College Tuition and Income Inequality

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Bristol, March 10, 2021

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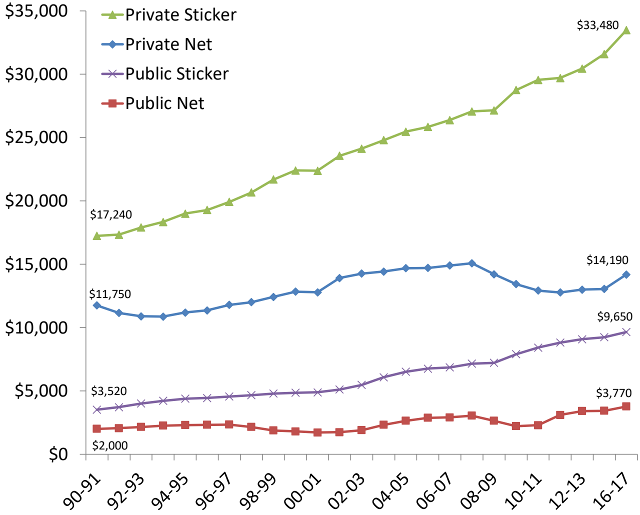
Introduction

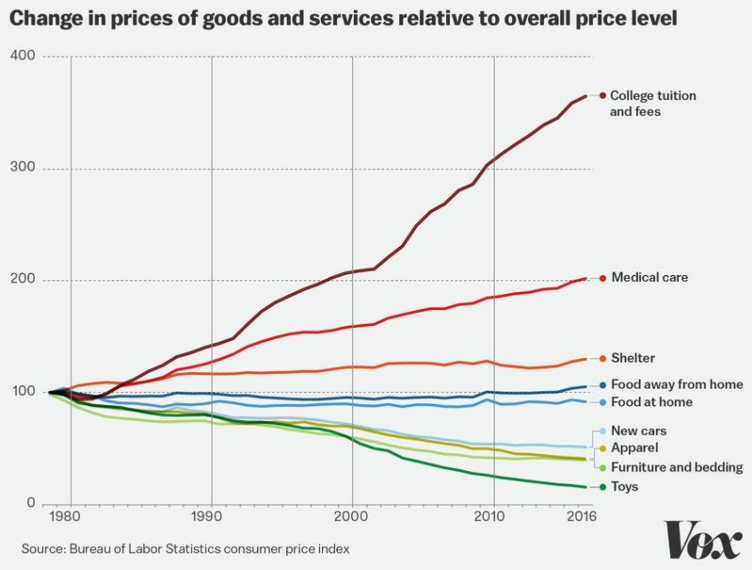
- Tuition at US colleges has risen fast in recent decades
- At the same time, income inequality has been rising

  $\rightarrow$ Concern that smart low income students priced out
- Our Hypothesis: Rising income inequality a key factor driving up tuition
- Logic: College disproportionately demanded by high income households, whose income has grown fast
- Model of the college market required to explore the impact of changing pattern of college demand

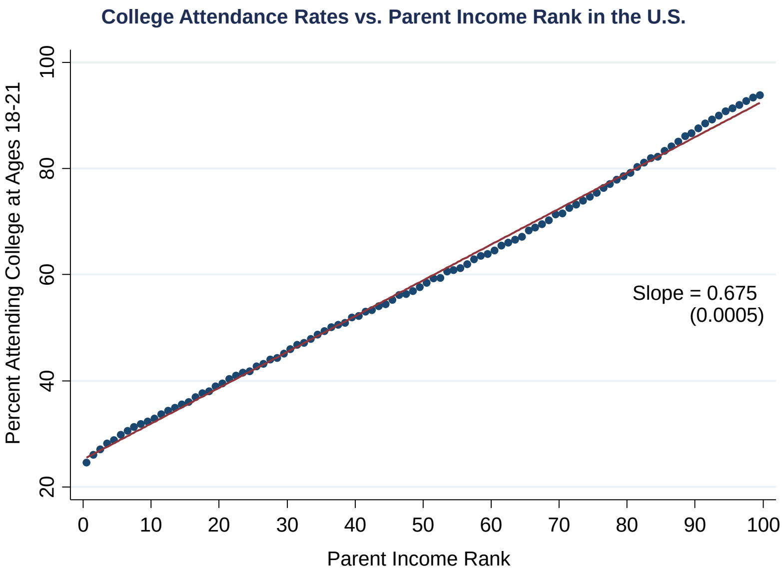
Tuition and Fees (College Board $2016)



