The U.S. Market for Higher Education: Access and Affordability

Holger Sieg

Competition in Higher Education

- One key feature of the U.S. system of higher education is that private colleges compete against public institutions for students and resources.
- About 70% of four year college students in the U.S. are enrolled in state colleges.
- The first objective is to provide compelling theoretical model that captures the coexistence of public and private colleges.
- The second objective is to determine whether our model is consistent with observed admission and pricing policies.
- The third objective is to explore the impact of institutional, state and federal aid policies within this model.

Price Discrimination

- Within private colleges and universities in the U.S., there is tremendous variation in the amount of tuition paid by students. This price discrimination is in the form of a high posted tuition coupled with awards of financial aid in differing amounts to different students.
- For example, Haverford's posted tuition is \$50,564; more than 50% of students receive some financial aid; the average aid award among such students is \$40,014.
- How is this price discrimination sustained when the overall market share of the typical college is small?
- Haverford's enrollment is 1,194 students compared to enrollment in four-year institutions in the U.S. of more than 13 million students.

Merit Aid and Aid to Minorities

- For all other students at private colleges, net tuition can be expressed as "effective marginal cost" plus a mark-up.
- Effective marginal cost depends on the ability and minority status of a student.
- Pricing by ability or merit-based aid arises because high ability students increase college quality through reputation and peer effects.
- Discounts for minority students arise because they enhance diversity.

Some Forms of Price Discrimination are Less Readily Understood

- Among non-minority students of the same ability, tuition is higher for students from higher income families.
- How can this pricing by income be sustained?
- Students' preferences across colleges are based on:
  - Common features: average ability of peers, instructional expenditure per student;
  - Idiosyncratic features such as the "feel" of the campus.
- Product differentiation and idiosyncratic shocks create market power.
- With third degree price discrimination, the mark-up term – the difference between price and marginal costs – does not depend on the overall market share of the college, but on the market share conditional on observed student characteristics.

State Aid to Public Universities

- The federal government and state governments use different approaches to subsidize higher education.
- Public universities obtain direct subsidies from their state legislatures. State aid was $62.18 billion (about $4,818 per student) in 2008.
- Public colleges face regulated price caps and only have limited powers to set tuition and financial aid policies.
- The average in-state tuition in 2007-08 was $6,200, and the average out-of-state tuition was $15,100 for full-time undergraduates enrolled in public 4-year institutions.
- State governments thus provide access to higher education at subsidized rates to in-state students.

Federal Aid to Students

- The federal government provides direct aid to students and their families.
- The amount of available aid is basically determined by the difference between the tuition that is charged by the college and the federally determined expected family contribution, as long as the difference is below a maximum amount of aid.
- During 2010-11 school year, Federal Student Aid provided \$144 billion in aid to about 15 million students.
- Federal aid, therefore, can benefit students at public and private universities, while state subsidies are primarily targeted at in-state students that attend public colleges.

Data

- Our data source is the 2011-12 National Postsecondary Student Aid Study (NPSAS) from the National Center for Education Statistics (NCES).
- We construct our sample using first-year students, who are oversampled in this wave of the NPSAS and constitute more than half of all observations.
- We drop some students whose behavior or characteristics require separate modeling such as foreigners and athletes.
- We measure ability by predicting students' first-semester GPA as a function of their high school GPA, ACT score (or SAT score converted to ACT score), gender, major, and college choice.

Characteristics of Private School Clusters

cluster	mean ability	mean ACT	mean sticker	mean tuition	instruct. expend.	% black	% hisp	count colleges	count students	weighted students
Private 4-Year Colleges										
1	1.66	28.59	39.31	25.28	37.96	0.07	0.11	20	450	36,758
2	1.48	27.77	41.63	29.75	17.30	0.06	0.10	20	290	38,264
3	0.93	24.81	30.74	19.30	12.86	0.03	0.09	10	130	16,269
4	0.82	24.47	36.66	22.25	11.52	0.08	0.11	40	420	45,429
5	0.76	23.07	23.76	15.41	9.07	0.16	0.11	40	330	30,431
6	0.61	22.61	31.11	17.26	8.34	0.16	0.16	50	390	51,837
7	0.49	21.80	26.73	14.47	6.66	0.14	0.09	60	490	49,517
8	0.43	21.33	18.22	12.07	6.29	0.18	0.10	30	170	27,424
9	0.39	21.09	21.78	11.57	5.42	0.19	0.12	40	240	26,491
10	0.22	20.93	12.19	8.18	5.47	0.36	0.06	30	170	20,099

