An Analysis of the Cost of an Undergraduate Degree and the Incentives of the State, the University, and the Student

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21 September 2015

1 Abstract

To expand undergraduate enrollments or to make decisions regarding rule changes for degrees, administrators need information on how much expansions and contractions in each department cost. This paper presents several methods of accounting for per-credit hour cost across departments. Using internal data from UCSD, we find that most social sciences are relatively cheap and engineering is relatively expensive.

This paper then simulates the university's allocation of funding to undergraduate departments and the student response. We find that a university with static undergraduate fund-per-student preferences will allocate funds-per-student away from departments with large number of students to discourage them from majoring in those departments and instead majoring in a less-filled field. Using data from UCSD, we show that departments with large numbers of graduates are cheaper per degree, have higher modified student-to-faculty ratios, and graduate *sooner* than their colleagues in a different program at the university.

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§We would like to thank Devaney Kerr, Financial Manager in the Mechanical & Aerospace Engineering Department, and Sue King, Chief Administrative Officer in the Economics Department, with help procuring and understanding the administrative data. Further, we would like to thank Christine Hurley and Kirk Belles. Christopher Beliare from the real estate firm Newmark Grubb Knight Frank assisted us in locating lease data for the UCSD area. Further, input from department chair Valerie Ramey was invaluable.

2 Introduction

2.1 Instruction-Related Cost per Degree

Decades of higher-than CPI education inflation in higher education have led administrators and policy makers to look inward at cost. For bachelors degrees, which are the focus of much of the policy debate on the cost of education, we can measure many different parts of the degree. The first is actual, instruction-related cost. The other two other large categories would include largely fixed costs: first, the cost of running the university, such as building maintenance, libraries, police, and utilities. The second is contract and grant related research. Our goal in this study is to determine how much money it costs *to add students* to the university; thus, we are concerned with instruction related costs.

Few studies attempt to deconstruct cost on a department basis (an attempt is found in Johnson (2009)). However, policy makers have discussed or hypothesized about the cost of different departments. These statements have often generated controversy, as did one made by former University of California President James Yudolf:

> Many if our, if I can put it this way, businesses, are in good shape. We're doing very well there. Our hospitals are full, our medical businesses, our medical research, the patient care. So, we have this core problem: Who is going to pay the salary of the English department? We have to have it. Who's going to pay it in sociology, in the humanities? And that's where we're running into trouble (Michels 2009).

Yudolf may not have been engendering any sympathy from the humanities. In contrast to Yudolf, Watson (2010) mentions a system, the Responsibly Controlled Management System (RCM), which showed that the humanities were among the most efficient users of university money. Watson implies in the article that the RCM was mysteriously abandoned when it found that Yudolf's "businesses" were using the system least effectively.

2.2 Funding

Higher education in the United States is funded at the individual and household, state, and federal levels. In 2008, the U.S. spent a combined 2.7% of its GDP on tertiary education, which was virtually unchanged since 2000 (OECD 2011). What had changed, however, was the level of student indebtedness, the direct cost of education to the students, and the late-2000's recession. Student debt in the first quarter of 2007 amounted to $363 billion; seven years later, this had ballooned to $920 billion (NY Fed).

Part of the problem in public education is state funding; state funding for the University of California fell from an inflation-adjusted per-student outlay of $16,430 in 1990-91, to $8,220 in 2010-11 (UC Office of the President 2011). Increasing cost and decreasing state funding has led universities to raise tuition. Tuition increases, however, leverage students' future earnings and are unsustainable in the long-run. As an example, likely in response to worse hiring outcomes and higher law school tuition, those taking an LSAT dropped dramatically from 2009-10 to 2011-12 – 25%, or around 42,000 test takers (Segal 2012).

This paper will model resources allocated to students within a university. Students themselves are both a resource and a cost. Bound and Turner (2007) find that states that have abnormally large college cohorts in comparison to other states that year graduate *less* students. Further, large universities experience very little outflow to other schools; more commonly, students change majors. A university can be seen to be a customer-locked institution (Arcidiacono 2004).

2.2.1 Funding: Differential Tuition

States, however, also face large budget shortfalls and are questioning the wisdom of funding higher education – and what to fund. Some majors take longer to complete (Babcock and Marks 2011), and some majors earn more than others as well, leading to *potentially* higher net tax revenues. California has provided subsidies on a per-student basis, but other states are exploring providing *more* funding for students who major in STEM fields (science, technology, engineering, and mathematics). Florida considered stopping increases in STEM fields while allowing non-STEM tuition to increase (Webley 2013). This is clearly controversial.

Differential tuition has only recently been in the direction of encouraging enrollment in more expensive STEM majors (Webley 2013, Carter and Curry 2011). This is because the actual delivery system of educating these majors is (perhaps) higher. However, it is not clear that this policy is rational for the state that is funding public institutions. Particularly in the light of same per-student allocations, there is little, besides salary, in the university-student relationship to encourage study of high paying majors. Could it be rational for the state to fund STEM majors at a higher rate?

Recent work on differential tuition has shown that students are price conscious of tuition; however, the elasticity of this response in respect to enrollment ratios is controversial. Carter and Curry (2011) attribute this to the setup of various studies. In their analysis, they look at an individual's choice to major in a particular major instead of a cross-school analysis.

3 Measuring the Cost

In the first part of this study, we quantify the resources needed to train additional undergraduate students in each particular field. Our hope here is to provide a summary statistic that encompasses small (but not *infinitely small*) desires to increase undergraduate enrollments in particular departments, holding the essential departmental characteristics intact. Here, we assume the additional students in these departments will provide little additional cost to the broadly cost-distributed university goods, such as libraries, gyms, roads, etc.

One particularly challenging problem is that of the marginal student. We are not calculating the cost of the marginal student; her contribution to a large department is essentially zero, but not quite. The theoretical underpinnings of adding one additional student to a department are outlined in Hoenack, et.al. (1986). In the case of dropping an additional student in a lecture, the only marginal cost is the cost of meeting with that particular student, grading that particular student's exams, and any other minor administrative cost which is directly attributed to that student (such as the small burden of record keeping, etc.). This marginal cost is clearly small.