BLS Price Indexes

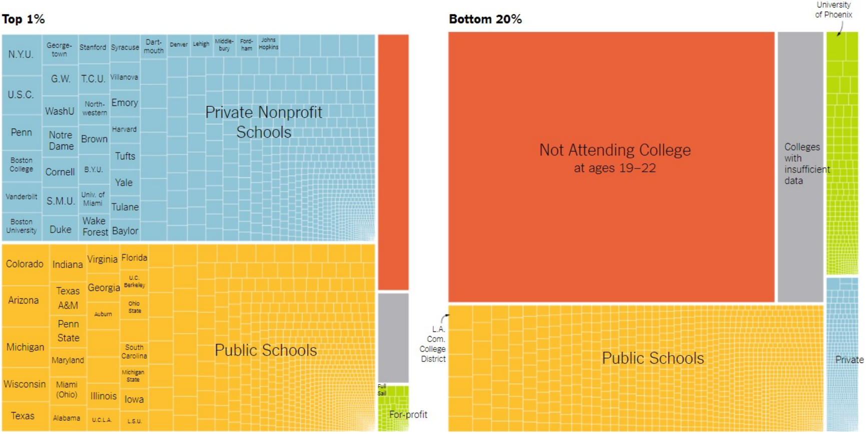


College Attendance by Family Income (Chetty et al.)

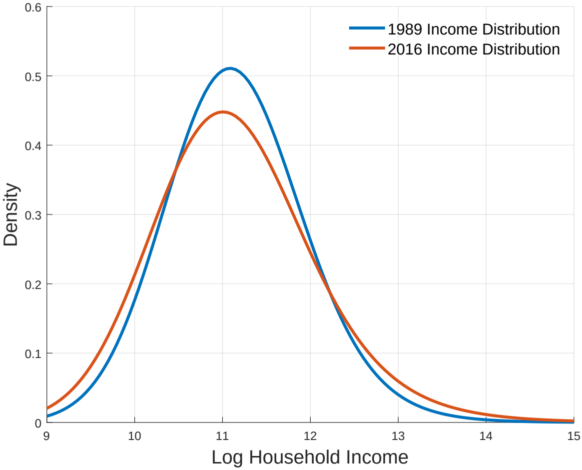


College Quality also Correlated with Income (NYT)

Where the top 1% and the bottom 20% go to college



Estimated EMG Dist. of Log HH Income (SCF)



College Market

- Peers are important
  - Input to learning and skill acquisition
  - Behavioral effects (study habits, drug & alcohol use)
  - Future professional connections
  - Pool for potential spouses
- Thus natural to model college as a “club good”:
  - students are both consumers and inputs to the production of college quality
- Club good feature affects how changes in demand propagate to changes in tuition and enrollment
  - e.g., because desirable potential peers are scarce, changes in demand have larger impact on tuition

Club Good Model

- Households differ by income and student ability, make college choices
- Colleges choose who to admit & resource spending
- College quality increasing in avg. ability of student body
- Allocation through markets $\Rightarrow$ Students and colleges both happy with their choices
- Lots of these consistency / market clearing conditions if lots of household types and lots of different college qualities

Existing Literature

- Existing papers assume small number of colleges
  - Epple & Romano (1998), Epple, Romano & Sieg (2006, 2017), Fu (2016), Gordon & Hedlund (2016)
- Limitations:
  - Counterfactual $\Rightarrow$ applied analysis difficult
  - Equilibrium existence problems (Scotchmer, 1997)
  - Price-taking assumption questionable – game theoretic oligopolistic price setting more natural

Model Innovation

- Continuous distribution of college quality
  - Distribution of college characteristics and prices can be compared to data
  - Quality distribution can change smoothly and flexibly in response to changing drivers of college demand
  - No existence problems
  - Price taking natural
  - No role for lotteries as in Caucutt (1999)

Outline

1. Model description
2. Closed-form special case
3. Calibration and model-data comparison
4. Explore impact of 1990–2016 changes in income inequality
5. Decompose rise in college tuition into roles of changes in:
    - income inequality
    - average income
    - fed. and state aid to students (Pell grants etc.)
    - direct support to colleges
    - cost of instructional inputs