Characteristics of Public School Clusters

cluster	mean ability	mean ACT	mean sticker	mean tuition	instruct. expend.	% black	% hisp	count colleges	count students	weighted students
Public 4-Year Colleges										
11	0.69	23.05	15.52	13.18	10.43	0.05	0.19	10	140	31,538
12	0.58	22.50	11.17	9.33	9.36	0.13	0.08	60	840	165,888
13	0.43	22.04	7.33	6.06	7.50	0.15	0.15	110	1,180	242,419
14	0.27	20.64	4.31	3.50	6.05	0.28	0.15	80	750	143,998
Public 2-Year Colleges										
15	0.00	19.72	3.18	2.98	4.48	0.18	0.19	300	3,510	521,638

Student Sorting at High Quality Colleges: Local Market Power

	income percentile									
ability	10	20	30	40	50	60	70	80	90	100
10	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.02	0.00
20	0.01	0.02	0.00	0.00	0.00	0.03	0.01	0.02	0.03	0.06
30	0.01	0.00	0.00	0.00	0.02	0.05	0.00	0.04	0.03	0.05
40	0.03	0.02	0.01	0.01	0.04	0.01	0.01	0.00	0.04	0.02
50	0.02	0.01	0.00	0.02	0.02	0.06	0.03	0.04	0.09	0.11
60	0.00	0.02	0.01	0.00	0.02	0.04	0.08	0.05	0.04	0.05
70	0.00	0.01	0.01	0.02	0.06	0.05	0.03	0.10	0.08	0.08
80	0.04	0.08	0.05	0.07	0.07	0.11	0.04	0.05	0.07	0.24
90	0.08	0.07	0.04	0.07	0.13	0.20	0.10	0.07	0.20	0.23
100	0.22	0.28	0.37	0.18	0.29	0.28	0.38	0.31	0.41	0.53

Note: Table gives proportion of each income-ability percentile combination attending colleges in Cluster 1 or 2.

Model: Overview

- We model selection of student among a set of private and public colleges and universities using a differentiate product demand system.
- While public colleges typically do not engage in price discrimination, they offer a relatively affordable alternative to private colleges and thus impact the price and income elasticities of demand for private education.
- Public schools have regulated tuitions that differ by in-state and out-of-state status.

Objectives of Private and Public Colleges

- One key challenge is to explore the different objectives of private and public universities and the different constraints they face.
- Our approach builds on the insight that the vast majority of public and private colleges are NOT likely to be profit maximizers. (There is small and growing sector of private for-profit colleges.)
- Most private colleges focus primarily on legacy or reputation. This motivates our approach of modeling private colleges as maximizing quality, which depends on the measured abilities of their students and the educational resources they provide.
- Public universities face state mandates to provide affordable education to in-state students. This suggests modeling state universities as maximizing the aggregate achievement of in-state students.

Heterogeneity among Students

Students differ by

- household income, y;
- student ability, b,
- minority status, m;
- state of residence, s;
- idiosyncratic preference shocks.

Preferences

The utility function is given by:

$$U_j(y - p_j - L + A_j, q_j, b) = \alpha \ln(y - p_j - L + A_j) + \alpha \ln(q_j b^{\beta}) + \epsilon_j$$

where:

- p_j is the price charged at school j.
- L captures cost of living expenditures;
- A_j is non-institutional aid that the student receives;
- q_j is the quality of college j;
- ϵ_j is the McFadden style preference shock.

Note that α parameterizes the weight on the systematic component of utility.

The Effective Choice Set

- Let $J_a(m, s, b)$ denote the "effective choice set" of a student with characteristics (m, s, b).
- It consists of all private and public public that the student is admitted to and the outside option.
- In our model, all universities – private and public – face a binding price cap.
- As a consequence each school will use a threshold rule to determine admissions.