Continuing with Hoenack, et.al., once lectures need to be increased, however, the university can operate through several channels. They can have instructors repeat a course twice, which raises the cost, but not quite at the level of adding a completely new instructor. They can lower the marginal cost by ensuring that the faculty member teaches a subject they enjoy teaching.

The university can also raise teaching loads and decrease research and other activities. This essentially is a work increase and, equivalently, a pay decrease, as faculty will still have to be competitive in the same fields they were before the increase. As noted in Nelson and Hevert (1992), and applicable to our study.

> It would be inappropriate to assume that one could reduce the marginal costs to their allocated level by cutting faculty salaries or increasing teaching loads in proportion to the percentage of time allocated to research. Many faculty view the ability to do research as partial compensation for relatively low academic salaries: salaries would thus have to increase to attract sufficient numbers of faculty to positions with higher teaching loads.

Our analysis works at a more extensive margin. In this paper, we assume that the university wants to expand a department to accommodate a large number of students – but not so large that the university needs to add cost-distributed resources. An assumption that makes it possible to calculate this cost is that departments could scale up to teach a new block of students at its current average cost.

3.1 Cost Simulation

We create a simulation to explain how undergraduate spending on *instruction*. As mentioned, the university is a customer-locked institution (Arcidiacono 2004). In this simulation, we look at the attractiveness of majors, we lock students in the university, and we look at the post-admitted behavior of students after the university assigns funding.

In terms of undergraduate education, assume that the university is only concerned about the funds it allocates per student to each department; these funds per student are a measure of the amount of faculty that the department can hire per student, the quality of instruction it provides, etc. In this scenario, a dynamic relationship exists between the students and the university. Because the university allocates funds based on students, the students are actually interpreted by the university as a "cost." The university can manipulate this cost by increasing or decreasing the funds and making different majors more or less attractive.

The results show that higher salaries and fun majors actually lead to *less* funds per student, not more. Students pack these majors, and the university finds less costly majors to increase the quality and prestige of the undergraduate program at the university. Furthermore, it costs more to lure students away from majors with high salary or high utility.

3.1.1 Students

Students file into majors based on salary, funds-per-student, and likeability of majors. Denote students $s = 1, \ldots, S$ as choosing a major from a variety of majors, $m = 1, \ldots, M$. Denote year 1 as the year in which students enter, and all actors discount years 25 and further infinitely. Each major comes with an average time to graduation, G_m. The tuition payment per year is p_{tm}. Denote γ_m as the exogenous non-salary appeal of each major. Also denote the exogenous salary over the career years $G_m + 1$ to 24 as w_{tm}. Each student has an exogenous discount rate of r_s, and $\beta_{r_s} = \frac{1}{1+r_s}$. The university provides funds f_m to each major, and the number of students in each major is denoted S_m. Each major has an exogenous inefficiency factor of σ_m. This σ_m maps funds-to-students to effective quality of instruction. For instance, a major may have a high cost to teach – this implies a large σ_m. The quality of instruction is denoted by $\rho_m = \frac{f_m}{\sigma_m S_m}$. Here, ρ_m is a modified funds-per student ratio, which tells us the amount of instructional funds allocated to a student – but adjusted for cost of instruction. The mean-adjusted salary of students is:

$$w_m = \frac{1}{\bar{w}} \left[\left(\sum_{t=G_m+1}^{24} \beta_{r_s}^t w_{tm} \right) - \left(\sum_{t=1}^{G_m} \beta_{r_s}^t p_{tm} \right) \right] \tag{1}$$

Here, $\bar{w}$ is the average discounted income stream. The *proportion of students* in each major i given a funding allocation is given by:

$$S_i|\mathbf{f} = \frac{S}{\sum_{m=1}^{M} \left[\frac{\gamma_m}{\gamma_i}\right]^{\frac{b_1}{1+b_2}} \left[\frac{w_m}{w_i}\right]^{\frac{b_3}{1+b_2}} \left[\frac{\sigma_m}{\sigma_i}\right]^{-\frac{b_2}{1+b_2}} \left[\frac{f_m}{f_i}\right]^{\frac{b_2}{1+b_2}}} \tag{2}$$

We derive equation 2 in section 6.2.3. This proportion is similar to a multinomial logit framework, with the caveat that we assume that the proportions are given as in this equation instead of idiosyncratic. The equivalent utility function for each student is $b_1 \log \gamma_m + b_2 \log \rho_m + b_3 \log w_m$. Here, b_1, b_2, and b_3 are exogenous.

3.1.2 The University

We assume that a benevolent administrator will want to allocate cost-adjusted per-student funds relatively equally across departments so that the quality of instruction is as equal as possible across the university, subject to perhaps a known, exogenous administration preference parameter built into her utility function. The university administrator decides to spend $\xi < 1$ of its funds $f_1 + \ldots + f_M = F$ on undergraduate instruction, and $1 - \xi$ on other utility enhancing services, such as administration, consistent with Cobb-Douglas utility. For now, assume that F is given. The total quality of undergraduate departments is given by:

$$\begin{aligned} Q(\rho) &= \left(\sum_{m=1}^{M} \alpha_i \left[\frac{f_i}{\sigma_i (S_i|\mathbf{f})}\right]^r\right)^{\frac{1}{r}} \\ &= \frac{F}{S}\left(\sum_{m=1}^{M} \alpha_i \left[\frac{\frac{f_i}{F}}{\sigma_i \frac{(S_i|\mathbf{f})}{S}}\right]^r\right)^{\frac{1}{r}} \\ &= \frac{F}{S}\left(\sum_{m=1}^{M} \alpha_i \left[\frac{\widetilde{f}_i}{\sigma_i \left(\widetilde{S}_i|\mathbf{f}\right)}\right]^r\right)^{\frac{1}{r}} \end{aligned} \tag{3}$$

Here, $\widetilde{f}_i$ and $\widetilde{S}_i$ are the fractions of funds and students (respectively) in each major. The outer $1/r$ is not relevant to the maximization. The price of Q can be manipulated through student filing and the fraction of funds devoted to each major. The price of Q can be given by:

$$F = Q \frac{S}{\left(\sum_{m=1}^{M} \alpha_i \left[\frac{f_i}{\sigma_i (S_i|\mathbf{f})}\right]^r\right)^{\frac{1}{r}}}; p_Q = \frac{S}{\left(\sum_{m=1}^{M} \alpha_i \left[\frac{f_i}{\sigma_i (S_i|\mathbf{f})}\right]^r\right)^{\frac{1}{r}}} \tag{4}$$

Additionally, we start with the assumption that there is no tuition or state-funding differential. This implies that the only relevant part of the maximization problem is maximizing $Q(\rho)$, and because F and S are endogenous, only maximizing the utility over the fractional students and funds. We thus have a bounded problem and will perform a maximization search.

