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Do liberal arts colleges maximize profit?

Ann M. Gansemer-Topf  
*Iowa State University*, anngt@iastate.edu

Peter F. Orazem  
*Iowa State University*, pfo@iastate.edu

Darin R. Wohlgemuth  
*Iowa State University*, darinw@iastate.edu

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Do liberal arts colleges maximize profit?

Ann M. Gansemer-Topf¹ | Peter F. Orazem² | Darin R. Wohlgemuth²

¹School of Education, Iowa State University, Iowa, USA
²Department of Economics, Iowa State University, Iowa, USA

Correspondence
Peter F. Orazem, Department of Economics, 518 Farm House Lane, Ames, IA 50011-1054.
Email: pfo@iastate.edu

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JEL CLASSIFICATION
L1; I22; L21; L3

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INTRODUCTION

Colleges and universities in the United States collect large amounts of data on potential students (Goff & Shaffer, 2014; Lane & Finsel, 2014). By completing the Free Application for Federal Student Aid (FAFSA)¹ and the Student Profile portions of the ACT² and SAT³ exams, prospective students provide information about their interests and ability to pay during their college choice process. Colleges can leverage this information to set the sticker price (posted tuition rates) as well as the individual’s net price after consideration of financial aid.

Although institutions consistently are in competition with each other, these institutions do not act as perfectly competitive firms, charging all applicants a single price equal to the marginal cost of enrollment. Each school has some uniqueness to its educational services: a different mix of majors, reputed faculty, extracurricular activities, sports, traditions, clubs, and housing options. These factors, along with others such as location and selectivity, provide each school some degree of market power that allows it to charge different prices to different applicants (Breneman, 1994). Schools use their ability to price discriminate to adjust net tuition to reflect the willingness to pay and demand elasticities of applicants who differ in family income, academic ability, ethnic, racial, or gender diversity, athletic or music ability, and other attributes observable on their applications (Baum et al., 2010; Doyle, 2010). At the extreme, schools could perfectly price discriminate by charging each admitted applicant their maximum net tuition.⁴

Price discrimination is common practice among all institutional types, regardless of size, selectivity, and public or private control, but its use is most pronounced at small, private, liberal arts institutions (NACUBO, 2019). Most of the price discrimination comes in the form of tuition discounting, a practice that has increased dramatically in the past decade. In 2003, 35% of small, private liberal arts colleges were offering tuition discounts to 95% or more of the incoming cohort. By 2012, 58% were offering discounts to at least 95% of their freshman class (Behaunek & Gansemer-Topf, 2019). According to the College Board, published tuition and fees at private, nonprofit, 4-year institutions rose 26% over the past 10 years, but net tuition and fees are virtually unchanged (See Appendix Table A1). The growth in the published tuition price with no coincident change in average net tuition is consistent with increased reliance on price discrimination and discounting. Pressures to discount will continue to increase as the number of college-aged students is projected to decline (Grawe, 2018). Even so, some colleges will not be able to attract enough students to cover their expenses (Marcus, 2019), and already struggling institutions may not be able to survive the economic fallout from COVID-19 (Rosenburg, 2020).

This article addresses the question, “Do liberal arts colleges maximize profit?” by examining two competing incentives for price discrimination at liberal arts colleges. One is to use their ability to price discriminate to maximize their net revenue at their profit maximizing enrollment. The second is to use their ability to price discriminate to cross-subsidize from students who are willing and able to pay higher tuition to students who are less willing or cannot afford the higher cost of tuition, raising enrollment above the profit maximizing enrollment. To evaluate the relative importance of these incentives, we use a quadratic approximation to each

¹https://fsadownload.ed.gov/Repository/EDETechRef1819July/1819_EDE_TR201707.pdf.
²https://www.act.org/content/dam/act/unsecured/documents/ACT-StudentInfoBooklet2016-2017.pdf.
³https://collegereadiness.collegeboard.org/pdf/data-layout-sat-subject-tests-electronic-score-report-higher-ed.pdf.
⁴In fact, consulting services such as Maguire Associates promise that they can maximize net tuition per applicant http://blog.maguireassoc.com/blog/falpart1.
college’s average profit function to identify the college’s profit maximizing enrollment. We find that 37% of colleges have enrollment that is within one standard deviation bound from their estimated profit maximizing enrollment. An additional 11% have enrollments more than one standard deviation above their profit maximizing level, suggesting that these schools use a combination of cross-subsidization and endowment support to expand access. The balance of the schools have colleges below their profit maximizing level and would be more financially secure by expanding enrollment. The bottom tail of these schools representing 13% of the total have enrollments less than one standard deviation above their shut-down enrollment levels. As a group, these lower enrollment colleges are not selective on admissions, enroll students with relatively low admissions test scores and low incomes, and have small endowments. These colleges are particularly vulnerable to tuition revenue shocks, as may be occurring with the pandemic.

2 | LITERATURE REVIEW

Hoxby (2009) reports that the most selective private colleges charge well-below their average costs while lower ranked schools charge tuition closer to their average cost. The rationale is that students are both demanders of services and suppliers of peer externalities to their fellow students (Rothschild & White, 1995). Highly selective institutions which are assumed to be higher quality, can have higher tuition than their less selective peers because students who qualify for admittance at highly selective institutions are more willing to pay for this perceived quality (Caskey, 2018; Dimkpah et al., 2004; McDuff, 2007). However, as competition for students increases, a majority of institutions, regardless of selectivity, have relied on tuition discounting to meet enrollment goals (NACUBO, 2019). Grawe (2018) reported that the number of students who pay the full price of tuition has increased in the past decade but only at the most highly selective schools. Given anticipated drops in college-going students, he predicts that this number will remain flat.