Student Choices

- We assume that the preference shocks come from a Type I extreme value distribution (McFadden, 1974).
- The conditional choice probability for type (s, m, b, y) is given by:

$$r_{sj}(m, b, y) = \frac{[(y - p_{sj}(m, b, y) - L + A_{sj}(y))\ q_j]^{\alpha}}{\sum_{k \in J_a(m,s,b)} [(y - p_{sk}(m, b, y) - L + A_{sk}(y))\ q_k]^{\alpha}}.$$

- Note that the only difference to a standard Logit model is that we need to sum over the elements in the effective choice set of each student.

College Quality

The quality of a college, denoted by q_j, is given by

$$q_j = \theta_j^{\gamma} \; I_j^{\omega} \; \Gamma_j^{\kappa} \; e^{u_j}$$

where:

- I_j are instructional expenditures;
- θ_j is peer quality (measured by mean ability);
- Γ_j is a diversity measure (measured by the fraction of minority students);
- u_j is an unobserved exogenous characteristic.

Colleges also differ by endowments which gives rise to a ranking since higher endowed colleges and universities can offer higher quality.

Private Colleges

- Private colleges differ by endowment income denoted by E_j.
- Each college has a cost function given by

$$C(k_j, I_j) = F + V(k_j) + k_j I_j,$$

  where k_j is the size of college j.
- Private colleges choose pricing and admission policies to maximize quality.
- We assume monopolistic competition in which colleges take as given other colleges' prices and qualities when choosing their own.
- Thus, a college does not consider that variation in their own pricing and admission policies will have an impact on other colleges' qualities through size and peer effects.

Price Caps

- Almost all private schools impose a price cap, i.e. a certain fraction of students do not obtain financial aid and pay the maximum tuition.
- We do not explain the use of price caps, but take them as given.
- Our model implies that price caps give rise to a minimum ability threshold that characterizes admission policies of private colleges.
- Students at the cap are below the mean ability of the school and thus do not qualify for merit aid. Moreover, these students must have income sufficiently high so that the price cap is binding.

Quality Maximization

$$\max_{\theta_j, l_j, \Gamma_j, k_j, p_{sj}(b,y)} \; q(\theta_j, l_j, \Gamma_j)$$

subject to a revenue constraint

$$R_j = \int \int \sum_{s=1}^{S} \sum_{m} \pi_{sm} \; p_{sj}(m, b, y) \; r_{sj}(m, b, y; P(m, s, b, y), Q) \; f_s(b, y|m) \; db \; dy \; + \; E_j$$

a budget constraint

$$R_j = F_j \; + \; V_j(k_j) \; + \; k_j l_j$$

identity constraints,

$$\theta_j \; = \; \frac{1}{k_j} \iint b \left(\sum_{s=1}^{S} \sum_{m} \pi_{sm} r_{sj}(m, b, y; P(m, s, b, y), Q) f_s(b, y|m) \right) db \; dy$$

$$k_j \; = \; \iint \left(\sum_{s=1}^{S} \sum_{m} \pi_{sm} r_{sj}(m, b, y; P(m, s, b, y), Q) f_s(b, y|m) \right) db \; dy,$$

$$\Gamma_j \; = \; \iint \left(\sum_{s=1}^{S} \pi_{s1} r_{sj}(1, b, y; P(1, s, b, y), Q) f_s(b, y|1) \right) db \; dy \Big/ k_j,$$

and the price cap constraint

$$p_{sj}(m, b, y) \leq \bar{p}_j.$$

Pricing Equation

- The FOC that characterizes the pricing equation is given by:

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

- Price = mark-up + effective marginal costs
- Note that the mark-up is a function of the local or conditional market share.

