim. Variances

Estimating Variance Parameters

1. Transmission of Abilities Regression, get $\sigma_b^2 = 7$

$$h_{s,i} = (\xi_{b,i} h_i)^{\alpha_1}$$

   - In NLSY, observe parental income $y_{m,i}$ and rank($h_{s,i}$) (test score)
   - For a given (α_1, λ), $\exists!$ σ_b^2 that matches $\rho(y_{m,i}, rank(h_{s,i}))$
   - For next step, generate $\{h_{s,i}\}$ consistent with $(\alpha_1, \lambda, \sigma_b^2)$ and rank($h_{s,i}$)

2. Income Inequality, $\sigma_y^2 = .74$
   - Assume steady-state
   - Target Income Gini = .45 [**?**]

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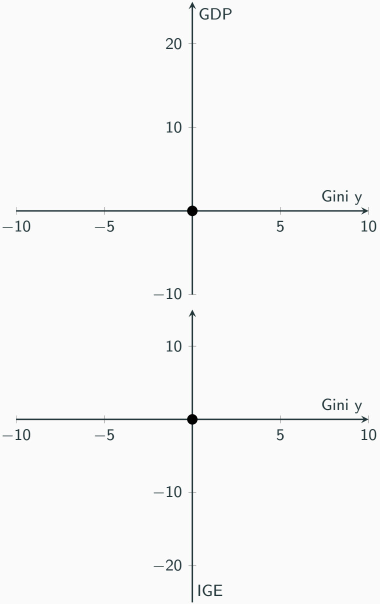
Calibration and Estimation Results

Parameter	Description	Value		Target/Source	Moments		
		M1	M2		Data	M1	M2
η	(Inv.) elast. labor	6	*id.*	?, Own Comput.			
τ_y	Income Tax Slope	.23	*id.*	?, Own Comput.			
a_u	Av. Transfer to College	.4	*id.*	Av. Transfer to College	.4	.4	*id.*
a_y	Av. Income Tax Rate	.2	*id.*	Av. Income Tax Rate	.2	.2	*id.*
a_h	Av. Financial Aid	.2	*id.*	Av. Financial Aid	.1	.1	*id.*
τ_u	Elas. Transfers to Coll.	.35	*id.*	Elas. Transfers to Coll. [?]	.35	.35	*id.*
$\underline{a}$	Borrowing Limit	(0)	.03	Borrowing Limit	.03	(0)	.03
τ_n	Elas. Gov. Fin. Aid to y	.195	*id.*	Elas. Gov. Fin. Aid to y_m	.195	.195	*id.*
τ_m	Elas. Gov. Financial Aid to z	.07	*id.*	Elas. Gov. Financial Aid to z	.07	.07	*id.*
ω_3	Social Obj. Param. of Coll.	0	*id.*	Elas. Tuition to y	.13	.13	*id.*
ω_2	Elas. q to Average Ability	.84		Elas. q to z in sorting rule	.94	.94	.96
ω_1	Elas. q to I	1	*id.*	Normalization	-	-	
α_1	Elas. h' to z	.21	*id.*	InterGen. Elas. [?]	.5	.5	*id.*
α_2	Elas. h' to q	.2	*id.*	Elas. y_m' to q	.13	.13	*id.*
α_3	Elas. h' to h	.2	*id.*	Elas. y_m' to y_m	.2	.2	*id.*
λ	Return to human capital	.5	*id.*	Elas. y_m' to z	.5	.5	*id.*
σ_y^2	Var. Lab. Mkt. shock	.74	*id.*	Income Gini Coef. [?]	.45	.45	*id.*
σ_b^2	Var. birth shock	6.6	*id.*	$\rho(y_{m,i}, rank(h_{s,i}))$	.43	.43	*id.*
β	Intergen. Preference	.235	.27	% Priv. Spend. High. Ed. in GDP (OECD)	1.3%	1.3%	*id.*
$\underline{q}$	Outside Option	(0)	.0278	Enrollment Rate (NCES)	70%	(100%)	70%
r	Interest Rate	-	3.5%	Elas. q to y in sorting rule	.2	(.4)	.21

Details Non-Targ Mom.