Therefore, colleges require a nontuition revenue source to break even because tuition will be insufficient. Winston (1999) notes that colleges are both commercial nonprofits who generate revenues from the sale of goods and services and donative nonprofits who generate revenue from charitable gifts. Colleges with the richest endowment incomes and highest selectivity are at a significant advantage as they can tap into their endowments to cover the amount they have to pay to attract high-quality students. In his analysis of enrollment and tuition at small, private liberal arts institutions, Caskey (2018) found that institutions with high endowments can use these funds to cover their educational costs. These institutions award fewer merit and need-based scholarships than their peers with weaker endowments. Caskey also recognizes that less selective institutions or institutions with less market power must rely more heavily on merit-based scholarships in order to fill seats. If their costs are fixed, it is in their best interest to offer discounted tuition as a way to increase enrollment. It is possible, as assumed by Rothschild and Weiss (1995), that the schools will maximize profit, meaning that they will set the marginal cost of adding a student equal to the marginal revenue of adding a student. However, the existence of endowment income enables colleges to subsidize their students by charging them a tuition price below the cost of production. If colleges choose to do so, they will serve more students than their profit maximizing enrollment at a point where marginal revenue is less than marginal cost, a possibility consistent with the data presented in Hoxby (2009).

Past research on college enrollment strategies has focused on the cost side, as reviewed by Toutkoushian and Lee (2018) and Zhang and Worthington (2018). The focus has been to
examine the existence of returns to scale as enrollment rises, and returns to scope where colleges have outputs of undergraduate and graduate teaching and research. Toutkoushian (1999), Laband and Lentz (2003), and Agasisti and Johnes (2015) found evidence of returns to scope, but the review by Zhang and Worthington (2018) suggests that economies of scope are not relevant for liberal arts colleges that focus heavily on undergraduate education. Virtually all of the studies find that cost structures for liberal arts colleges are distinct from public universities or universities with graduate programs. They also find evidence of falling average costs for a range of enrollments, although studies disagree regarding the cost minimizing enrollments.

Our analysis takes a different strategy because we need to evaluate both costs and returns to educational services. We will allow each college to have its own unique demand and supply relationships that will relate net tuition rates to enrollment. Some will have high costs, high prices, and high quality with substantial subsidies offered to attract quality applicants. Others will have low costs, low prices, and lower quality and offer lower subsidies. In our empirical work, we will need to allow the demand and supply parameters to vary by college. We develop methods to derive the profit maximizing enrollment level for each college, allowing each college to price discriminate. A comparison of actual enrollment compared to the estimated profit maximizing enrollment will tell whether the college exploits its market power to maximize profit or to expand enrollment beyond the profit maximizing level.

3 | METHODOLOGY

A liberal arts college’s power to price discriminate is based on its substantial information from the Free Application for Federal Student Aid (FAFSA) which defines available financial resources. Combined with the application for admission, high school performance, and national tests that define relative student ability, past ties to the school, and likely options at other schools, the college can estimate each applicant’s willingness to pay to enroll. Colleges can use scholarships to lower the net tuition for an applicant whose expected reservation price is below the listed tuition. Financial aid offers are not transferable, and so price discrimination strategies cannot be undone by low reservation price applicants reselling their scholarship offers to high reservation price applicants. Our sample of liberal art colleges uses price discrimination aggressively. Only 15% of their students pay the full stated tuition.

To determine whether a college is maximizing profit, we need to derive an estimate of the enrollment level that maximizes net revenue. To do that, we need to allow colleges to adjust both costs and revenues through their decisions on net pricing and enrollment size. In our empirical work, we will estimate a separate profit maximizing enrollment level for every college. We assume that the instructional operations including tuition revenue and expenses are separable from other college business operations such as residence halls and dining operations, licensing, or research. Let $q$ represent a college’s enrollment and let $p(q)$ be the college’s inverse demand. Total tuition revenue is $R = p(q)q$. Cost is given by $c(q)$, where beyond some level of enrollment, $c'(q) > 0$ and $c''(q) > 0$ so that the marginal cost of instruction is positive and rising as enrollment increases.

The profit maximizing college selects $q$ so as to maximize $\pi(q) = p(q)q - c(q)$. The typical first order condition for a single price monopolist is $\frac{d\pi}{dq} = p(q) - qp'(q) - c'(q) = 0$. However, the
The school’s enrollment choice is illustrated in Figure 1. For price discriminating colleges, the marginal revenue is the inverse demand curve, and so the profit maximizing enrollment is where the marginal cost crosses the inverse demand at \( q_{\text{max}} \). The other point where marginal cost crosses the inverse demand is at \( q_{\text{min}} \). Schools with enrollments below \( q_{\text{min}} \) will lose money on each enrolled student because \( (p(q) < c'(q) \mid q < q_{\text{min}}) \). At all enrollments above \( q_{\text{min}} \) but below \( q_{\text{max}} \), \( (p(q) > c'(q) \mid q_{\text{min}} < q < q_{\text{max}}) \) and so schools are making marginal profit on each additional student. Schools that expand access beyond \( q_{\text{max}} \) will sacrifice revenue because \( (p(q) < c'(q) \mid q > q_{\text{max}}) \).

There is no reason for any school to have enrollment below \( q_{\text{min}} \) as the school would be losing money and would be better off shutting down. However, profit maximizing schools may land between \( q_{\text{min}} \) and \( q_{\text{max}} \) because they failed to get the expected yield from their admitted applicants. Schools whose admissions are beyond the profit maximizing level \( q_{\text{max}} \) are clearly sacrificing profit by expanding access into the range where marginal revenue is less than the educational costs incurred by serving the last enrolled student. It is those schools that we will view as emphasizing access over profit.

To identify \( q_{\text{min}} \) and \( q_{\text{max}} \), we use a Taylor series expansion of the unknown profit function to find the enrollment level that maximizes profit. Complicating such an analysis of college enrollment strategies is that colleges are simultaneously selecting enrollment and net price and so both are endogenous.