Model: Households

- Continuum of measure 1 of households, each containing a parent and a college-age child
- Heterogeneous wrt:
  1. student ability a
  2. income y
  3. residence status $r \in \{i, o\}$ (in-state tuition discounts)
- Fraction μ_a of ability level a
- Continuous distribution for income, CDF $F_a(y)$

Utility

- Expected utility from non-durable consumption c and enrolling child at college of quality q

$$E\left[u\left(c,q\right)\right]=\log\left(c\right)+\varphi\left\{\gamma_a\log\left(\kappa+q\right)+\left(1-\gamma_a\right)\log\left(\kappa\right)\right\}$$

  - Ability-specific dropout risk γ_a

Household Problem

- Take as given tuition functions $t(q, y, a, r)$
- Solve

$$\max_{c \geq 0, q \in \mathcal{Q}} \mathbb{E}_{|a} \left[u(c, q) \right]$$
$$s.t.$$
$$c + \mathbb{I}_{\{q>0\}} \left[t(q, y, a, r) + \omega - p(y) \right] = y.$$

  - Financial aid (Pell grants etc.)

$$p(y) = p_0 + p_1 \qquad y \leq y^*$$
$$p(y) = p_0 \qquad y > y^*$$

  - Foregone earnings: ω

Alternative Model of College Demand

- Parents care about child's consumption
- Child earnings reflect ability and college quality
- Inter-generational transfers via college or via saving

$$\max_{\{c_1, c_2, s, q \in \mathcal{Q}\}} \{\log(c_1) + \beta \log(q + \kappa) + \delta \log(c_2)\}$$

$$c_1 = y - \mathbb{I}_{\{q>0\}} [t(q, y, a, r) + \omega - p(y)] - s$$

$$c_2 = A(q + \kappa)^{\zeta} a^{\lambda} + \mathbb{I}_{\{s>0\}} R^s s + \mathbb{I}_{\{s<0\}} R^b s$$

- Observationally identical to "consumption" model when R^s small & R^b big, so $s = 0$ for all (y, a, r)

Model: Colleges

- Competitive, profit maximizing (i.e., cost minimizing)
- CRS technology for producing education of a given quality
- Quality (per student) reflects:

  (i) average ability of student body

  (ii) consumption good input (per student) e (faculty etc)

$$q = \left(\sum_a \eta(a) a \right)^{\theta} e^{1-\theta}$$

where $\eta(a)$ is share of student body that is of ability a

- Fixed consumption cost ϕ per student admitted

College Problem

- Take as given $t(q, y, a, r)$ & subsidies per student $s(q, a, r)$
- Let $v(q, a) = \max_{y,r}\{t(q, y, a, r) + s(q, a, r)\}$ denote revenue from most profitable admits of ability a
- Sub-problem for college supplying mass 1 spots at $q > 0$

$$\max_{\{\eta_a\}\geq 0, e\geq 0} \left\{\sum_{a\in A} \eta_a v(q, a) - e - \phi\right\}$$

s.t.

$$q = \left(\sum_a \eta_a a\right)^\theta e^{1-\theta}$$

Equilibrium

$\chi(Q)$: measure of students in colleges with $q \in Q \subset \mathcal{Q}$

Equilibrium is $\{\chi(q),\, t(q,y,a,r),\, \eta_a(q),\, e(q),\, c\&q(y,a,r)\}$ s.t.

1. Given t, q & c solve household's problem
2. Given t, η_a & e solve college problem
3. Zero profits: $\pi(q) \leq 0\ \forall q$, and $\int_Q \pi(q) d\chi(q) = 0\ \forall Q$
4. Goods market clearing
5. College market clearing

$$\mu_a \sum_r \mu_r \int \mathbb{I}_{\{q(y,a,r)\in Q\}} dF_a(y) = \int_Q \eta_a(q) d\chi(q)$$

for all a and Q, where for all y & r and all $q^* \in Q$

$$q(y,a,r) = q^* \Rightarrow (y,r) \in \arg\max \{t(q^*,y,a,r) + s(q^*,y,a,r)\}$$

Equilibrium Tuition Properties

1. Tuition is independent of income
2. Full pass-through of in-state subsidies:
   $t(q,a,o) - t(q,a,i) = s(q,a,i) - s(q,a,o)$
3. Tuition increasing in quality (holding fixed ability):
   $q_2 > q_1 \Rightarrow t(q_2,a,r) > t(q_1,a,r)$
4. Tuition declining in ability (holding fixed quality):
   $a_2 > a_1 \Rightarrow t(q,a_2,r) < t(q,a_1,r)$
5. Tuition linear in ability:
   $t(q,a,r) = b(q,r) - d(q,r)(a - a_{min})$