Policy Experiments (IGE and Gini)



•	0	*Status-Quo*
		Policy
	1	Random Admission
	2	Equal Resources
	3	Need-based Aid by Coll.
	4	Laissez-faire
	4a	No Transfer to College
	4b	No Need-based Aid
	4c	No Merit-based Aid
	5	College for All (conservative)
	6	Transfers to College, 1980

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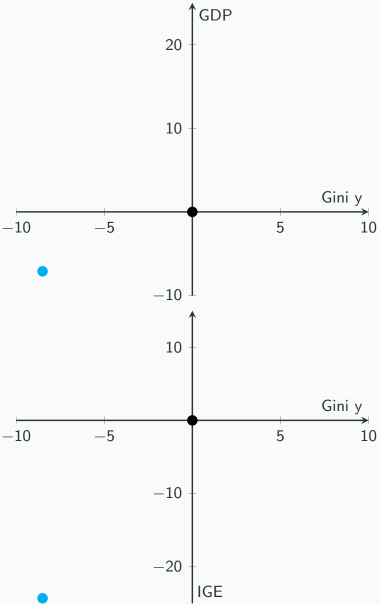

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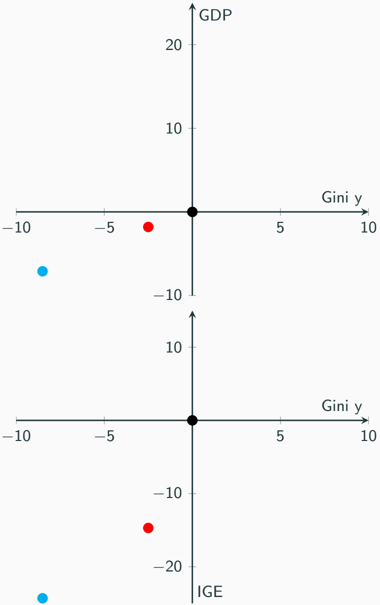

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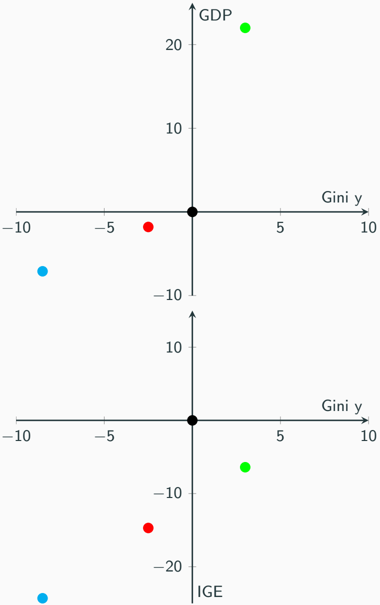

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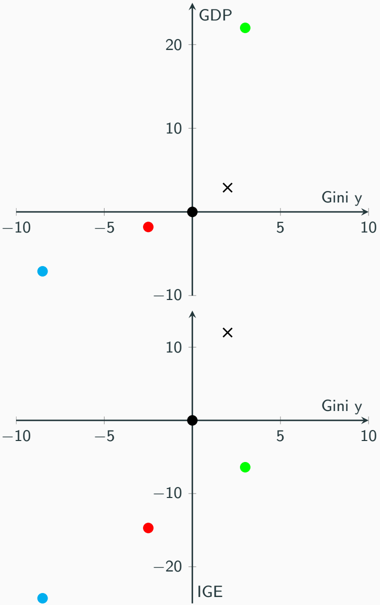

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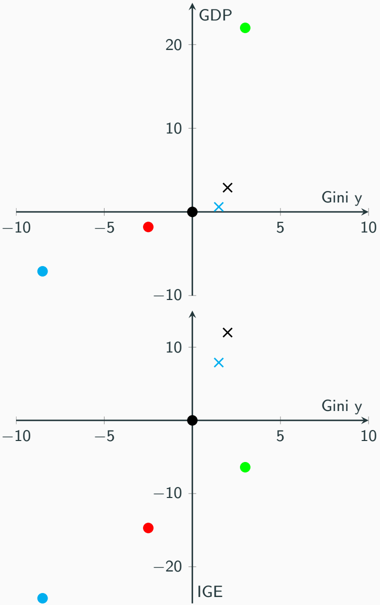