Effective Marginal Costs

Effective marginal costs at private college j are given by:

$$EMC_j(m, b) = V_j' + I_j + \frac{\gamma I_j}{\omega \theta_j}(\theta_j - b) + \frac{\kappa I_j}{\omega \Gamma_j}(\Gamma_j^m - m)$$

where:

- V_j' are marginal custodial costs (such as housing, administration)
- I_j are educational expenditures per student
- The third term is the shadow price of ability times the peer externality. It is positive (negative) for students with $b < (>)\ \theta_j$.
- The last term is the shadow price for diversity times the diversity externality. It is positive (negative) for non-minority (minority) students.

Admission

Students are admitted to the college if and only if

$$\min\{\bar{p}_j, p_{sj}(m, b, y)\} \geq EMC_j(m, b)$$

The equation above yields minimum ability thresholds that vary with minority status for each private college implicitly defined by:

$$\bar{p}_j = EMC_j(m, b_{jm}^{min})$$

Since effective marginal cost decreases with ability and is lower for a minority student of given ability, the admission threshold for minorities is lower.

State Colleges

- The state legislature sets tuition for in-state and out-of-state students: T_s and T_{so}.
- State governments provide an exogenous per student subsidy of z_s that is financed by a state income tax denoted t_s.
- State budgets need to be balanced.
- Given tuition rates and subsidies, a state college maximizes aggregate achievement of its in-state students subject to feasibility, revenue, size and peer constraints.

Achievement Maximization

State colleges maximize in-state achievement:

$$\max_{\theta_s, I_s, k_s, \Gamma_s, \gamma_s(b,y), \gamma_{so}(b,y)} \iint \sum_m \pi_{sm}\ a(q(\theta_s, I_s, \Gamma_s), m, b)\ \gamma_s(m, b, y)\ r_{ss}(m, b, y; P, Q)\ f_s(b, y|m)\ db\ dy$$

subject to the identify constraints:

$$\begin{aligned}
\theta_s &= \frac{1}{k_s} \iint \sum_m b\ \pi_{sm}\ \gamma_s(m, b, y) r_{ss}(m, b, y; P, Q) f_s(b, y|m) dbdy \\
&+ \frac{1}{k_s} \iint \sum_m b\ \gamma_{so}(m, b, y) \left(\sum_{t \neq s} \pi_{tm} r_{ts}(m, b, y; P, Q) f_t(b, y|m) \right) dbdy \\
k_s &= \iint \sum_m \pi_{sm} \gamma_s(m, b, y) r_{ss}(m, b, y; P, Q) f_s(b, y|m)\ db\ dy \\
&+ \iint \sum_m \gamma_{so}(m, b, y) \left(\sum_{t \neq s} \pi_{tm} r_{ts}(m, b, y; P, Q) f_t(b, y|m) \right)\ dbdy \\
\Gamma_s &= \frac{1}{k_s} \iint \pi_{s1} \gamma_s(1, b, y) r_{ss}(1, b, y; P, Q) f_s(b, y|1)\ db\ dy \\
&+ \frac{1}{k_s} \iint \sum_m \gamma_{so}(1, b, y) \left(\sum_{t \neq s} \pi_{t1} r_{ts}(1, b, y; P, Q) f_t(b, y|1) \right)\ dbdy
\end{aligned}$$

Achievement Maximization (cont)

budget and revenue constraints:

$$
\begin{aligned}
R_s &= F_s + V_s(k_s) + k_s I_s - z_s k_s \\
R_s &= \iint \sum_m p_{ss}(m, b, y)\pi_s \gamma_s(m, b, y) r_{ss}(mb, y; P, Q) f_s(b, y|m) dbdy \\
&+ \iint \sum_m \gamma_{so}(m, b, y) \left(\sum_{t \neq s} \pi_{tm} p_{ts}(m, b, y) r_{ts}(m, b, y; P, Q) f_t(b, y|m) \right) dbdy
\end{aligned}
$$

the tuition regulation constraint:

$$
p_{ts}(m, b, y) = \begin{cases} T_s \text{ for all students } (t, m, b, y) \text{ with } t = s \\ T_{so} \text{ for all students } (t, m, b, y) \text{ with } t \neq s \end{cases}
$$

and the feasibility constraints:

$$
\gamma_s(m, b, y), \gamma_{so}(m, b, y) \in [0, 1] \text{ for all students } (s, m, b, y)
$$