Equilibrium Properties

1. A competitive equilibrium exists
2. A competitive equilibrium, absent government subsidies, is Pareto efficient

Special Case in Closed Form

- Pure club good model: $\theta = 1$
- Two ability types, (a_h, a_l)

  $\Rightarrow q = \eta a_h + (1-\eta) a_l, \qquad \eta(q) = \frac{q-a_l}{a_h-a_l}$
- $u(c,q) = \log c + \log(\kappa + q)$
- No fixed costs or subsidies: $\phi = \omega = p(y) = s(q,a,r) = 0$
- Uniform income distribution:

$$y \sim U\left[\mu_y - \frac{\Delta_y}{2}, \mu_y + \frac{\Delta_y}{2}\right]$$

$$F_h(y) = F_l(y)$$

- Let $\mu_a = \frac{a_h+a_l}{2}$

The Club Good Model

- College distribution: $\forall Q \subset (a_l, a_h)$

$$\chi(Q) = \frac{2}{a_h - a_l}\left(\frac{2}{4+\pi}\right)\int_Q \left[(1-\eta(q))^2 + \eta(q)^2\right]^{-2} dq$$

$$\chi(a_h) = \chi(a_l) = \frac{2}{4+\pi} = 0.28$$

- Tuition functions:

$$t(q, a_i) = \bar{y}\left(\frac{q - a_i}{\kappa + q}\right)\left[1 - \left(\frac{2}{4+\pi}\right)\frac{\Delta_y}{\mu_y}\arctan(1 - 2\eta(q))\right]$$

1. Distribution of quality independent of $(\mu_y, \Delta_y, \kappa)$
2. Tuition **non-linear** in q
3. Tuition **depends on** Δ_y

Sketch of Solution Method

1. Given any college distribution $\chi(q)$, derive income of households attending q quality college: $y(q, a; \chi(.))$
2. Given $y(q, a; \chi(.))$, household's FOC gives an ODE that pins down the college tuition function: $t(q, a; \chi(.))$

$$\frac{dt(q, a; \chi(.))}{dq} \frac{1}{y(q, a; \chi(.)) - t(q, a; \chi(.))} = \frac{1}{\kappa + q}$$

3. Given $t(q, a; \chi(.))$, derive a college profit function:

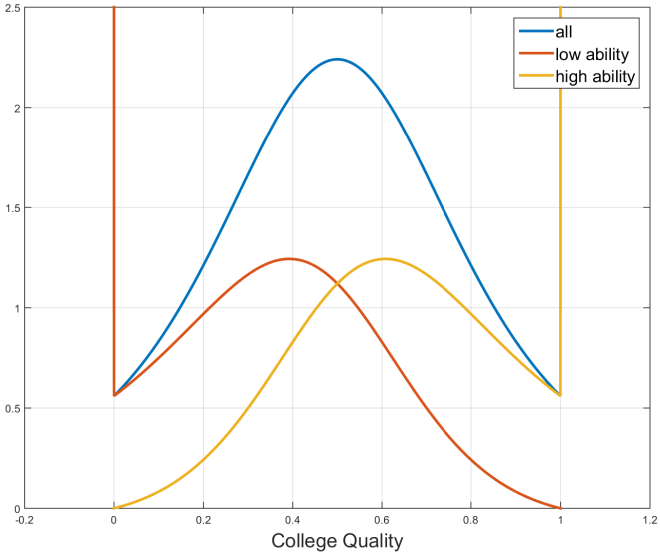
$$\pi(q; \chi(.)) = \eta(q) t(q, a_h; \chi(.)) + (1 - \eta(q)) t(q, a_l; \chi(.))$$