Our empirical strategy presumes that colleges are more likely to vary their net tuition price in order to attain a relatively fixed target enrollment as opposed to adjusting enrollment using a rigidly preset price. Enrollment targets are likely to be set based on a college’s residence hall capacity, instructional staff size, or available classroom and lab facilities. Schools can adjust net tuition at the student level to ensure the enrollment target is met. Evidence from studies of prices of goods and services suggests that prices are quite variable (Bils & Klenow, 2004;
Nakamura & Steinsson, 2008; Klenow & Malin, 2010). Nevertheless, while we would expect that liberal arts colleges have great flexibility to adjust their tuitions downward in order to raise enrollments, if they fall below their targets, it would be difficult for schools to raise posted tuition as flexibly.

We can test our assumption that enrollments are relatively fixed and that net tuition is relatively variable by decomposing variation in \( p \) and \( q \) into school-specific, time-specific, and idiosyncratic components. With \( T \) time periods and \( J \) schools, we can conduct an analysis of variance using.

\[
y_{jt} = \sum_{j=1}^{J} \theta_j D_j + \sum_{t=1}^{T} \tau_t d_t + \xi_{jt}; y = p, q
\]

where \( y_{jt} \) is either price or enrollment, the dummy variables \( D_j \) will measure the variation due to fixed effects across schools, the time dummies \( d_t \) will control common responses across schools due to temporal factors, and the remaining error variance will capture idiosyncratic school changes in tuition or enrollment. The greater the variance attributed to fixed factors or common time effects, the less variation that can be attributable to discretionary choices regarding enrollment or tuition policy.

### 4 DATA DESCRIPTION

As a condition of receiving federal aid, colleges were required to report their endowment levels starting in 2003. In 2007, they began reporting net tuition. We exploit that increased data availability on college assets and prices along with already available information on revenues and costs to derive profit maximizing enrollment levels for 405 private, nonprofit, liberal arts colleges in the United States. We then examine whether colleges set their enrollment levels in a manner consistent with profit maximization.

The primary data is contained in the Department of Education’s Integrated Post-Secondary Education System (IPEDS). Each academic institution reports its enrollment, staffing, student body demographics, revenue, and cost. We restricted the sample to include schools labeled as “Baccalaureate Colleges” in “Arts and Sciences” or in “Diverse Fields” using the Carnegie Classifications.\(^5\) We chose this sample of institutions because they primarily serve undergraduate

\(^{5}\)These were coded 21 or 22 in the Carnegie 2010 classification.

| TABLE 1 Analysis of variance for enrollment, tuition, school physical plant, personnel and reputation |
|-----------------------------------------------|
| Enrollment | Tuition | Net tuition\(^a\) | Residence hall capacity | Faculty FTE | Value of buildings | US News ranking |
|-----------|---------|------------------|------------------------|-------------|-------------------|----------------|
| School fixed effect | 0.951 | 0.809 | 0.846 | 0.968 | 0.972 | 0.943 | 0.974 |
| Time fixed effect | 0.002 | 0.163 | 0.052 | 0.004 | 0.003 | 0.015 | 0.001 |
| Idiosyncratic effect | 0.047 | 0.028 | 0.103 | 0.028 | 0.024 | 0.041 | 0.025 |
| Total | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.00 |

\(^a\)Only available since 2008.
students, meaning that there is a tight relationship between enrollments and institutional revenues. Graduate students often have tuition waived or paid by grants and their enrollment is only weakly tied to tuition revenue. It is at the undergraduate level that institutions use price discrimination aggressively to raise revenue.

The analysis reported in Table 1 covered the period from 2003 to 2013. Enrollment is measured by the total undergraduate enrollment, and tuition is measured by the discounted price of admission to the university, not including room and board or fees.6

Enrollment is less subject to adjustment than is tuition. The school fixed effects explain 95% of the variation in enrollment across the schools over 11 years, leaving only 5% for common year effects and idiosyncratic enrollment changes. It is possible that the remaining 5% of the variation in enrollment is due to strategic annual variation in the number of enrolled students, but we find it more plausible that a college sets its targeted enrollment levels at a relatively constant number tied to the school’s physical and personnel capacity, and that the variation reflects random college-specific shocks to the yield from its admissions.7

In contrast to our enrollment results, less of the variation in gross or net tuition is due to fixed differences across colleges. Idiosyncratic variation in net tuition varies twice as much as idiosyncratic variation in enrollment. It is possible that the year-to-year fluctuations in tuition price are outside the control of the school, but we find that less probable than the likelihood that enrollments are subject to exogenous shocks. As such, we find it more appealing to try to instrument for the endogenous variation in enrollments rather than net tuition.

Our finding of greater variation within college net price variation is consistent with several papers that found colleges alter their pricing in response to local competition (Allen & Shen, 1999; Epple et al., 2004; McMillen et al., McDuff, 2007) and that applicants respond elastically to tuition changes (Dynarski, 2003; Hübner, 2012). The competition with other schools also affects admissions policies where schools will take lower quality but high probability of enrolling applicants over high ability but difficult to attract prospects (Che & Koh, 2016). Competition leads to a sorting equilibrium where selective schools admit high quality students while lesser schools concentrate on the lower tail of the ability distribution (Eppele et al., 2006).

In our empirical application, we assume that the attributes of the college including its size, its source of students by state, its physical and instructional capacity, and its quality are relatively fixed over time. This is consistent with the view that schools have a target enrollment capacity, evident in Table 1. We present comparable variance decompositions for college personnel, physical plant, and school reputation. The college fixed effect explains 97% of the variation in residence hall capacity, instructional FTEs, and school reputation as measured by their U.S. News rating. The fixed effect explains only 94% of the variation in building value, but the greater variation in value reflects local variation in the growth of property value and not changing square feet of building capacity. The relatively fixed capacity and reputation are consistent with the relatively constant number of enrollees.