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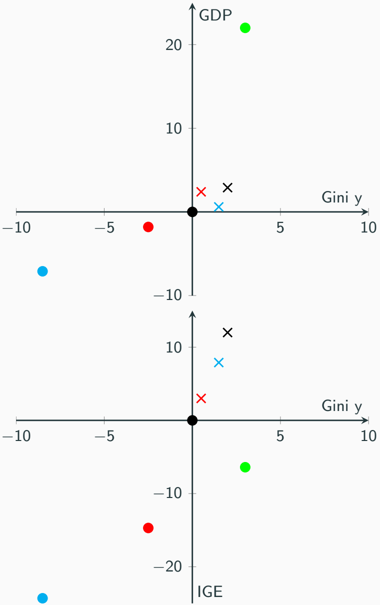

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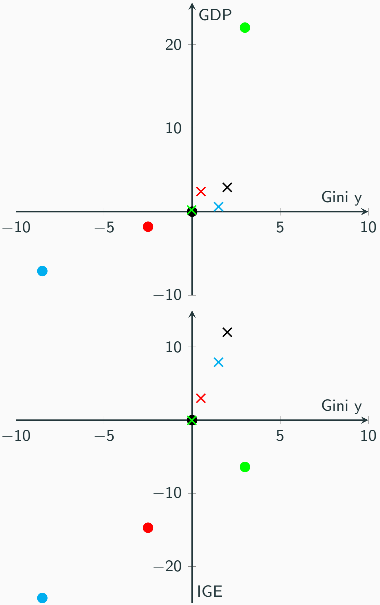

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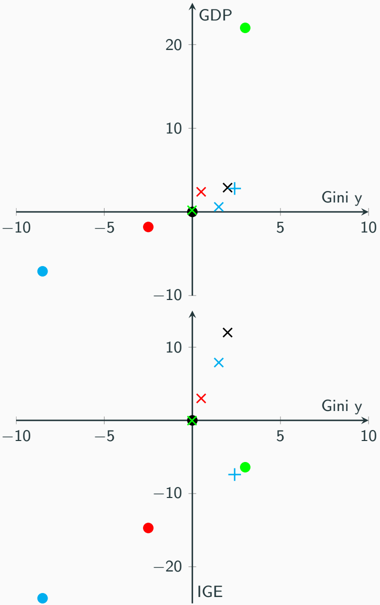

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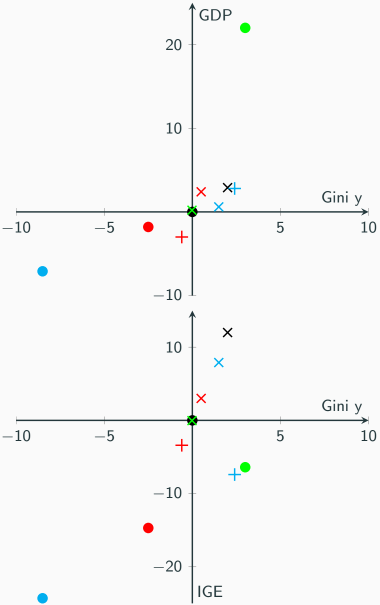

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Rise in Returns to Ed. & Amplification through Higher Ed.

Results 1: The increase in λ accounts for 130% of rise in income Gini and 100% of rise in college spending Gini.

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- What part is due to reallocation of resources *v.s.* reallocation of students?

Results 3: More than 100% of amplification of inequality is coming from endogenous change in spending per student and in tuition. Details Graphs

Counterfactual , details

$$e(q,z,y) = Cp^I q^{\frac{1}{\epsilon_1}} z^{-\frac{\epsilon_2}{\epsilon_1}} (y)^{\frac{\epsilon_3}{\epsilon_1}}$$

$$e(\mathrm{rank}_q, \mathrm{rank}_z, \mathrm{rank}_y) = Cp^I \left(F^{-1}_{q,1980}(rk_q)\right)^{\frac{1}{\epsilon_1}} \left(F^{-1}_{z,1980}(rk_z)\right)^{-\frac{\epsilon_2}{\epsilon_1}} \left(F^{-1}_{y,1980}(rk_y)\right)^{\frac{\epsilon_3}{\epsilon_1}}$$

where $F_{z,1980}(z), F_{y,1980}(y), F_{q,1980}(q)$ denote the marginal CDF of z, y, q and $F^{-1}_{.}(.)$ their respective quantile function and $rk = rank$ is the rank, i.e. the CDF w.r.t. the current distribution.