4. Solve for $\chi(q)$ from the functional equation

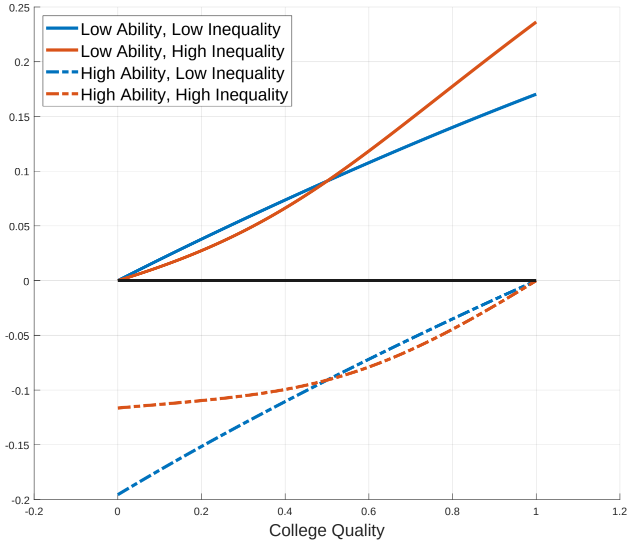
$$\pi(q; \chi(.)) = 0$$

   - This is a Volterra integral equation of the second kind with degenerate kernels, which has an analytical solution

College Distribution



Tuition



0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
Low Ability, Low Inequality
Low Ability, High Inequality
High Ability, Low Inequality
High Ability, High Inequality
College Quality

Quantitative Example: Calibration

- Focus on 4 year non-profit colleges, public & private, 2016-2017
- $a \in \{a_l, a_h\}$, $\mu_{a_l} = \mu_{a_h} = 0.5$
- $\ln y \sim EMG(\mu_y(a), \sigma^2, \alpha)$
- (σ^2, α) estimated from SCF, households aged 40-59
- $\mu_y(a_h) - \mu_y(a_l)$ s.t. $\frac{E[y|a_h]}{E[y|a_l]} = 1.59$
  - (avg. family income given AFQT score above / below median, 1997 NLSY).
- $\gamma_{a_h} = 0.78$, $\gamma_{a_l} = 0.52$ (Hendricks et al., 2018)

Calibration cont.

- κ: Enrollment rate 50.7% $\Rightarrow$ Graduation rate 36.1% (CPS)
- φ: Average net tuition $\$9,250$
- $\omega = \$10,020$: Opportunity cost of work
- $\theta = 0.5$: Peers and goods equally important (sensitivity)
- $a_l/a_h = 0.375$: Avg. institutional aid (unconditional) $\$5,808$
- $p_1 = \$6,870$: Avg. need-based aid (conditional on receipt)
- y^*: 32% receive Pell grants
- $p_0 = \$1,896$: Average sticker tuition $\$19,152$

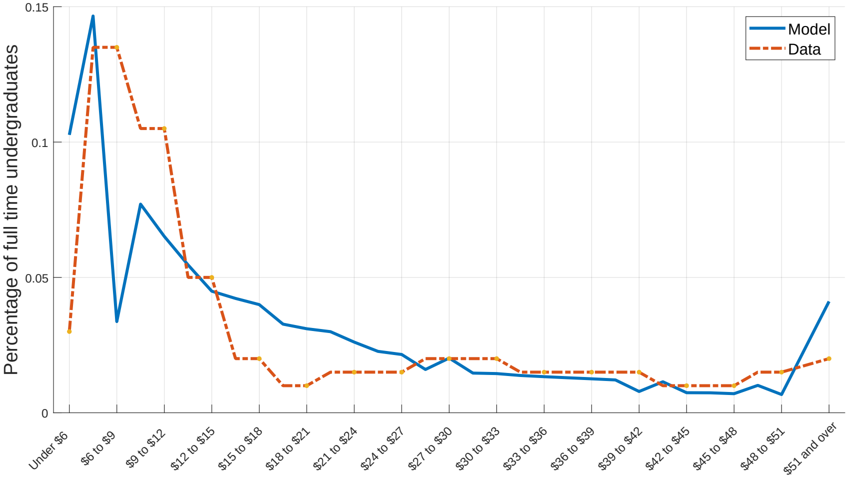
Calibration cont.