6National Association of College and University Business Officers guidance stipulates that “institutional aid represents consideration payable to a customer and, as such, reduces the transaction price.” Additionally, “excess aid [aid beyond tuition and fees] is considered a separate transaction that is not related to the institution’s tuition performance obligation. https://www.nacubo.org/News/2019/2/NACUBO-Issues-Guidance-on-Tuition-Revenue-Recognition.

7The college fixed effect explains only 86% of its number admitted and 65% of the yield (enrolled relative to admitted), and so schools respond to adverse yield shocks by admitting more students in order to get to the target enrollment.
ESTIMATING THE PROFIT MAXIMIZING ENROLLMENT

Liberal arts colleges choose both their costs and their tuition net of scholarship offers. That approach suggests using revenues minus costs as the endogenous variable rather than just net tuition or just cost as has been common in past studies. Both revenues and costs respond to changing enrollments. A school’s average profit per student is given by total profit, $\pi_{jt}$, divided by enrollment, $q_{jt}$. We confine our revenues to income derived from tuition and fees net of scholarship offers and so we exclude revenue for ancillary services such as housing or meal service and we exclude revenue from grants and contracts. To match our revenue sources, we limit our costs to instructional expenses that represent an average of 33% of total expenses for our colleges. Implicitly, we are assuming that the instructional costs and revenues are separable from other business lines in the college. We approximate the average profit structure for the $J$ colleges using:

$$\frac{\pi_{jt}}{q_{jt}} = \sum_{j=1}^{J} D_{j} \left( \gamma_{0j} + \gamma_{1j} q_{jt} \right) + \gamma_{2} q_{jt}^2 + \epsilon_{jt}$$

which we estimate using an identification strategy we will outline in the next section. Notice that we allow both the constant term $\gamma_{0j}$ and the linear term in enrollment $\gamma_{1j}$ to vary for each college so that each college has its own profit structure. This is our variation on the Epple et al. (2006, 2017) or Agasisti and Johnes (2015) strategy that allows the cost structure to differ for every school to reflect the quality of its students, mix of majors, faculty quality, and academic infrastructure. In our context, the qualities of the school and its student body are embedded in the school-specific profit per student.

The quadratic form in average profit translates to a cubic form in expected profit from instructional services.

$$\pi_{jt} = \gamma_{0j} q_{jt} + \gamma_{1j} q_{jt}^2 + \gamma_{2} q_{jt}^3.$$  \hspace{1cm} (4)

Differentiating with respect to enrollment $q_{jt}$ and solving for the profit maximizing enrollment, we obtain.

---

8We also approximated the average profit using cubic and quartic terms in enrollment and found that they did not add significantly to the explanatory power of the equation. Laband and Lentz (2003), Epple et al. (2006, 2017) and Toutkoushian and Lee (2018) assumed a quadratic relationship between total cost and enrollment which would convert to a linear relationship between average profit and enrollment in our context. Toutkoushian (1999) used a cubic that corresponds to our quadratic form using average profit as the dependent variable.

9Past work has focused on cost or revenue equations. Our focus on unit profit can be related to those strategies as follows. Let average cost be total cost divided by enrollment approximated by $TC_{jt}/q_{jt} = \alpha_{0j} + \alpha_{1j} q_{jt} + \alpha_{2} q_{jt}^2 + \epsilon_{jt}^C$, and let average revenue be approximated by $P_{jt}/q_{jt} = \beta_{0j} + \beta_{1j} q_{jt} + \beta_{2} q_{jt}^2 + \epsilon_{jt}^R$. We are interested in profit, and so we difference the two, getting $P_{jt}/q_{jt} - TC_{jt}/q_{jt} = \epsilon_{jt} = \left( \beta_{0j} - \alpha_{0j} \right) + \left( \beta_{1j} - \alpha_{1j} \right) q_{jt} + \left( \beta_{2} - \alpha_{2} \right) q_{jt}^2 + \left( \epsilon_{jt}^R - \epsilon_{jt}^C \right)$. Which is our Equation (3) with $\gamma_{0j} = \left( \beta_{0j} - \alpha_{0j} \right)$, $\gamma_{1j} = \left( \beta_{1j} - \alpha_{1j} \right)$, $\gamma_{2} = \left( \beta_{2} - \alpha_{2} \right)$, and $\epsilon_{jt} = \left( \epsilon_{jt}^R - \epsilon_{jt}^C \right)$. The coefficients $\gamma_{0j}$, $\gamma_{1j}$, and $\gamma_{2}$ represent the differences in marginal revenue and marginal cost with respect to enrollment.
$$q_{jt} = \frac{-2\gamma_{1j} \pm \sqrt{(2\gamma_{1j})^2 - 12\gamma_2\gamma_{0j}}}{6\gamma_2}$$  \hspace{1cm} (5)$$

which yields estimates of $q_{min}$ and $q_{max}$. If we can generate credible estimates of Equation (3), we should be able to derive estimates of $q_{min}$ and $q_{max}$ which can then be compared with actual enrollment to establish if colleges do admit more students than is consistent with profit maximization.

Note that in this analysis, we maximize profit with respect to quantity where the coefficients reflect the differences between marginal revenue and marginal cost (see Footnote 9). Therefore, the solution to Equation (5) sets the school’s marginal revenue, the added tuition it generates from the last student enrolled, equal to the marginal cost of accommodating that student. In defining the profit maximizing quantity, the school also defines the price that will attract that number enrolled. To the extent that it can exploit its power to price discriminate for the inframarginal students, it will increase its profits even more.

### 5.1 Identification of college enrollment

Identification of the parameters in Equation (3) requires that we generate an exogenous source of variation in college enrollment. From Table 1, we know that most of the variation in enrollment is between colleges and explainable by a college-specific constant. The balance of the variation is due to time-varying but idiosyncratic sources.

