Market Power and Price Discrimination in the US market for higher education

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Motivation

- Colleges in the US charge different students different prices for the same service
- Why?
  - Because they can—market power
  - Because they want to—subsidizing 'good' students
- The paper tries to quantify the contributions of the two motives to the observed price heterogeneity

Data

- 2011–2012 National Postsecondary Student Aid Study (NPSAS)
- The sample includes first year students at two-year and four-year colleges who
  - Were American, not athletes and not veterans
  - Attended full-time and didn't switch schools in the first year
  - Attended schools with known institutional expenditures
  - Weren't missing data on grades
- Ability is measured in two steps:
  - $GPA_{ic} = \beta_0 + \beta_1 HSGPA_i^s + \beta_2 SAT_i + \beta_3 male_i + maj_i + f_c + \epsilon_{ic}$ in a sample of nonminority four-year college students
  - $\hat{b}_i = \hat{\beta}_0 + \hat{\beta}_1 GPS_i^s + \hat{\beta}_2 SAT_i + \hat{\beta}_3 male_i$

Descriptive Statistics: Students

TABLE 2 Selected Characteristics for NPSAS 2012 Sample

	Two-Year Public	Four-Year Public	Four-Year Private	All
Number of students	3,510	2,910	3,070	9,490
Number of students *(weighted)*[*]	521,638	583,844	342,519	1,448,001
Number of colleges	300	250	350	900
Number of colleges *(weighted)*[**]	1549	713	1286	3548
Average ACT score	19.72	21.88	23.79	21.55
Average ability	0.00	0.45	0.81	0.37
Average in-state net tuition[***]	3.00	5.73	26.37	12.02
Average out-of-state net tuition	6.48	15.48	26.37	15.50
Average income	48.4	76.9	94.8	70.9
Female	0.53	0.54	0.57	0.55
Black	0.18	0.17	0.14	0.17
Hispanic	0.19	0.13	0.11	0.15

[*] Students are weighted to be nationally representative, using inverse probability weights provided by the NCES. All other student-level statistics (e.g., ACT score, gender) are also weighted.
[**] Colleges are weighted to be nationally representative, using inverse probability weights provided by the NCES. Tuition values are also weighted.
[***] Tuition and income reported in $1000s.
Note: Unweighted counts rounded to nearest 10 as per NCES policy.

Colleges

- 900 colleges in the sample, average of 11 students per college
- Clustering of "similar" colleges into one college
- Colleges within a group do not compete against each other

Descriptive Statistics: Colleges

TABLE 3 Characteristics of Clusters

Cluster	In-State Admit.	Out-State Admit.	Mean Ability	Mean ACT	Mean Posted	Mean Tuition	Instruct. Expend.	Percent Black	Percent Hispanic	Count Colleges	Count Students	Weighted Students
Private Four-Year Colleges												
1	−0.40	−0.40	1.66	28.59	39.31	25.28	37.96	0.07	0.11	20	450	36,758
2	0.35	0.35	1.48	27.77	41.63	29.75	17.30	0.06	0.10	20	290	38,264
3	−1.42	−1.42	0.93	24.81	30.74	19.30	12.86	0.03	0.09	10	130	16,269
4	−1.26	−1.26	0.82	24.47	36.66	22.25	11.52	0.08	0.11	40	420	45,429
5	−1.88	−1.88	0.76	23.07	23.76	15.41	9.07	0.16	0.11	40	330	30,431
6	−1.42	−1.42	0.61	22.61	31.11	17.26	8.34	0.16	0.16	50	390	51,837
7	−1.86	−1.86	0.49	21.80	26.73	14.47	6.66	0.14	0.09	60	490	49,517
8	−1.87	−1.87	0.43	21.33	18.22	12.07	6.29	0.18	0.10	30	170	27,424
9	−1.61	−1.61	0.39	21.09	21.78	11.57	5.42	0.19	0.12	40	240	26,491
10	−1.45	−1.45	0.22	20.93	12.19	8.18	5.47	0.36	0.06	30	170	20,099
Public Four-Year Colleges												
11	−0.53	−0.53	0.69	23.05	15.52	13.18	10.43	0.05	0.19	10	140	31,538
12	−1.73	−1.17	0.58	22.50	11.17	9.33	9.36	0.13	0.08	60	840	165,888
13	−1.76	−1.42	0.43	22.04	7.33	6.06	7.50	0.15	0.15	110	1,180	242,419
14	−2.38	−1.49	0.27	20.64	4.31	3.50	6.05	0.28	0.15	80	750	143,998
Public Two-Year Colleges												
15			0.00	19.72	3.18	2.98	4.48	0.18	0.19	300	3,510	521,638