- Subsidies to colleges

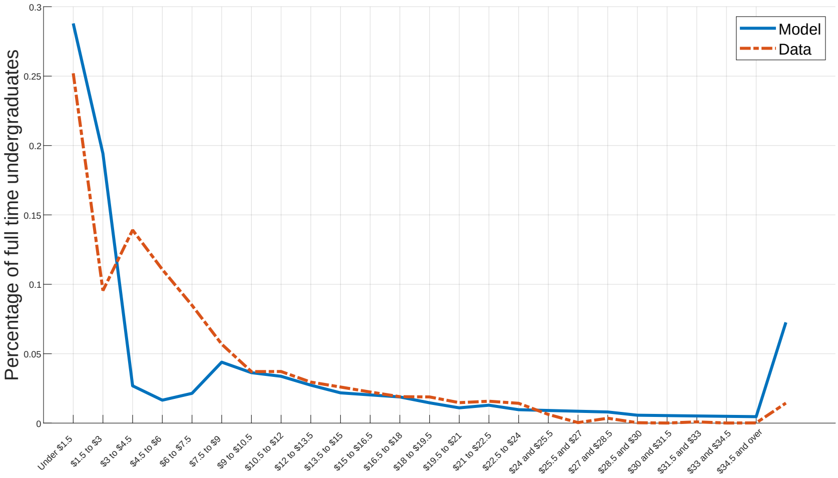
$$\begin{aligned} s(q,a,o) &= \bar{s} \\ s(q,a,i) &= \bar{s} + \max\left\{(1-\lambda)t(q,a,o),0\right\}. \end{aligned}$$

- $\lambda = 0.49$: Avg. public out-of-state sticker tuition $\$24,930$, in-state $\$9,650$
- $\phi - \bar{s} = \$4,610$: Instruction & student services $\$17,077$

Model vs Data Sticker Tuition



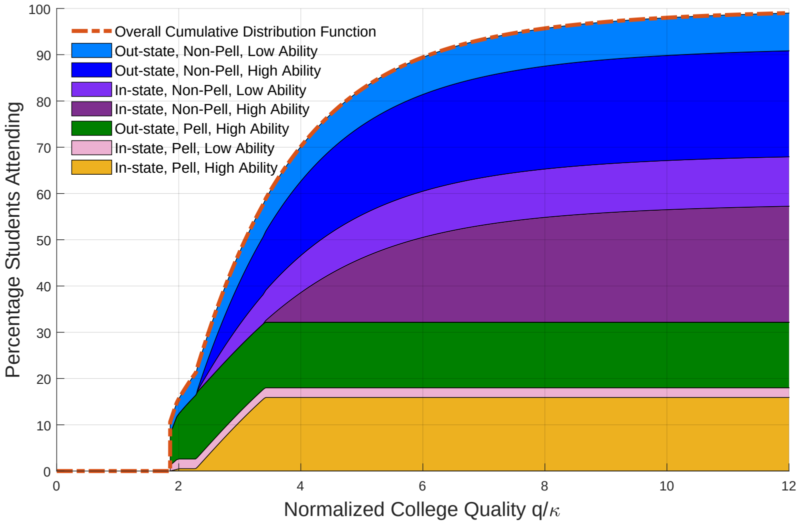
Model vs Data Net Tuition



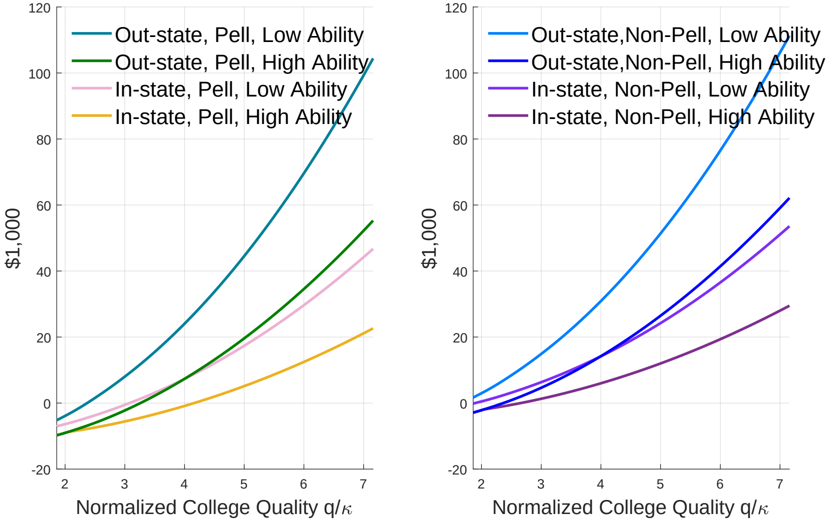
Non-targeted Moments

	Data	Model
Enrollment Patterns		
Family income enrolled / Mean	1.560	1.567
Share of high ability enrolled	0.749	0.802
Share of low ability enrolled	0.265	0.212
Graduation Rate	0.361	0.369
College-level Moments		
Standard Deviation / Mean		
Net tuition	0.99	1.31
Sticker tuition	0.77	0.80
Avg. family income	0.51	0.92
Fraction of high ability	0.26	0.10
Correlation		
Sticker tuition vs. Net tuition	0.83	0.98
Net tuition vs. Family income	0.60	0.97
Net tuition vs. Fraction of high ability	0.22	0.71
Family income vs. Fraction of high ability	0.59	0.77