Let $M = 3$, $\mathbf{b} = (1, 0.5, 3)$, and $r = 0.25$. Let total funds for undergraduates equal \$500 million, and let the number of undergraduates equal 30,000 (\$16,667 per degree). For simplicity, call the majors economics, engineering, and psychology (in that order, $m = 1,2,3$). We will vary $\boldsymbol{\alpha}$, $\boldsymbol{\gamma}$, and $\mathbf{w}$ to show how differently the university responds. This procedure is run using the Nedler-Mead simplex algorithm for local minima, with a grid search of initial points (0.01-0.97 per major). The local maximum are compared, and the global maximum is selected. We ignore behavior at the far extremes where one major is incredibly unattractive to students such that it is not a viable major.

Assume $\sum \alpha_i = 1$ and $\bar{w} = 1$. Here, letting $\sum \alpha_i = 1$ will allow the utility to be a standard weighted average, and allowing the average income stream, $\bar{w} = 1$, will make interpretation easier as well. Here is a table of initial values; we will systematically vary these throught the simulation:

	α	σ	γ	**w**
Economics	0.33	1.5	0.33	1.0
Engineering	0.50	3.0	0.17	1.2
Psychology	0.17	1.0	0.50	0.8

- University Preference

First, lets vary α. We set $\alpha_3 = 1/6$, and we vary α_1 from 0.001 to 0.83. For engineering, α_2 is simply $1 - \alpha_1 - \alpha_3$. Firstly, as α_1 increases, funding in engineering drops and funding in economics increases. Funding in psychology is not constant, even though α_3 is constant.

As funds are shifted into economics, more students want to major in economics, eroding some of the increased funds. The modified funds per student ratio, ρ_1, also increases. As α_2 dips, ρ_2 goes down as well.

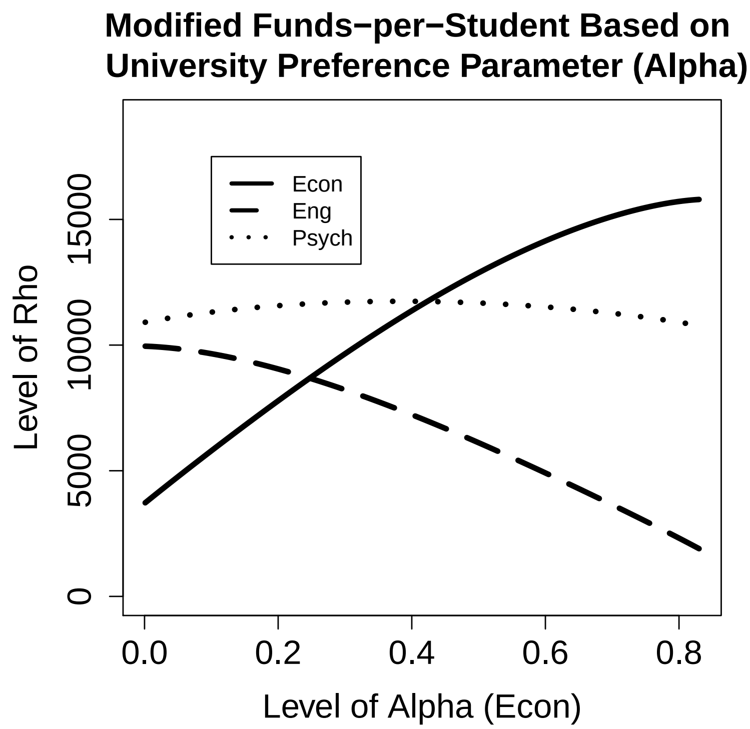

Figure 1: The University Preference Parameter and Modified Funds-Per-Student. The university's department preference parameter on economics, α_1, is varied from 0.001 to 0.83, and the engineering parameter, α_2, changes in tandem so that $\alpha_1 + \alpha_2 + \alpha_3 = 1$ with fixed $\alpha_3 = \frac{1}{6}$. In the picture, we see the effective funds per student in economics, $\rho_i = \frac{f_i}{S_i \sigma_i}$, increases in tandem with its relative preference parameter. This happens even given given the larger number of students in economics (see Figure 2).

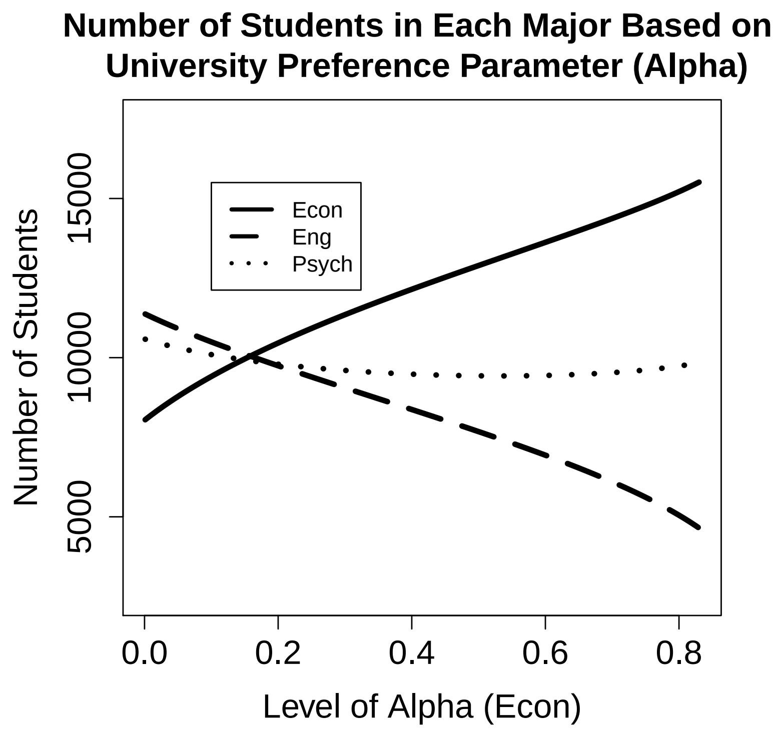

Figure 2: The University Preference Parameter and Student Major Choices. The university's department preference parameter on economics, α_1, is changed from 0.001 to 0.83, and the engineering parameter, α_2, is also changed so that $\alpha_1 + \alpha_2 + \alpha_3 = 1$ and $\alpha_3 = \frac{1}{6}$. In the picture, we see the number of students in economics increases as the university begins increasing effective per-student funds into this department.