Instructional expenditures weighted by institutional weight. All other means weighted by individual weight.
Unweighted counts rounded to the nearest 10 as per NCES policy.
Tuition and expenditures reported in $1000s.

Environment

- S states, each having a mass π_s of students and 1 public college
  - $\sum_s \pi_s = 1$
- Mass π_{sm} are a minority, with $m = 1$. The rest have $m = 0$
- Students differ by income y and ability b according to $f_s(b, y|m)$
- There are P private schools and 1 two-year college in the country
  - Total number of options is $J = S + P + 1$
  - 2 year college is an outside option
- Colleges differ by the endogenous quality q_j

Demand for Colleges

- A student with ability b at school with quality q achieves $a(q_j, b)$
  - $a(q_j, b)$ is increasing, twice differentiable, and strictly quasiconcave

- Net tuition is $p_{sj}(m, b, y)$, $A_{sj}(y)$ is the federal aid, and L is the nontuition cost of college

- The utility of student (s, m, b, y) from college j is

$$U_j(s, m, b, y, \varepsilon_j) = U(y - p_{sj} - L + A_{sj}, a) + \varepsilon_j$$

  - U(money, a) is increasing, twice differentiable, and quasiconcave

- This gives rise to CCP's $r_{sj}(m, b, y; P, Q)$, where P and Q are vectors of tuitions and qualities
  - Student can choose any college for which she passes the threshold announced in equilibrium

State College

- Maximize aggregate achievement of their in-state students
- Have tuition for in-state (T_s) and out-of-state students (T_{os}) fixed exogenously
- Use ability threshold as admission policy
- Could have higher or lower threshold for out-of-state students
  - → They bring more money, so why not admit less bright ones
  - → Peer-effect concerns incentivize to admit the brighter ones

Private Colleges

- Cost function of college j: $C_j(k_j, I_j) = F_j + V_j(k_j) + k_j I_j$
  - k_j: the size of college j's student body
  - I_j: expenditures per student on educational resources
  - $F_j + V_j(k)$ are quality-independent costs
- Exogenous outside funds E_j and maximum tuition $\bar{p}_j$
- Quality is a function of mean ability θ_j, fraction of minority students Γ_j, and investment I_j:
$$q_j = q(\theta_j, I_j, \Gamma_j)$$
- Monopolistic competition: colleges maximize quality constrained by demand, competition, and costs, taking choices and qualities of other colleges as given

Private College Problem

$$\max_{p_{sj},a_{sj},I_j,\theta_j,\Gamma_j,k_j} \; q(\theta_j, I_j, \Gamma_j)$$

- $p_{sj}(m, b, y)$ is tuition, $a_{sj}(m, b, y) \in [0, 1]$ is the admission probability
- **Budget**: $R_j = F_j + V(k_j) + k_j I_j$, where $R_j = \mathbb{E}\left[\pi_{sm} r_{sj} p_{sj} a_{sj}\right] + E_j$
- **Identity**: $\theta_j = \mathbb{E}\left[\pi_{sm} r_{sj} b a_{sj}\right]/k_j$, $k_j = \mathbb{E}\left[\pi_{sm} r_{sj} a_{sj}\right]$, $\Gamma_j = \mathbb{E}\left[\pi_{s1} r_{sj} a_{sj}\right]/k_j$
- **Price:** $p_{sj} \leqslant \bar{p}_j$

F.O.C.