We posit that the idiosyncratic shock to enrollment comes from variation in the high school graduation in the states from which the college draws its enrollment. This suggests a Bartik (1991) style instrument that captures variation in the demand for each college. Let $S_{js0}$ be the share of college $j$ freshmen that come from state $s$ in a base period zero, and let $H_{st}$ be the number of high school graduates from state $s$ in year $t$. Then an index of the college $j$-specific high school graduation class in year $t$ would be

$$H_{jt} = \sum_{s=1}^{50} \frac{S_{js0}H_{st}}{S_{js0}H_{s0}}$$  \hspace{1cm} (6)$$

where we measure the average share of each college’s freshman enrollees from each state in 2002–2003. We set the base period high school enrollment, $S_{js0}H_{s0}$, in 2002–2003. Then all values of $H_{jt}$ will be the size of the relevant high school graduating class for college $j$ in year $t$ relative to its value in 2002–2003. Over the sample period, growth in college-specific high school class size varied from $-2\%$ to $+32\%$. Goldsmith-Pinkham et al. (2020) show that Bartik-like instruments are equivalent with identification through the shares $S_{js0}$ and not the high school graduating classes, $H_{jt}$. A sufficient condition for the validity of the instrument is to demonstrate the exogeneity of the state shares. Applying their strategy to our context, they propose regressing the state shares on observed factors that would affect the demand for the school. We use measures of school quality (SAT scores and the Barron’s index of selectivity) and local economic factors (growth and level of per capita income, the employment rate, employment growth, and the average wage). Of the 10 most populous states, only New York had an $R^2$
greater than 0.1 and we could not reject the null hypothesis that all the regressors were equal to zero at the 0.05 level except in New York. The evidence is broadly consistent with the assumed exogeneity of the state shares.

College \( j \) enrollment is related to its changing supply of high school graduates by

\[
q_{jt} = \sum_{j=1}^{J} \beta_{0j} D_j + \beta_1 (DC_{0j} \ast H_{jt}) + \varepsilon_{jt}^q
\]

Table 2

| \( \beta_1 \) | 0.386** |
|---------------|---------|
|                | (5.31)  |

| College fixed effects | Included** |
|-----------------------|------------|
| R²                    | 0.952      |
| N                     | 4474       |
| F(1,406)              | 28.2       |

Note: \( t \)-statistics in parentheses. \( (DC_{0j} \ast H_{jt}) \) represents the interaction between residence hall capacity in the base year and a college-specific share-weighted average of the size of the state high school graduating classes from which it recruits.

** Significant >1%. Standard errors clustered at College ID.

Table 3

Average profit equation using instrumented enrollment, liberal arts colleges, 2003–2013

\[
\frac{\tau_{jt}}{\gamma} = \sum_{j=1}^{J} \left( \gamma_{qj} + \gamma_1 \left( D_j \cdot q_{jt} (DC_{0j} \ast H_{jt}) \right) \right) + \gamma_2 \left( q_{jt} q_{jt} (DC_{0j} \ast H_{jt}) \right)^2 + \varepsilon_{jt}
\]

| \( \gamma_{qj} \) | -100719** |
|-------------------|-----------|
| \( \gamma_1 \)    | 106.5**   |
| \( \gamma_2 \)    | -0.032    |

| R²                 | 0.923     |
| N                  | 4427      |

Note: \( t \)-statistics in parentheses. Wooldridge test of endogeneity: \( F(1, 404) = 0.082 (p = .77) \). \( \gamma_{qj} \) is the average of 405 values of \( \gamma_{qj} \) which are jointly significant. \( \gamma_1 \) is the average of 405 estimates of \( \gamma_1 \) which are jointly significant.

** Significant >1%, *significant >5%. Standard errors clustered at College ID.

We embed the instrumented enrollment into our average profit equation.
The estimates are summarized in Table 3. We easily reject the null hypotheses that the \( \gamma_0 \) and the \( \gamma_1 \) terms are equal across schools, and so each school has a unique profit structure that will determine its target enrollment if it wishes to maximize profit. The common quadratic term, \( \gamma_2 \), is negative but quite small and statistically insignificant. Using these coefficients, we derive estimates of \( q_{\text{min}} \) and \( q_{\text{max}} \) for each college. \( q_{\text{min}} \) is the enrollment level below which variable costs

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\[ \frac{\pi_{jt}}{q_{jt}} = \sum_{j=1}^{J} (\gamma_{0j} + \gamma_{1j} [D_j \cdot q_{jt} (D_j \cdot (DC_{0j} \ast H_{jt}))] + \gamma_2 [q_{jt} (D_j \cdot (DC_{0j} \ast H_{jt}))]^2 + \epsilon_{jt} \]

The estimates are summarized in Table 3. We easily reject the null hypotheses that the \( \gamma_{0j} \) and the \( \gamma_{1j} \) terms are equal across schools, and so each school has a unique profit structure that will determine its target enrollment if it wishes to maximize profit. The common quadratic term, \( \gamma_2 \), is negative but quite small and statistically insignificant. Using these coefficients, we derive estimates of \( q_{\text{min}} \) and \( q_{\text{max}} \) for each college. \( q_{\text{min}} \) is the enrollment level below which variable costs

10Ordinary least squares estimates treating enrollment as exogenous yielded results that were comparable in sign to those in Table 3. However, the coefficients generated excessively variable estimates of \( q_{\text{min}} \) and \( q_{\text{max}} \) with unreasonable outliers for both.
exceed revenue and the school should close. $q_{\text{max}}$ is the enrollment level that would maximize tuition revenue net of instructional costs.\textsuperscript{10}

The coefficients are not easily interpretable on their own, and so we present comparisons of actual enrollment with the profit maximizing enrollment average across the 11 years in Figure 2. The 45° line would equate actual enrollment with profit maximizing enrollment. Points above the 45° line represent colleges whose average actual enrollments exceed the profit maximizing level over the 11 years while points below indicate colleges whose enrollments are less than the profit maximizing level. Most of the liberal arts colleges, 72.2%, consistently had enrollments at or below the profit maximizing level. These schools would generate more in tuition revenue than in added instructional costs by adding students. The remaining 27.8% of colleges had actual enrollment above the profit maximizing level, indicating that they sacrificed some profit by expanding access to students in the range where marginal revenue fell below marginal cost.