Optimal Admission at State Colleges

Solving the optimization problem, we find that a state college s admits all in-state students with $b \geq b_{sm}^{\min}$, the latter satisfying

$$a(q(\theta_s, I_s, \Gamma_s), b_{sm}^{\min})/\lambda + T_s + z_s - EMC_s(m, b_{sm}^{\min}) = 0;$$

where λ is the positive multiplier on the budget constraint. All out-of-state students with $b \geq b_{om}^{\min}$ are admitted, where

$$T_{so} + z_s - EMC_{sm}(m, b_{om}^{\min}) = 0$$

Out-of-state students are admitted if and only if the revenue they generate covers their $EMC(m, b)$.

Cross Subsidization

- Out-of-state students provide tuition revenue and, perhaps, positive peer effects on in-state peers.
- In-state students have an additional marginal value of attendance, specifically their direct contribution to the college's objective of in-state achievement maximization.
- The term a/λ in equals the monetized value of the increase in aggregate state achievement from the in-state student's attendance.

Differential Admission Standards

Given minority status, comparing admission thresholds of in-state and out-of-state students:

$$b_{sm}^{\min} < (=)\ (>)\ b_{o,m}^{\min} \text{ as } a(q(\theta_s, I_s, \Gamma_s), b_{sm}^{\min})/\lambda + T_s > (=)\ (<)\ T_{so}.$$

While $T_s < T_{so}$ empirically, it may also be that $a(q(\theta_s, I_s, \Gamma_s), b_{sm}^{\min})/\lambda + T_s > T_{so}$, implying lower admission standards for in-state students. This is what we find empirically.

Definition of Equilibrium

An equilibrium consists of a price and quality vector with corresponding college characteristics and state admission criteria, a set of student choices and choice probabilities that satisfy:
(a) quality maximization by all private colleges,
(b) in-state achievement maximization by all state colleges,
(c) utility maximization by all students, and
(d) state budget balance.

Estimation Strategy

- Our estimator has two components: a) a pricing equation for private schools; and b) a demand system for all colleges and universities.
- The two equations are linked through the mark-up which depends on demand.
- We can identify and estimate a subset of the parameters based on the difference between the observed and predicted price functions at private colleges.
- The remaining parameters of the demand system can be estimated using a modified version of Berry's (1994) discrete choice estimator.

Some Challenges

- The potential college choice set is unobserved by the econometrician.
- Our model implies, however, that both private and public schools use minimum-ability threshold rules to determine admission functions.
- The institutional aid is only observed at the college that is attended in equilibrium. The econometrician does not observe the financial aid packages and, hence the net tuition, that were offered by the colleges that also admitted the student, but were ultimately rejected by the student.
- We need to estimate the conditional market shares for each type to evaluate the pricing equation.

Estimation I

- We assume that prices are measured with error, v_{sj}.
- For our parametrization, we obtain

$$\begin{aligned} p_{sj}(m,b,y) &= \frac{(1-r_{sj})\alpha}{1+(1-r_{sj})\alpha} EMC_j(m,b) \\ &\quad + \frac{1}{1+(1-r_{js})\alpha}\left(y - L + A_{sj}(y)\right) + v_{sj} \end{aligned}$$

- Note that the first term arises because private schools can discriminate based on ability and minority status, while the second term captures price discrimination by income.
- Note that α declines and r_{js} rises there is more price discrimination by income.
- We need a plug-in estimator of the conditional market share, $r_{sj}(m,b,y)$.
- Given this plug-in, we can estimate the parameters using NLLS.