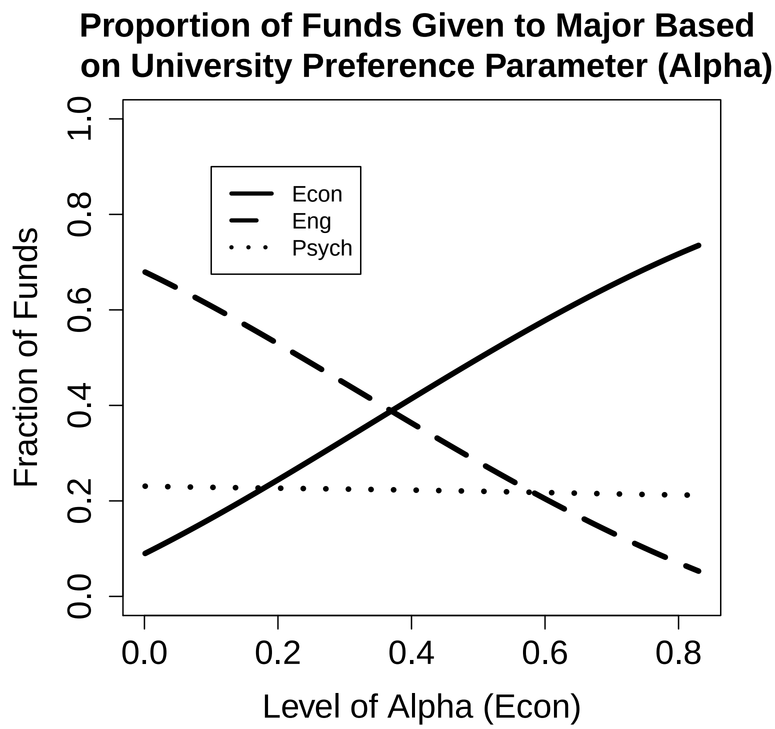

Figure 3: The University Preference Parameter and Funds Given to Each Department. The university's department preference parameter on economics, α_1, is changed from 0.001 to 0.83, and the engineering parameter, α_2, is also changed so that $\alpha_1 + \alpha_2 + \alpha_3 = 1$ and $\alpha_3 = \frac{1}{6}$. In the picture, we see, unsurprisingly, the funds in engineering drop and the funds for economics rise.

- Cost of Education Parameter

Next, we vary the cost of delivering effective undergraduate economics education. In this simulation, we vary σ_1, but we do not alter σ_2 or σ_3. As the cost increases, the university decides to change the funding proportions *out* of economics and into the other two majors. In response, students leave economics, and, in this simulation, not enough students leave to increase the modified funds-per-student ratio. The increased cost also has a negative effect on engineering and psychology; increased costs are bad for all majors.

One important note should be made in this section: Often, high costs are associated with high salaries for students after school. This is an important point. Most of the discussion around higher paid professors are around cost – but this simulation shows that this association both results in fewer majors through the cost channel and more majors through the salary channel. The end result will depend on the sum of these effects (and hence underlying parameters). But methods that universities use to control costs could result in students shifting out of high-paying departments.

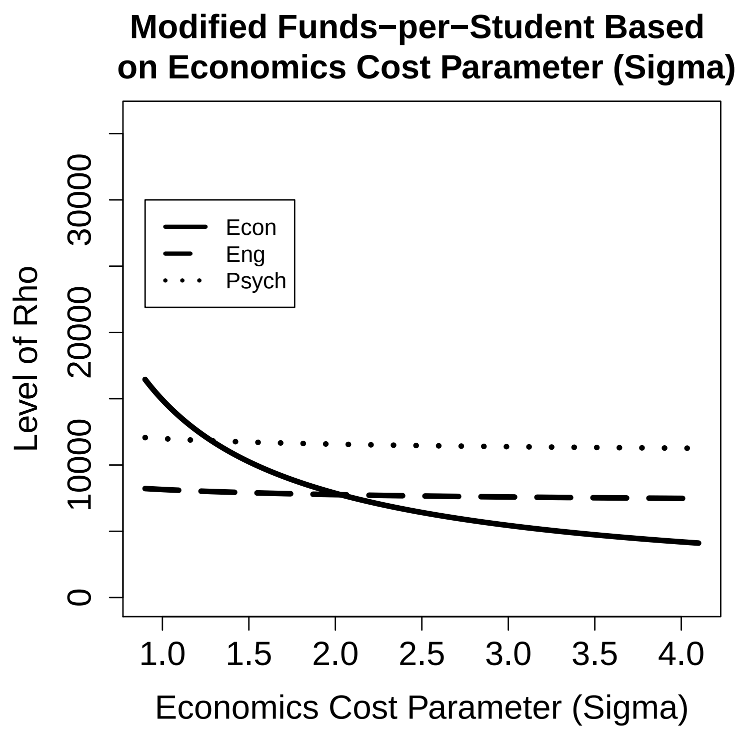

Figure 4: Modified Funds-per-Student Based on Economics Cost Parameter (Sigma). As σ_1 (economics) increases, the effective funds per students drop – in all majors but in particular, in economics.