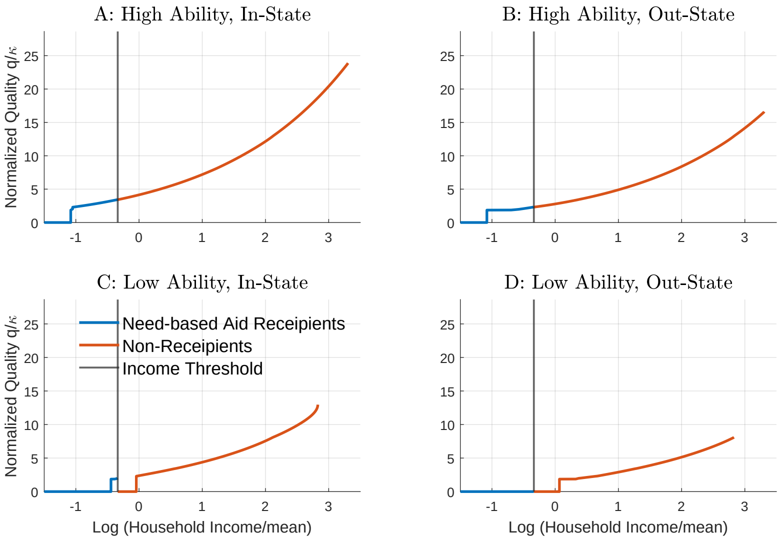
College Quality Distribution



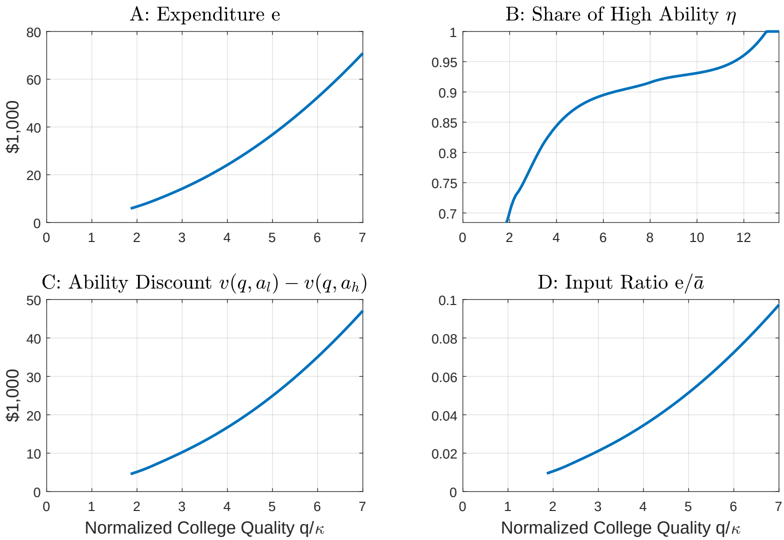
Net Tuition Schedules



Attendance by Type



College Inputs



Changes in College Market

	2016 Data	1990 Data	% Growth
Net tuition	\$9,250	\$6,034	53.3
Expenditure per student e	\$17,077	\$10,503	62.6
Total subsidies per student net of ϕ	\$7,828	\$4,469	75.2
Need-based aid	\$2,198	\$1,377	59.6
In-state subsidies	\$8,343	\$5,413	54.1
General subs. to colleges net of ϕ	-\$4,609	-\$2,396	-16.9
General subs. to students	\$1,896	\$76	
Enrollment	0.507	0.327	+18.0pp
Share in-state	0.546	0.581	-3.5pp
Share Pell	0.32	0.30	+2.0pp
Graduation	0.361	0.233	+12.8pp