Estimation II

- We can construct the minimum ability threshold for each college, by computing the minimum ability of the students.
- We then non-parametrically estimate the prices for each student at each college to which the student was admitted based on the observed tuition levels of "similar" students that attended the school.
- Substituting the nonparametric estimates of the tuitions into the conditional choice probabilities, we obtain

$$\hat{r}_{ji} = \frac{[(y_i - \hat{p}^{np}_{sji} - L + A_{s_i,j}(y_i))q_j]^{\alpha}}{\sum_{k \in J_a(m_i,s_i,b_i)}[(y_- \hat{p}^{np}_{ski} - L + A_{sk}(y_i))q_k]^{\alpha}}$$

Estimation III

Following Berry (1994), the quality levels for each school are determined by the fixed point of the following mapping:

$$\tilde{q}_j = q_j + ln(s_j^N) - ln(s_j(q)) \quad j = 1, ..., J-1$$

where: q_j is initial guess of the quality, s_j^N is the average empirical market share of college j observed in the data, and $s_j(q)$ is the predicted average market share using the initial guess about the vector of qualities:

$$s_j(q) = \frac{1}{N} \sum_{i=1}^{n} \hat{r}_{ji}$$

We can identify q_j's for each college, subject to a normalization such as $q_1 = 1$. The normalization of quality is necessary since market shares add up to one.

Estimation IV

Using the fact that $q_j = \theta_j^{\gamma} \; I_j^{\omega} \Gamma_j^{\kappa} e^{u_j}$ we obtain the the following regression model:

$$\ln(q_j/q_1) = \omega \left(\frac{\gamma}{\omega} \ln(\theta_j) + \frac{\kappa}{\omega} \ln(\Gamma_j) + \ln(I_j) - \frac{\gamma}{\omega} \ln(\theta_1) - \frac{\kappa}{\omega} \ln(\Gamma_1) - \ln(I_1) \right) + u_j - u_1$$

and hence ω can be estimated using least squares.

Note that the last step of the estimator requires a large number of colleges or preferably multiple markets.

Parameter Estimates I

	(1)	(2)	(3)	(4)	(5)
Clusters		all	all	1 & 2	1 & 2
Weights	No	Yes	Yes	Yes	Yes
α	86.56***	70.26***	72.72***	76.88***	78.54***
	(8.58)	(6.68)	(7.13)	(17.01)	(17.75)
$\frac{\gamma}{\omega}$	0.074***	0.0734***	0.079***	0.046	0.056
	(0.012)	(0.012)	(0.012)	(0.049)	(0.049)
$\frac{\kappa}{\omega}$			0.012***		0.008
			(0.003)		(0.006)
Implied Pricing by Ability and Income					
$\frac{\partial p}{\partial b}$	-0.095	-0.105	-0.112	-0.066	-0.096
$\frac{\partial p}{\partial y}$	0.013	0.015	0.014	0.014	0.015
Reduced Form (OLS) Estimates of Pricing by Ability and Income					
$\frac{\partial p}{\partial b}$	-0.113***	-0.112***	-0.121***	-0.063***	-0.052***
$\frac{\partial p}{\partial y}$	0.017***	0.016***	0.016***	0.027	0.028

Note *p<0.1; **p<0.05; ***p<0.01

Predicted Mark-ups and Pricing by Income, Ability, and Minority Status

	(1)	(2)	(3)	(4)	(5)
markup	13.16	13.22	5.30	4.11	4.05
ability	-1.80	-0.92	-1.11	-1.12	-0.94
income	0.35	0.31	0.21	0.25	0.26
minority status	-5.75	-3.08	-4.23	-1.60	-0.58
	(6)	(7)	(8)	(9)	(10)
markup	2.66	3.09	2.86	0.75	2.77
ability	-1.06	-1.06	-1.14	-1.09	-1.96
income	0.47	0.37	0.42	0.51	0.28
minority status	-0.51	-0.50	-0.33	-0.27	-0.11

Note: Markups include pricing by minority status. Figures (in $1,000) calculated using full sample, not just those observed to receive aid.

Predicted Markups at Quintile Medians

Cluster 1					
ability\income	0%-20%	20%-40%	40%-60%	60%-80%	80%-100%
0%-20%	-	0.25	0.66	1.17	9.40
20%-40%	-	0.27	0.68	1.19	9.47
40%-60%	-	0.28	0.70	1.21	10.12
60%-80%	-	0.29	0.71	1.28	11.59
80%-100%	0.00	0.32	0.74	1.24	19.47

Figures in $1,000. Predicted prices are capped.