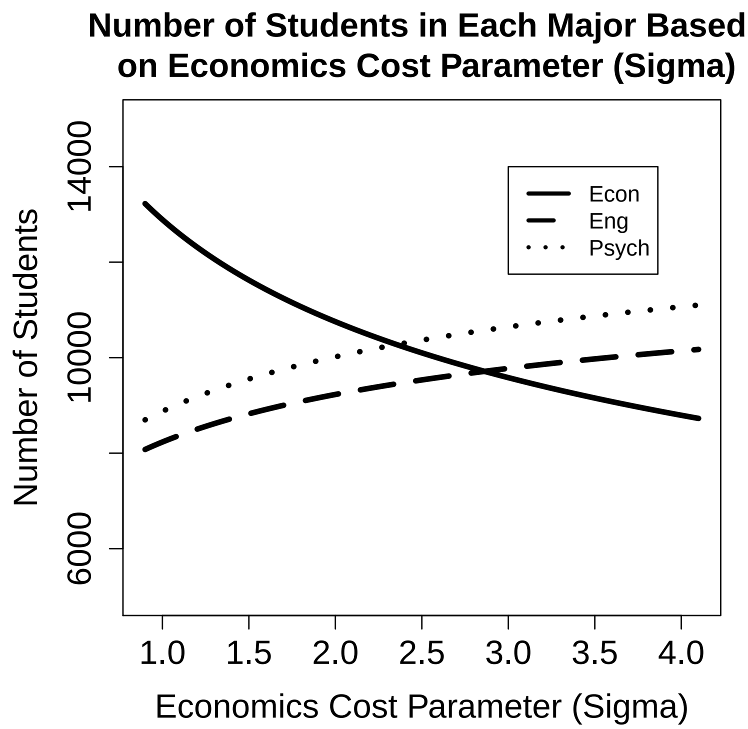

Figure 5: Number of Students in Each Major Based on Economics Cost Parameter (Sigma). As σ_1 (economics) increases, the effective funds per students drop – in all majors but in particular, in economics. This leads students who are on the margin of majoring in economics to leave economics and join the other majors.

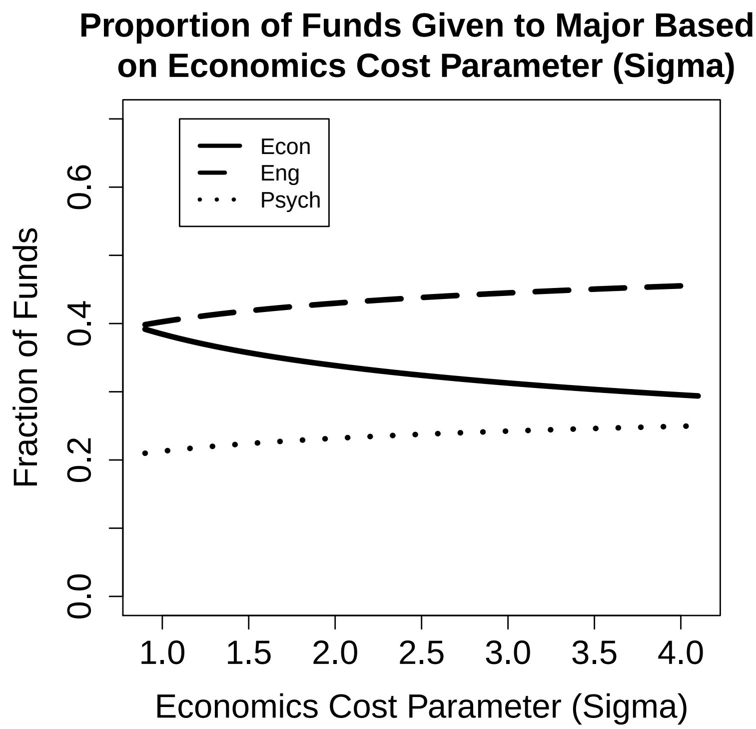

Figure 6: Number of Students in Each Major Based on Economics Cost Parameter (Sigma). As σ_1 (economics) increases, the effective funds per students drop – in all majors but in particular, in economics. In our simulation, the university also drops funds to economics.

- Student Preference Parameter

Next, we vary γ_1. We keep $\gamma_3 = 0.5$, but we vary $\gamma_2 = 1 - \gamma_1 - \gamma_3$. At extremely low γ_1, the university gets a great deal for students who actually do major in economics. For low funding, the university awards a few very high quality degrees to students who really like the field relative to their colleagues in engineering and psychology. On the other hand, having university preferences so out of line with student preferences may not be desirable.

After an initial drop in funding as γ_1 increases, increased students in economics drive total funding of the department higher. Still, it is not enough to increase the total funding per student. Students liking economics have major impacts on ρ_2 and ρ_3.

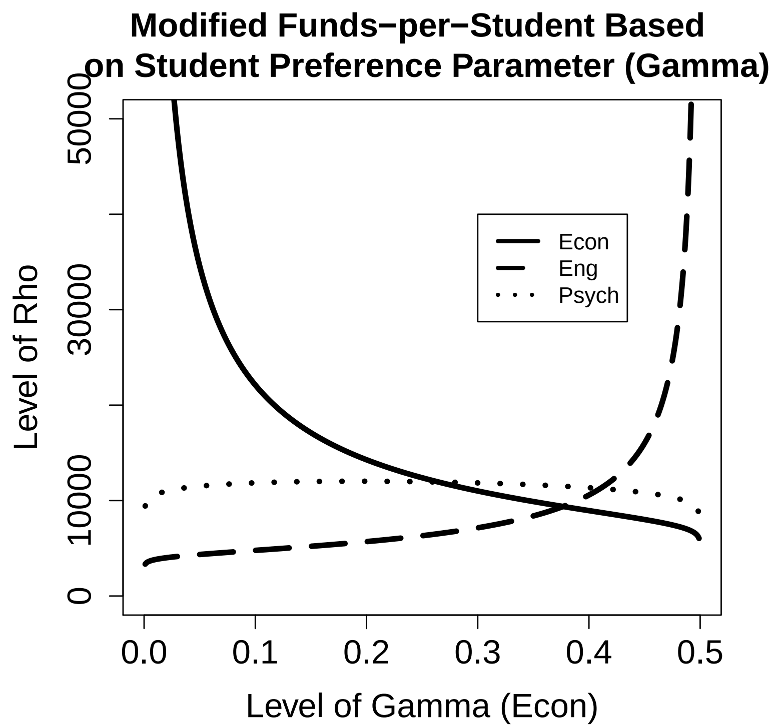

Figure 7: Modified Funds-per-Student Based on Student Preference Parameter (Gamma). In this simulation, we vary γ_1 (student preference parameter on economics) so that $\gamma_3 = 0.5$ and $\gamma_2 = 1 - \gamma_1 - \gamma_3$. Economics (major 1) experiences an influx of majors, making the funds-per-student more expensive for that major. This leads to decreased ρ_1, as the university tries to lower its cost for funds-per-student by making the other majors more attractive.