Figure 3 presents a second illustration of the model implications that uses a standardization to place all colleges in the same relative enrollment units. Actual college enrollment is calibrated to our estimates of $q_{\text{min}}$ and $q_{\text{max}}$ as follows.

\[
\text{If } q_{ij} < q_{\text{min}}, \text{ then } q_{ij}^R = \frac{q_{ij}}{q_{\text{min}}},
\]

\[
\text{If } q_{\text{min}} \leq q_{ij} \leq q_{\text{max}}, \text{ then } q_{ij}^R = \frac{q_{ij}}{q_{\text{max}}} + 1
\]

\[
\text{If } q_{ij} > q_{\text{max}}, \text{ then } q_{ij}^R = \frac{q_{ij}}{q_{\text{max}}} + 1
\]

This monotonic transform provides a valid comparison across colleges of each college’s enrollment relative to its predicted critical values. Transformed relative enrollments less than 1 indicate enrollments in the range where marginal revenue is below marginal cost. No schools should have enrollments below 1. Values between 1 and 2 are in the range where marginal revenue is greater than or equal to marginal cost. Values above 2 are in the range where marginal revenue is less than marginal cost and schools are sacrificing profit to increase student access. Because marginal revenue is less than marginal cost both below $q_{\text{min}}$ and above $q_{\text{max}}$, and rising between $q_{\text{min}}$ and $q_{\text{max}}$, average profit, $\pi_{jt}$, should be quadratic in our rescaled relative enrollments, $q_{ij}^R$. That pattern is apparent in Figure 3.

The computation of $q_{\text{min}}$ and $q_{\text{max}}$ is highly nonlinear, and so we approximate the standard deviation in the estimates by bootstrapping the coefficients and their associated values of $q_{\text{min}}$ and $q_{\text{max}}$. We replicated the estimation 100 times, sampling the colleges with replacement. From the sampling variation, we generated one standard deviation bounds, $[q_{\text{min}} \pm \sigma]$ and $[q_{\text{max}} \pm \sigma]$.

No colleges have enrollments below $q_{\text{min}}$. The truncation is sensible because a college would be better off shutting down than remaining open with enrollments below $q_{\text{min}}$. However, 13% are less than one standard deviation above $q_{\text{min}}$. These are among the 72% of the colleges whose average enrollment lies between $q_{\text{min}}$ and $q_{\text{max}}$. For these, marginal revenue is above marginal

\textsuperscript{11}Reported using 2013 actual data. There were 16 colleges that had negative average profit over the 2003–2013 sample period.
cost. With sufficiently extensive losses on the first $q_{\text{min}}$ students, it is possible that these colleges would have negative average profit, but only 13 of these colleges had negative tuition revenue net of instructional cost. The rest (95%) of the colleges with relative enrollments between 1 and 2 had a positive average profit.

Thirty-seven percent of the colleges were within one standard deviation above or below the profit maximizing enrollment. For all the colleges in the relative enrollment range between 1 and 2, raising enrollments up to the point where marginal revenue equals marginal costs would make them better off financially. Effectively, those colleges that lie more than 1 standard deviation below $q_{\text{max}}$ are not using their price discriminating power sufficiently to meet their profit maximizing potential. They could make themselves better off by expanding access to more applicants by discounting more aggressively.

The remaining 28% of the colleges have $q^{R}_{ij} > q_{\text{max}}$, and 11% of all colleges have enrollments more than 1 standard deviation above $q_{\text{max}}$. This is the range where marginal revenue is below marginal cost, and 21% of these colleges (6% of the total) had negative profit in 2013. All of these colleges with $q^{R}_{ij} > q_{\text{max}}$ are sacrificing some profit in order to add students beyond their profit maximizing level. Schools can afford to have enrollments above $q_{\text{max}}$ by cross-subsidizing the extra students from profits earned on their higher-paying students or by using their endowments to absorb losses incurred on the extra students.

5.2 What do colleges do with their profits?

Maximizing instructional revenue relative to instructional cost does not mean that the school is generating profits. The school can have marginal tuition revenues above its marginal instructional costs and still not cover its total instructional costs. The ability to price discriminate may be why the schools are able to cover their expenses, as there is no guarantee that the school would make profit if it charged a single monopoly price. In short, maximizing profit could be consistent with breaking even or losing money on operations.

As nonprofit entities, private schools that can generate excess revenues have numerous alternatives for applying their available funds. Jacob et al. (2018) show that some schools have invested in improved amenities such as better residence halls. More generally, maintenance and upgrading of existing facilities and other capital improvements have absorbed retained
earnings at many schools, and these projects generally require additional infusion of funds through private donations.

Our finding that college enrollments are explained almost entirely by college fixed effects suggests that schools do not experience windfalls of tuition revenue. Tuition provides a reasonably steady revenue stream based on relatively stable student numbers. Schools that fail to maintain their enrollments and fall closer to $q_{\text{min}}$ than $q_{\text{max}}$, as is true for the 13% of the colleges within 1 standard deviation of $q_{\text{min}}$, may have marginal revenues above costs but are in substantial danger of failing if they face a revenue shock. The current enrollment drop during the pandemic represents a sudden move of enrollment toward $q_{\text{min}}$ and away from $q_{\text{max}}$. Compounding the effect will be the loss of ancillary revenues from shuttered residence halls and sports and cultural venues that complement instructional expenses. Many colleges will find it difficult to generate sufficient revenue through tuition discounting to make up for the losses. Absent a cushion provided by endowments, these colleges may face closure (Marcus, 2019; Rosenburg, 2020).