- Individuals buy a college rank Back
  - Not possible to fix the schedule in terms of q, because endogenous object
- Tuition depends only on their ranks in the distribution
  - If we left tuition as a function of y and z, an increase in income of top 1% would imply increase in tuition

$$\Rightarrow rank_q = F_{q,1980}\left[\left(\frac{sy}{Cp^I}\right)^{\epsilon_1} \left(F^{-1}_{z,1980}(rank(z))\right)^{\epsilon_2} \left(F^{-1}_{y,1980}(rank(y))\right)^{-\epsilon_3}\right]$$

Counterfactual , details

- Compute (counterfactual) transition path to (counterfactual) steady-state where
  - HHs s and ℓ are equal to their value in the final steady-state of the "true" equilibrium.
  - Quality $q = I^{\omega_1}\bar{z}^{\omega_2}$ at a given rank is computed w/ initial I but update average student quality $\bar{z}$

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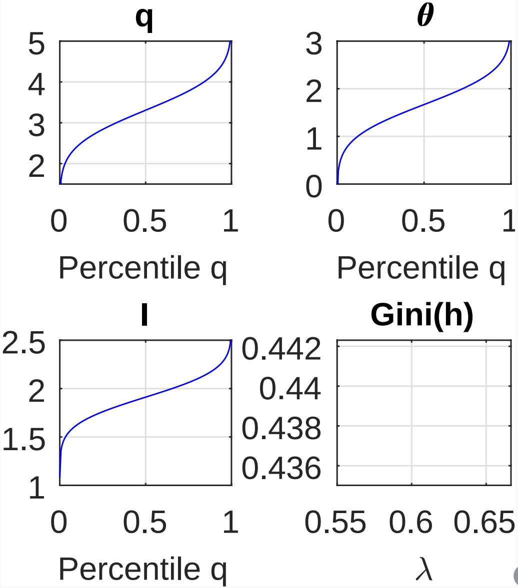
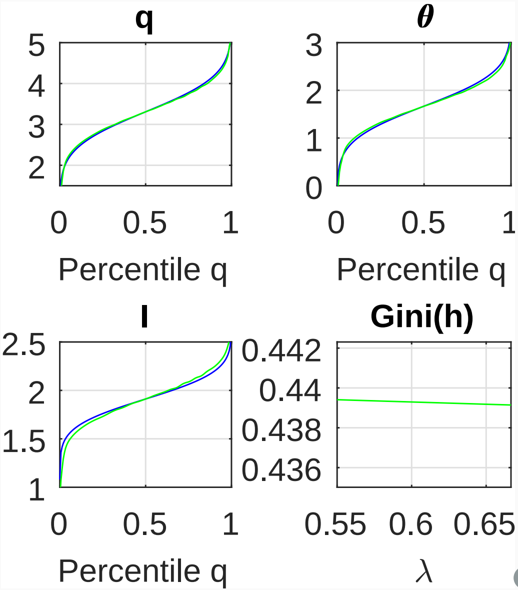
Initial Allocation



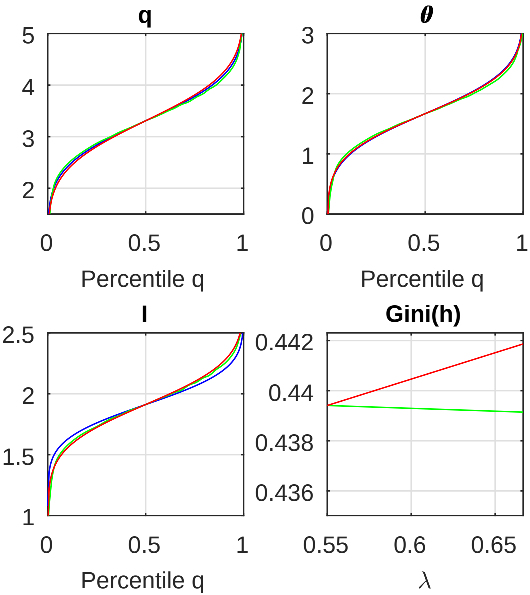
α_h

Initial+Counterfactual Allocation



α_h

Initial+Counterf.+Final Allocation



α_h

Counterfactual allocation

In counterfactual:

- Initial increase in inequality boosts demand by wealthy families for top colleges
- Top colleges have surpluses, bottom colleges have deficits
- Average student quality is flatter with college rank

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From counterfactual to actual equilibrium:

- By budget constraint, adjustment of expenditures per students
- Qualities increase at top, decrease at bottom
- Implies steeper tuition slope with quality rank

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