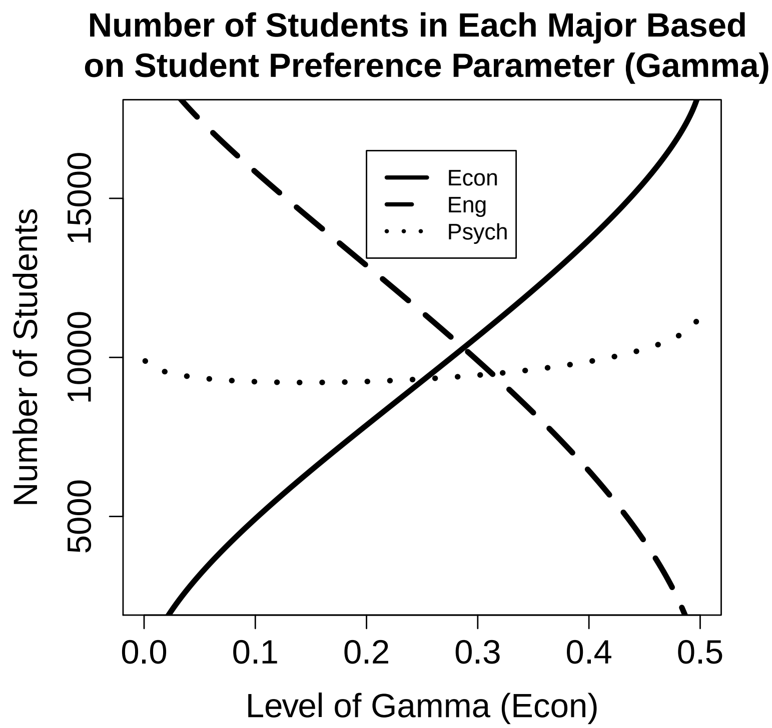

Figure 8: Number of Students in Each Major Based on Student Preference Parameter (Gamma). In this simulation, we vary γ_1 (student preference parameter on economics) so that $\gamma_3 = 0.5$ and $\gamma_2 = 1 - \gamma_1 - \gamma_3$. Economics (major 1) experiences an influx of majors, making the funds-per-student more expensive for that major. This leads to decreased ρ_1 and increased S_1, as the university tries to lower its cost for funds-per-student by making the other majors more attractive.

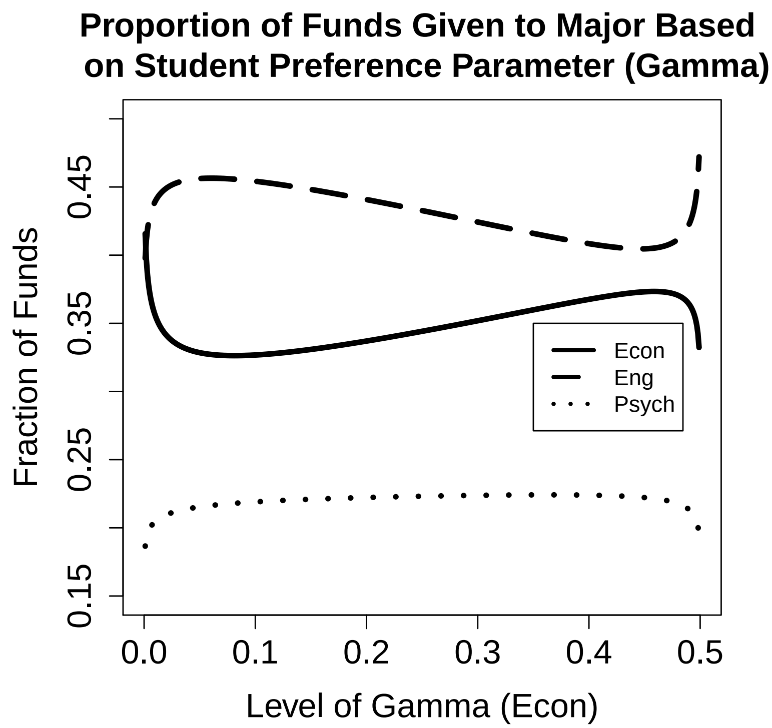

Figure 9: Proportion of Funds Given to Major Based on Student Preference Parameter (Gamma). In this simulation, we vary γ_1 (student preference parameter on economics) so that $\gamma_3 = 0.5$ and $\gamma_2 = 1 - \gamma_1 - \gamma_3$. Economics (major 1) experiences an influx of majors, making the funds-per-student more expensive for that major. The university, at very low levels of γ_1, first lowers funding as students start to come in. Over more reasonable relative γ_1's, the funds increase, but not enough to make up for the students in the major (Figure 8).

- Salary Parameter

Similarly, we see what increased salary does in terms of attracting students to major in economics. As we increase w_1, more students flow into the major. The dynamics of this simulation are similar to γ_1, as the parametrization is the same with different parameters. In this simulation, we set $w_3 = 0.8$ and $w_2 = 3 - w_1 - w_3$.