Parameter Estimates II

	(1)	(2)	(3)
ω	0.0369***	0.0293***	0.0154
	(0.008)	(0.008)	(0.0124)
	Implied by ω Estimate		
γ	0.0027	0.0021	0.0012
κ			0.0002
R^2	0.6328	0.5026	0.1054
Weights?	No	Yes	Yes

Note: Column 3 accounts for minority status.

Goodness of Fit: Average Tuition by Income and Ability

Private College Students											
	Predicted						Actual				
	b_1	b_2	b_3	b_4	b_5		b_1	b_2	b_3	b_4	b_5
y_1	13.62	12.93	13.10	12.83	12.59	y_1	15.48	15.66	16.71	16.25	17.35
y_2	14.47	13.91	14.05	13.50	12.66	y_2	15.91	16.82	17.38	17.14	17.87
y_3	15.70	15.68	14.60	14.60	15.24	y_3	18.10	17.60	17.24	15.29	23.63
y_4	15.88	16.41	15.42	16.56	18.17	y_4	17.34	20.12	20.43	20.24	21.74
y_5	18.84	19.86	20.27	20.43	22.29	y_5	22.67	22.36	25.39	25.37	29.18

Figures in $1,000.

Private College Aid Receivers											
	Predicted						Actual				
	b_1	b_2	b_3	b_4	b_5		b_1	b_2	b_3	b_4	b_5
y_1	13.65	12.78	13.04	13.04	12.63	y_1	12.41	13.84	13.88	12.42	9.71
y_2	14.28	13.63	13.94	13.09	12.53	y_2	13.23	13.49	13.89	12.60	8.90
y_3	15.43	15.04	14.27	14.84	13.70	y_3	14.87	13.48	14.50	12.73	10.95
y_4	15.51	15.51	15.21	15.66	15.88	y_4	13.57	15.31	16.31	14.57	12.22
y_5	18.84	19.12	19.11	18.54	20.12	y_5	19.97	19.05	21.77	19.15	20.86

Figures in $1,000.

Summary of Findings

- We find that a \$10,000 increase in family income increases tuition at private schools by on average \$120 to \$140.
- A one standard deviation increase in ability decreases tuition by approximately \$830 to \$1,750 depending on the selectivity of the college.
- Discounts for minority students are up to \$5,750 at the most selective private colleges.
- Average mark-ups are modest and range between 7 and 20 percent.

General Equilibrium Analysis of Funding Policies

- To conduct some general equilibrium analysis, we simply the analysis.
- We ignore race.
- We consider a model with 2 identical states and 5 private colleges.
- We use a slightly different calibration.
- In our baseline model the maximum federal aid is set at \$6,000.
- We consider a policy experiments that increases (decreases) the maximum aid by \$2,000.
- We also consider the case in which the state subsidy decreases by \$2,000, and tuition increases by same amount.

Goodness of Fit

	Data	Baseline
Total Enrollment	40%	40%
Share of state schools	70%	70%
Proportion of in-state at state	90%	90%
Average federal aid (state schools)	1.25-1.5	1.50
Average federal aid (private schools)	2-2.5	2.44
Average price cap	29.5	29.5
Average institutional aid	6.1	6.04
Private tuition average	23.40	23.46
State tuition average	7.09	7.09
Fraction Receiving Aid (state)	35%	37.8%
Fraction Receiving Aid (private)	35%	44.9%

Characterizing the Equilibrium

j	k_j	θ_j	I_j	q_j	Ave.Tuit.	Ave.Aid	Ave.Inc
1	0.139	2.92	8.84	3.37	7.09	1.51	73.16
2	0.139	2.92	8.84	3.37	7.09	1.51	73.16
3	0.028	3.36	14.66	4.08	21.38	2.46	101.72
4	0.027	3.38	15.57	4.13	22.46	2.47	104.76
5	0.026	3.39	16.47	4.18	23.48	2.47	107.90
6	0.023	3.42	17.41	4.24	24.55	2.49	111.04
7	0.016	3.55	20.21	4.47	27.00	2.24	123.65

Aid and Student Cost

	State Colleges	Private Colleges
Average Tuition	7.09	23.43
Average Student Cost	5.58	20.98
Average Aid	1.51	2.44
Average Aid (conditional)	3.98	5.44
Fraction Receiving Aid	0.38	0.45