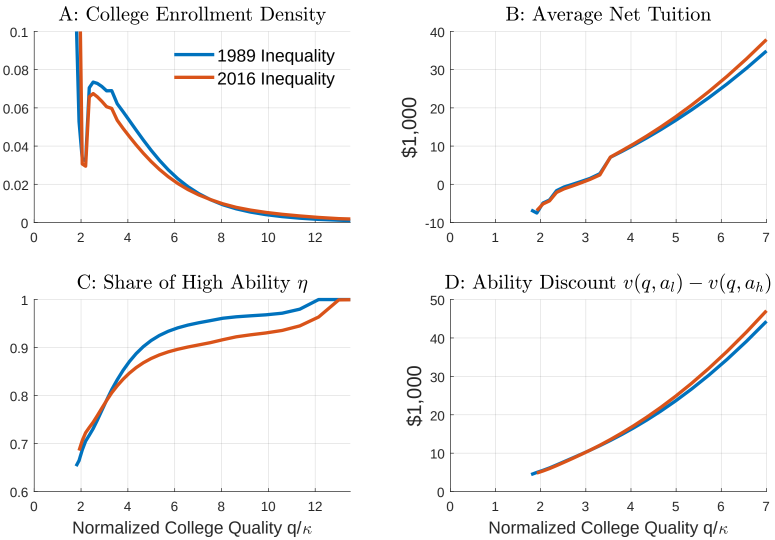
Changing Parameters

2016 Income distribution		1989 Income distribution	
$\bar{y}$	$\$774,590$	$\bar{y}$	$\$621,221$
σ^2	0.548	σ^2	0.478
α	1.67	α	2.40
2016 Subsidies		1990 Subsidies	
μ_i	0.529	μ_i	0.578
λ	0.490	λ	0.536
$y^*/\bar{y}$	0.714	$y^*/\bar{y}$	0.884
p_1	$\$6,870$	p_1	$\$4,590$
p_0	$\$1,896$	p_0	$\$76$
$\phi - \bar{s}$	$\$4,610$	$\phi - \bar{s}$	$\$2,396$

Effects of Changing Inequality

	(1) 2016	(2) 1989 Ineq.	(3) 1989 Mean	(4) 1989 Dist.	(5) Dist.+ Subs.
Parameters changed	–	σ^2, α	$\bar{y}$	$\bar{y}, \sigma^2, \alpha$	
Net tuition	$9,250	$7,359	$7,746	$5,921	$7,476
Expenditure	$17,077	$13,904	$13,982	$10,944	$12,389
Enrollment	0.507	0.562	0.428	0.477	0.447
Income enrolled / mean	1.567	1.407	1.747	1.543	1.625
Share high ability	0.802	0.889	0.714	0.807	0.746
Share low ability	0.212	0.235	0.143	0.147	0.149
Quality / κ	3.724	3.604	3.569	3.448	3.594

How Higher Inequality Changes the Equilibrium



Summary: Rising income inequality

1. Rich are richer, willing to pay more for high quality colleges (poor are poorer, but were not going to college anyway)
2. Income of marginal students falls $\Rightarrow$ graduation rate falls
3. Greater demand for quality $\Rightarrow$ more instructional spending
4. But diminishing returns, esp. at high quality colleges where demand increases most $\Rightarrow$ small rise in average college quality
5. Complementarity between expenditure and peer effects $\Rightarrow$ price of ability goes up (bigger discounts for high ability)
6. Less density in the middle of the income distribution $\Rightarrow$ less demand for inexpensive (public) colleges

Roles of Different Factors

- Changes in household income distribution can account for observed growth in college tuition
- Growth in inequality and higher average income both drive up tuition ...
- ... But have opposite effects on enrollment
- Larger subsidies have boosted enrollment and moderated growth in net tuition
- Also explored impact of growth in the price of e
  - Implies reduction in average college quality, but negligible impact on net tuition

Importance of Peer Effects

	$\theta = 0.25$	$\theta = 0.5$	$\theta = 0.75$
Enrollment Pattern			
Family income enrolled / mean	2.020	1.567	1.498
Share of high ability enrolled	0.731	0.802	0.876
Share of low ability enrolled	0.283	0.212	0.139
Impact of Rising Inequality (1989 to 2016)			
Enrollment rate (change, percentage points)	– 6.30	– 5.46	– 3.74
Net tuition (change, $)	+ 453	+1,891	+2,210

Conclusions

- Widening income inequality driving enrollment down, tuition up:
  1. rich demand higher quality colleges $\Rightarrow$ college spending goes up
  2. marginal high ability become poorer, but are offered larger discounts $\Rightarrow$ little change in average student ability
  3. decreasing returns to extra spending, especially at the top $\Rightarrow$ modest quality gains
- Average income growth also pushing up average tuition, while growth in subsidies has moderated tuition increases