- $MR = EMC$. Note that it is not profit maximization!

$$p_{sj}(m,b,y) + \frac{r_{sj}(m,b,y;\cdot)}{\partial r_{sj}(m,b,y;\cdot)/\partial p_{sj}(m,b,y)} = EMC_j(m,b)$$

- *Effective Marginal cost*: how does the cost of providing the service, accounting for quality and diversity, change, when the school enrolls an additional person of type (m, b)

$$EMC_j(m,b) := V_j' + I_j + \frac{q_\theta}{q_I}(\theta_j - b) + \frac{q_\Gamma}{q_I}(\Gamma_j - m)$$

  - $b = \theta_j$: no change to the average ability
  - $\Gamma_j - 1 < 0$: minority students decrease "costs"

- Student (s, m, b, y) is admitted iff $p_{sj}(m,b,y) \geqslant EMC_j(m,b)$.
  - Seems to hold all the time?

Comments on the Model

- The model is not solved properly
  - The 2017 *JoPE* piece is like that as well
- Problem of the private college is assumed to be well-behaved
  - Solution must depend on $f(b, y|m)$—nothing is mentioned in this respect
- The model is not properly closed:
  - What is the choice set of students? This is a matching market
  - Not a single word is said about solving for an equilibrium
  - Multiple equilibria: if schools are equally efficient, it is all about coordination
- Estimation doesn't require solving for equilibrium, so maybe it is all right

Functional Forms

- $q_j = \theta_j^{\gamma} I_j^{\omega} \Gamma_j^{\kappa} e^{u_j}$, where $\gamma, \omega, \kappa > 0$, u_j is an unobserved component
- $U = \alpha \log \left[(y - p_{sj} - L - A_{sj}) q_j b^{\beta} \right] + \varepsilon_j$, where $\alpha > 0$, $\varepsilon_j \sim$ EV-TI
- This leads to CCP's:

$$r_{sj}(m, b, y; P, Q) = \frac{\left[(y - p_{sj} - L - A_{sj}) q_j\right]^{\alpha}}{\sum_{j' \in J_a(m,s,b)} \left[(y - p_{sj'} - L - A_{sj'}) q_{j'}\right]^{\alpha}}$$

- Prices are $p_{sj}(m, b, y) = \frac{(1-r_{sj})\alpha}{1+(1-r_{sj})\alpha} EMC_j(m, b) + \frac{1}{1+(1-r_{sj})\alpha}(y - L - A_{sj}(y))$
- $EMC_j(m, b) = V'(k_j) + I_j + \frac{\gamma I_j}{\omega \theta_j}(\theta_j - b) + \frac{\kappa I_j}{\omega \Gamma_j}(\Gamma_j - m)$

Econometric Model

We observe:

- Students $i = 1, \ldots, N$ we know m_i, b_i, y_i, tuition at the chosen college p_{sji}, received federal aid $A_{sji}(y_i)$
- Colleges: we know θ_j, l_j, k_j, posted tuition $\bar{p}_{(s)j}$, non-tuition cost of attendance L
- Tuition with error: $\tilde{p}_{sji} = p_{sji}(m_i, b_i, y_i) + v_{ij}$

We don't observe:

- Parameters $(\gamma, \omega, \kappa, \alpha, \beta)$, structural errors $v_{ij}, \varepsilon_j, u_j$
- Values $V'(k_j)$ (and no functional form assumptions)
- Counterfactual tuition and federal aid at non-chosen colleges,

Estimation of CCP's

- Any student of type (m, b, y) has the same choice probabilities
- For a fixed (m, b, y) $r_{sj}(m, b, y)$ is identified as shares of colleges among this group
  - Logit model predicts that all options will be chosen by at least some fraction of students
  - You see in the data that $(0, 100500, 100500)$ never goes to bad colleges
  - You exclude half of colleges from her choice set—is it kosher?
- Non-parametrically estimate $r_{sj}(m, b, y)$ across different values of (m, b, y)