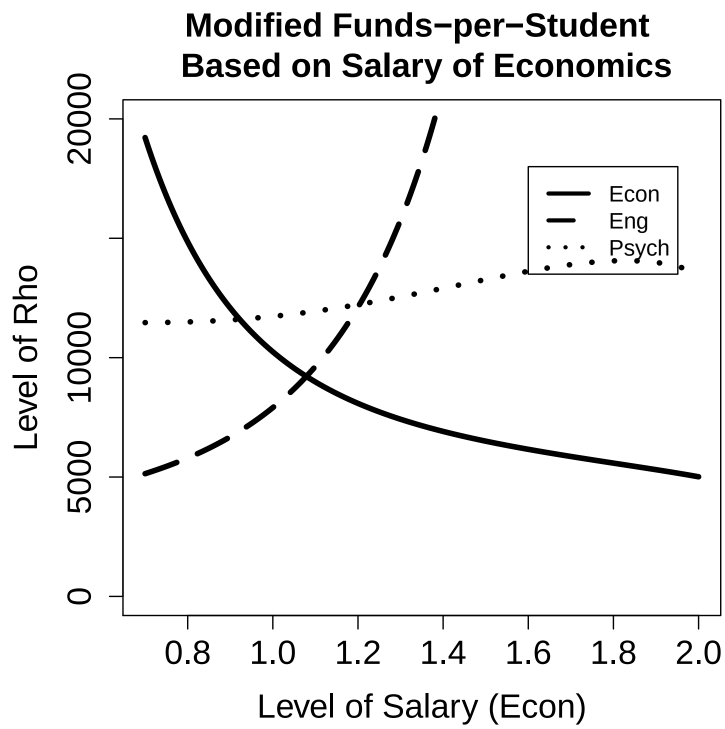

Figure 10: Modified Funds-per-Student Based on Salary of Economics (Salary). As we increase the salary of economics and decrease the salary of engineering, the modified funds-per-student (ρ) increases in engineering and decreases in economics. This is even with more total funds entering in economics (see Figure 12.)

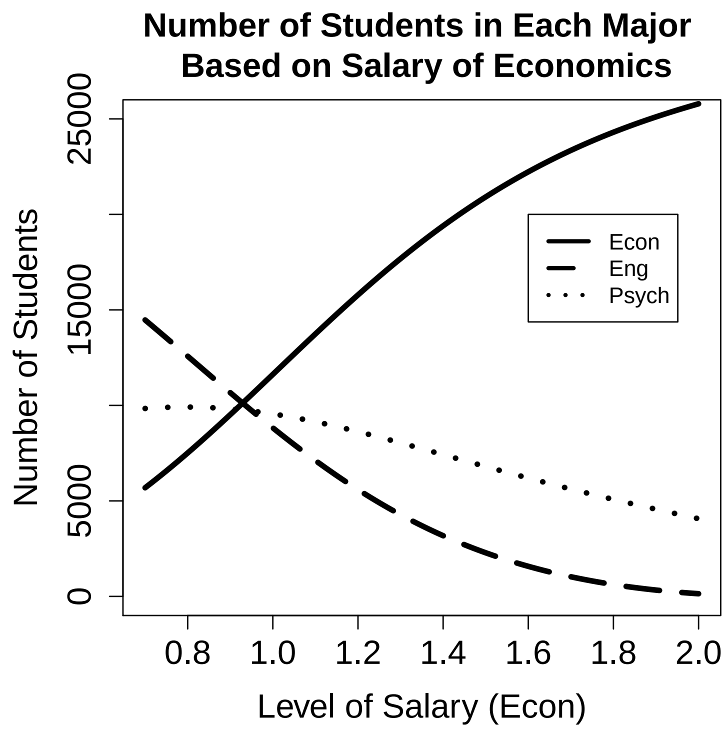

Figure 11: Number of Students in Each Major Based on Salary of Economics (Salary). As we increase the salary of economics and decrease the salary of engineering, more students enter economics – even students who once majored in psychology.

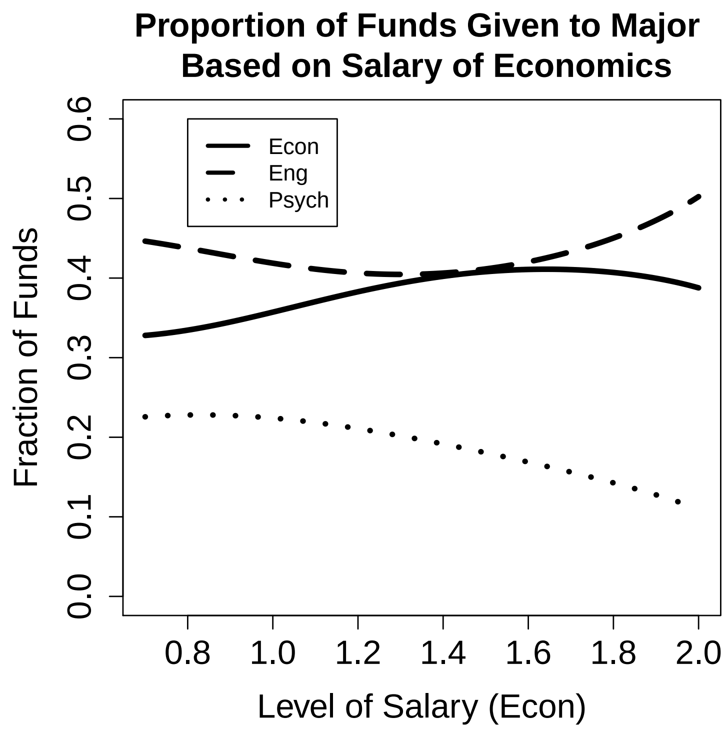

Figure 12: Proportion of Funds Given to Major Based on Salary of Economics (Salary). As we increase the salary of economics and decrease the salary of engineering, the impact on the actual proportions of funds in each department is ambiguous.

3.1.3 Differential Payments

To evaluate the impact of differential tuition, we need to look at two factors. Overall, we find that the results of the simulation are ambiguous. This may seem counter-intuitive; most economists view differential tuition in the prism of (a) higher tuition leads to less students in the major and (b) higher payments will let the university provide more resources to allow more students into the major.

However, in the context of our model, higher tuition payments lead to an incentive for the university to offer higher ρ_i to the department to attract more students. This may outweigh the loss in w_i. Thus, these differential payments are parameter dependent and ambiguous.

We have already shown what happens in our simulation with changed w_i under particular parameters. However, we have not shown what happens to the university with an influx of variable money. To do this, we run a separate simulation where the state differentially funds engineering majors. We will show that the university devotes more resources to engineering, leading to an increased enrollment in engineering.