College Attendance Proportions

Income Deciles	Ability Deciles* 1	2	3	4	5	6	7	8	9	10
	State Colleges									
1	0	0	0	0	0.032	0.042	0.046	0.061	0.046	0.037
2	0	0	0	0	0.347	0.523	0.530	0.523	0.543	0.488
3	0	0	0	0	0.422	0.617	0.621	0.626	0.621	0.474
4	0	0	0	0	0.358	0.540	0.545	0.541	0.539	0.324
5	0	0	0	0	0.331	0.495	0.498	0.499	0.477	0.177
6	0	0	0	0	0.411	0.592	0.598	0.594	0.510	0.165
7	0	0	0	0	0.466	0.685	0.686	0.654	0.444	0.114
8	0	0	0	0	0.611	0.766	0.771	0.646	0.345	0.121
9	0	0	0	0	0.605	0.842	0.843	0.656	0.354	0.130
10	0	0	0	0	0.596	0.903	0.907	0.547	0.192	0.076
	Private Colleges									
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0.106
3	0	0	0	0	0	0	0	0	0.000	0.227
4	0	0	0	0	0	0	0	0	0.003	0.405
5	0	0	0	0	0	0	0	0.002	0.044	0.644
6	0	0	0	0	0	0	0	0.012	0.148	0.721
7	0	0	0	0	0	0	0	0.050	0.353	0.834
8	0	0	0	0	0	0	0	0.157	0.552	0.845
9	0	0	0	0	0	0	0	0.223	0.581	0.846
10	0	0	0	0	0	0	0	0.395	0.786	0.917

Increasing Maximum Federal Aid to $8,000

	MaxFed=6	MaxFed=8
Total Enrollment	40%	40.96%
Share of state schools	69.53%	70.15%
Proportion of in-state at state	90%	87.96%
Average aid (state schools)	1.50	1.74
Average aid (private schools)	2.44	3.55
Average institutional aid	6.04	5.6
Private tuition average	23.46	23.90
State tuition average	7.09	7.27
Fraction Receiving Aid (state)	37.8%	38.8%
Fraction Receiving Aid (private)	44.9%	49.5 %
Chg. in Avg. St. Cost (state)		-49
Chg. in Avg. St. Cost (private)		-630

Decreasing Maximum Federal Aid to $4,000

	MaxFed=6	MaxFed=4
Total Enrollment	40%	37.7%
Share of state schools	69.53%	68.1%
Proportion of in-state at state	90%	90.7%
Average aid (state schools)	1.50	0.92
Average aid (private schools)	2.44	1.43
Average institutional aid	6.04	6.7
Private tuition average	23.46	22.83
State tuition average	7.09	7.02
Fraction Receiving Aid (state)	37.8%	32.3%
Fraction Receiving Aid (private)	44.9%	38.8%
Chg. in Avg. St. Cost (state)		521
Chg. in Avg. St. Cost (private)		414

Changes in State Aid: $2000 decrease in the subsidy with a $2000 increase in regulated tuition.

	Baseline	StChg=2
Total Enrollment	40%	36.8%
Share of state schools	69.53%	66.75%
Proportion of in-state at state	90%	89.1%
Average aid (state schools)	1.50	1.81
Average aid (private schools)	2.44	2.51
Average institutional aid	6.04	5.79
Private tuition average	23.46	23.71
State tuition average	7.09	9.16
Fraction Receiving Aid (state)	37.8%	41.4%
Fraction Receiving Aid (private)	44.9%	46.7%
Chg. in Avg. St. Cost (state)		1,768
Chg. in Avg. St. Cost (private)		218

Summary of Changes in Funding Policies

- There are some strong asymmetries in the effects of increases and decreases in federal aid.
- Increases in federal aid have only moderate affects on college attendance and does not lower student costs.
- Decreases in aid have drastic effects on poorest two deciles of the income distribution that lose access to higher education.
- A reduction is state aid has even larger negative effects on access to education than a similar reduction in federal aid.