5.3 Which colleges have enrollments beyond the profit maximizing level?

In this section, we group colleges based on their actual enrollment relative to their estimated $q_{\text{min}}$ and $q_{\text{max}}$. By comparing colleges that have extended enrollment access beyond the profit maximizing point, $q_{\text{max}}$, with colleges whose enrollments are consistent with $q_{\text{max}}$, we hope to highlight how and why colleges sacrifice profit to increase access. Groupings are based on rounding to 1 decimal.

Figure 4 provides the count of institutions in each of the rounded groups. The largest number of institutions are in the 1.8 and 1.9 groups, with 52 institutions each. To be consistent with the break at 2.0, the 34 institutions in the “2.0 group” (1.95–2.05) were placed in two groups: the 27 with ratios strictly below two, and the seven with ratios strictly above two.

Assuming that institutions above the profit-maximizing enrollment are focused on increasing student access to college at the expense of profit, these schools must have an alternative

---

12IPEDS reports data at a substantial lag, and so data showing the effect of the pandemic on enrollments, instructional and ancillary revenues, and costs will await future analysis.
FIGURE 6  Average percent admitted at liberal arts colleges by enrollment relative to profit maximizing level groups

FIGURE 7  Average ACT 25th and 75th percentiles at liberal arts colleges by enrollment relative to profit maximizing level groups

FIGURE 8  Average percent of undergraduates eligible for Pell Grants at liberal arts colleges by enrollment relative to profit maximizing level groups
revenue source. One possibility is that these are the colleges with larger endowments that can subsidize operations or scholarships. Figure 5 shows the average endowment per student for each relative enrollment group. The colleges with the largest average endowment (above $80,000 per student) are in the relative enrollment ranges of [2,2.5].\textsuperscript{13} Institutions near 1.0 have an average per student endowment levels near $15,000.

There are apparent differences in admissions policies between schools below and above their profit maximizing levels. Figure 6 shows that institutions that are closer to two admit the smallest percentage of their applicants, meaning that they are more selective, compared to schools closer to \( q_{\text{min}} \) or above \( q_{\text{max}} \). Schools close to \( q_{\text{min}} \) have the lowest college entrance exam scores (Figure 7), while those colleges above \( q_{\text{max}} \) have some of the highest average entrance scores despite taking a higher fraction of their applicants. The colleges that enroll beyond their profit maximizing level also enroll a large share of Pell grant students (Figure 8).\textsuperscript{14} Institutions near their profit maximizing enrollments admit the smallest share of Pell eligible students. Institutions that are near the \( q_{\text{min}} \) levels enroll the highest fraction of Pell eligible students.

While we cannot prove enrollment strategies or motives based on these enrollment metrics, the patterns suggest three types of liberal arts colleges. Those close to \( q_{\text{min}} \) would like to have larger enrollments but they lack strong demand. As a result, they attract relatively weak students, admit a high fraction of their applicants, and rely on external scholarship aid to enable their students to pay. These schools are vulnerable to adverse tuition shocks, particularly because they have modest-sized endowments.

The schools nearer \( q_{\text{max}} \) tend to attract more able and higher-income students and they charge them close to their reservation prices. They do not use their endowments aggressively to expand access through institutional scholarships, and so their endowments are able to grow. They use their ability to price discriminate to cover expenses and build retained earnings.

The third group has enrollments beyond \( q_{\text{max}} \). These schools attract good applicants and use their relatively large endowments to support lower income students and to support a larger student body than would be consistent with profit maximization. They use their ability to price discriminate to cross subsidize students of modest means.

The first group of colleges with enrollments near \( q_{\text{min}} \) would appear to be facing some serious financial exigencies. They lack the endowments to grow and they lack the ability to attract high income and high ability applicants. Because they have too few students relative to their optimum at \( q_{\text{max}} \), they have larger per student instructional expenses and a smaller number of students paying above their marginal costs. Absent the development of new enrollment strategies or public policies to bring these colleges closer to their optimal scale, it would appear that they will face a struggle to survive.

\section*{5.4 What do these estimates imply about market power?}

Our estimates presume that colleges are using their market power to price discriminate. This contrasts from traditional measures of market power such as the price cost margin (Lerner, 1934). Typically, we would apply the Lerner Index to a single price monopolist, but we can apply the coefficients in Table 3 to evaluate the implied market power at the school's

\textsuperscript{13}The 2.5 group consists of four institutions, two of which have extremely large per student endowments.

\textsuperscript{14}The Pell grant is the largest program providing tuition grants to students from very low family incomes.
position on its demand curve. Note that the dependent variable, $\frac{\pi_{jt}}{q_{jt}} = P_{jt} - C_{jt}$ is the unit price minus unit cost, the numerator of the Lerner Index. If we divide both sides of Equation (3) by the price and assume the error is zero in expectation, we get a measure of the Lerner Index.

$$LI_{jt} = \frac{\pi_{jt}}{P_{jt}q_{jt}} = \frac{P_{jt} - C_{jt}}{P_{jt}} = \frac{\gamma_0 + \gamma_1 q_{jt} + \gamma_2 q_{jt}^2}{P_{jt}} = -\frac{1}{E^D_{jt}}$$ (7)

Equation (7) will be positive if the liberal arts college charges above its marginal cost.