Estimation of Parameters

- Students who attend private colleges and receive some aid from them

$$\tilde{p}_{sji} = \frac{(1-\hat{r}_{sj})\alpha}{1+(1-r_{sj})\alpha}\left(V_j + \frac{\gamma I_j}{\omega\theta_j}(\theta_j - b) + \frac{\kappa I_j}{\omega\Gamma_j}(\Gamma_j - m)\right) + \frac{1}{1+(1-\hat{r}_{sj})\alpha}(y - L - A_{sj}(y)) + v_{ij}$$

- Formally, the assumption of the exogeneity of v_{ij} allows to estimate the equation above via non-linear OLS
  - → We could assume that $b = \tilde{b} + \tilde{v}_{ij}$ to motivate the error term. As long as the error in ability is uncorrelated with income, financial aid and average quality of the school, it should be all right.

- Consistent as $N \to \infty$, keeping J small.

Estimation of Qualities

- At this point we don't know $q_j = \theta_j^{\gamma} I_j^{\omega} \Gamma_j^{\kappa} e^{u_j}$ because we don't know ω
  - Recall that u_i was added for the estimation part
- Invert the CCP's to berry out values of q_j/q_1, and take the logs of the quality function to arrive at the regression equation

$$\log(q_j/q_1) = \omega w_j + u_j - u_1$$

  - Note that in $y_i = x_i\beta + u_i$ we can use $\mathbb{E}[y_i] = \mathbb{E}[x_i]\beta$ for identification in the presence of endogeneity. You don't need instruments!
  - Note that the sample size is $J = 15$ here

Comments on Estimation

- It looks to me that the entire identification relies on the model
- Abstract away from all the content: we are using prices to back out (effective) marginal cost and elasticity parameter (α) at the same time using

$$P = \frac{|\mathcal{E}|}{|\mathcal{E}| - 1} MC$$

- Normally in IO you estimate demand using instruments, so that at least you have identification under any functional forms
  - Might not be feasible here
- I am also not sure what exactly the parameters mean, given that we aggregate schools
  - You assume that a bunch of competitors act as a monopolist, and back out elasticity and marginal costs. What do you get?
  - A formal treatment of this issue would be really welcome

Estimates

TABLE 4 Parameter Estimates

	(1)	(2)	(3)
Weights	No	Yes	Yes
Minority status	No	No	Yes
α	86.56***	70.26***	72.72***
	(8.58)	(6.68)	(7.13)
$\frac{\gamma}{\omega}$	0.074***	0.0734***	0.079***
	(0.012)	(0.012)	(0.012)
$\frac{\kappa}{\omega}$			0.01***
			(0.003)
V_1	1.22***	1.21***	1.23***
	(0.07)	(0.07)	(0.07)
V_2	1.69***	1.65***	1.66***
	(0.07)	(0.07)	(0.07)
V_3	1.43***	1.40***	1.41***
	(0.08)	(0.08)	(0.08)
V_4	1.82***	1.81***	1.82***
	(0.05)	(0.05)	(0.05)
V_5	1.15***	1.14***	1.14***
	(0.05)	(0.05)	(0.05)
V_6	1.48***	1.46***	1.46***
	(0.04)	(0.04)	(0.04)
V_7	1.15***	1.13***	1.14***
	(0.04)	(0.04)	(0.04)
V_8	0.93***	0.92***	0.92***
	(0.07)	(0.07)	(0.07)
V_9	1.09***	1.08***	1.08***
	(0.05)	(0.05)	(0.05)
V_{10}	0.56***	0.54***	0.54***
	(0.08)	(0.08)	(0.08)

Values of Interest

- We are interested in $markup_j(m, b, y) = p_{sj} - EMC_j$, and partial derivatives of net tuition with respect to ability and income
- Markups among private colleges are between \$750 and \$13,000 per year
  - 3.5% and 35.5%. High market power among selective schools.
  - Market power is even stronger if you look at subgroups of students
- If a family income goes up by \$10,000, the net tuition goes up by between \$210 and \$510
- One standard deviation increase in ability cuts the price tag somewhere between \$920 and \$1,960
- High-ability private schools give a discount between \$1,600 and \$5,750

Counterfactual

- Consider a hypothetical state with the worst quality public school only
- Add remaining 3 levels of public schools
- Look at who switches and where