If liberal arts colleges were single price monopolists, the Lerner Index would lie between zero and one, meaning that the elasticity of demand would be in the elastic range. However, colleges can price discriminate, and so the marginal revenue of adding the student is the net price charged that student. As a result, colleges could charge a net price to the last student in the inelastic range. In addition, schools may use endowment income to offer scholarships or else cross subsidize so that positive net revenue received from low demand elasticity students is used to lower the tuition below cost for high demand elasticity students (high need, high aptitude or both). Consequently, the Lerner Index does not provide a sharp prediction of either the profit maximizing price or enrollment, unlike our derivation of the profit maximizing enrollment in Equation (5).

We illustrate the cumulative distribution of college Lerner Indexes in Figure 9. We find that 88% of the schools have Lerner indexes in the range between zero and one, consistent with the range of the demand curve where a single price monopolist would locate. Another 11% are in the negative range where they would locate if they are admitting students at a loss on the margin and using cross-subsidization through price discrimination and/or endowment financing to cover the losses. Only three schools are in the range where the Lerner Index exceeds 1, meaning the school's demand elasticity is in the inelastic range. In general, the results in Figure 9 are consistent with a finding of market power, but because liberal arts colleges could locate anywhere along their demand curves, there is no refutable hypothesis about the optimal position on the demand curve based on the Lerner Index.
Price discrimination is a common practice among U.S. colleges and universities and especially prevalent at small, private liberal arts colleges. Institutions have access to a significant amount of student information that allows them to charge different rates of tuition to meet their enrollment and revenue goals as well as goals related to increasing access. This study expands on past research by evaluating both costs and returns to educational services and market demand to determine the profit maximizing college enrollment. We address the question, “Do liberal arts colleges maximize profit?” by comparing actual enrollment against the profit maximizing enrollment. We assess whether colleges use their ability to price discriminate to maximize school profit or to expand access through cross-subsidization, taking net profits earned on wealthier students to lower the costs for low-income applicants.

We find that 37% of institutions have enrollments within 1 standard deviation of their profit maximizing level. These schools enrolled relatively higher income students, did not admit lower than average Pell-eligible students, and had relatively selective admissions policies targeting applicants with high test scores. An additional 11% of the institutions had enrollments more than 1 standard deviation above the profit maximizing level, indicating that they were sacrificing profit to increase access. These schools also had relatively high ability students, but admitted more Pell-eligible students and had relatively strong endowments that helped to cover the losses incurred on the extra students.

This 48% of the liberal arts colleges illustrate three reasons to use price discrimination. Some of these schools generate actual profits in the form of net earnings that they can retain for future capital investments or service expansion. These institutions may be reinvesting in buildings or programs that enhance the quality of the institution (Epple et al., 2019) or the amenities that they offer students (Jacob et al., 2018). Another possibility is that price discrimination is necessary to meet their recurring instructional expenses. In other words, if not for price discrimination, the schools would operate in the red. As the number of high academic ability, high-income students continues to decline and competition for these students increase (Grawe, 2018), these institutions may struggle to meet enrollment or revenue goals without exploiting their ability to charge each student their reservation price. The third reason is that the school can cross-subsidize from their higher ability-to-pay students to their lower ability to pay students to expand access beyond the profit maximizing enrollment.

The remaining 52% of the liberal arts colleges have enrollments more than 1 standard deviation below their profit maximizing level. Of these, the bottom 13% of all colleges were less than one standard deviation above \( q_{\text{min}} \), equivalent of a shut-down enrollment level. The remaining 39% of all colleges in this group are in better position but have not used their price discrimination powers sufficiently to raise enrollment to maximize net tuition revenue. All of these schools would increase profit by admitting more students and charging them net tuition above the marginal cost of providing them educational services.

As a group, the bottom tail of these colleges has relatively poor endowments which means that they are both atypically dependent on tuition revenue to cover expenses and yet generating relatively low amounts of tuition revenue due to smaller enrollments. These schools are susceptible to falling below \( q_{\text{min}} \) if they face an adverse enrollment shock and may be most vulnerable to closing. The pandemic represents an unforecastable enrollment shock that serves as a stress test for the sustainability of these colleges (Volk & Benedix, 2020). Our results suggest that the most adversely affected would be the colleges closest to \( q_{\text{min}} \) and those with weak endowments.
Future research will be able to test whether our measure of actual enrollments relative to $q_{min}$ and $q_{max}$ predict college financial distress.

Our results suggest that a large fraction of liberal arts colleges have untapped capacity to the point where the college could add additional students at marginal costs that are below marginal revenue. This may reflect alternative incentives for the college to limit enrollment, perhaps as an attempt to retain high ratios of faculty to students or to concentrate on a relatively homogeneous student body. However, with concerns at the national level regarding access to college for the low income or historically marginalized students, it may also be useful to consider policies that would induce these colleges to expand access to these underserved populations. Even small changes in the cost of admission can affect incentives to apply to more expensive private schools (Pallais, 2015), and there is convincing evidence that low income students atypically benefit from access to better schools (Canaan & Mouganie, 2018; Dale & Krueger, 2002; Pallais, 2015). Voucher systems for low income students have been shown to expand utilization of excess capacity in private schools in other settings (King et al., 1999). Perhaps such a program would induce private colleges to expand access as well.

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APPENDIX

| Academic year | Published tuition and fees | Net tuition & Fees | Published tuition, fees, room, & board | Net tuition, fees, room, & board | Grant aid & tax benefits per student |
|---------------|-----------------------------|--------------------|----------------------------------------|----------------------------------|--------------------------------------|
| 1998–1999     | $22,710                     | $12,750            | $31,590                                | $21,630                          | $9,960                               |
| 2008–2009     | $28,440                     | $14,580            | $38,420                                | $24,860                          | $13,860                              |
| 2018–2019     | $35,830                     | $14,610            | $48,510                                | $27,290                          | $21,220                              |

Percentage changes

| Academic years | Percentage change |
|----------------|-------------------|
| 1998–2018      | 57.8%             |
| 2008–2018      | 26.0%             |

Note: Trends in College Pricing, College Board, 2018.