To simulate the impact differential state funding would have on the university, we must first look at the maximization problem of the university. The university picks both the price of Q and the resulting amount of funds it receives from the state (under the prediction that it can forecast student enrollment). Summarizing, the university finds:

$$\begin{aligned}
\max_{\mathbf{f}} \quad & \quad Q(\rho)^{\zeta} O^{1-\zeta} \\
s.t.: \quad & \\
p_O O + p_Q Q \quad &= \quad S(B + b\widetilde{S}_2) \\
F \quad &\equiv \quad S(B + b\widetilde{S}_2) \\
p_Q \quad &= \quad S / \left[\sum_{i=1}^{M} \alpha_i \left(\frac{f_i}{\sigma_i \, (S_i|\mathbf{f})} \right)^r \right]^{\frac{1}{r}} \\
S_i|\mathbf{f} \quad &= \quad \frac{S}{\sum_{m=1}^{M} \left[\frac{\gamma_m}{\gamma_i}\right]^{\frac{b_1}{1+b_2}} \left[\frac{w_m}{w_i}\right]^{\frac{b_3}{1+b_2}} \left[\frac{\sigma_m}{\sigma_i}\right]^{-\frac{b_2}{1+b_2}} \left[\frac{f_m}{f_i}\right]^{\frac{b_2}{1+b_2}}}
\end{aligned} \tag{5}$$

List of variables and initial parameters:

$M = 3, \mathbf{b} = (1, 0.5, 3)$, and $r = 0.25$

		α	σ	γ	$\mathbf{w}$
(1)	Economics	0.33	1.5	0.33	1.0
(2)	Engineering	0.50	3.0	0.17	1.2
(3)	Psychology	0.17	1.0	0.50	0.80

Parameter	Initial Value	Description
B	\$16,667	Base payment, regardless of major.
b	(will vary)	Additional payment per student enrolled in engineering.
$\mathbf{f} = (f_1, f_2, f_3)$		Funds devoted to each department.
$\tilde{\mathbf{f}} = (\widetilde{f}_1, \widetilde{f}_2, \widetilde{f}_3)$		Fraction of funds devoted to each department.
O		Amount of spending not related to $Q(\rho)$.
p_O	\$50,000	Price of O.
p_Q		Price of Q.
S	30,000	Number of students.
S_i		Number of students in each major i.
$\widetilde{S}_i$		Fraction of students in each major i.
ζ	2/3	Proportion of funds devoted to $Q(\rho)$; which is also the Cobb-Douglas parameter.

This maximization is simulated and proceeds the following way:

1. A previous utility, the current maximum, is stored. If this is the first round, set to zero.
2. An initial funding vector, $\tilde{\mathbf{f}} = (\widetilde{f}_1, \widetilde{f}_2, \widetilde{f}_3)$, is selected.
3. $\widetilde{S}_2$ is determined from the funding vector, $\tilde{\mathbf{f}}$.
4. Price p_Q is determined from the initial vector.
5. F is found.
6. 2/3 of F is devoted to Q, 1/3 to P. This is based on prices $p_O = \$50,000$, and p_Q from step 4.
7. The utility function is calculated. If higher than it was in step 1, this is the new calculation.

The results of the simulation show that as a state-funded subsidy of engineering occurs, funds increase and more students major in engineering. The modified funds-per-student improves in every major, but it grows fastest in engineering. An important point: per-student allocation increase not just in engineering – some of the subsidy is going to educate students in other majors. Further, by assumption, some of the money is going to other (O) parts of the university.

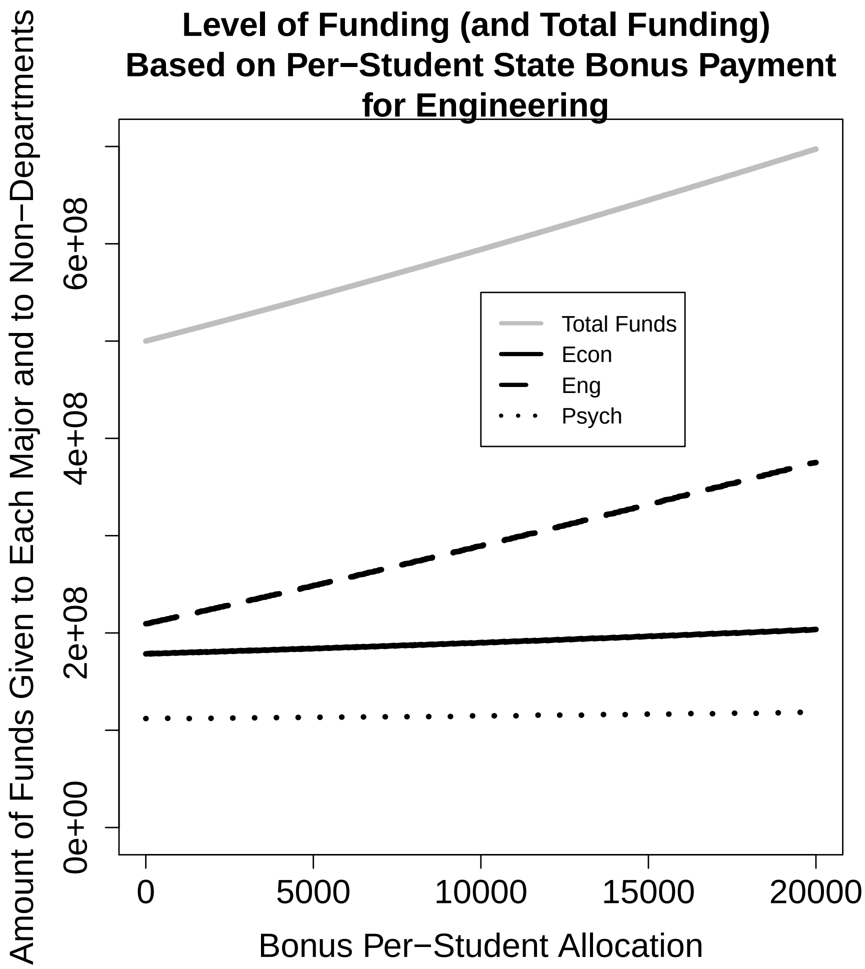

Figure 13: Simulation: Level of Funding and Total Funding Based on Per-Student State Bonus Payment for Engineering. As the state increases b, the per-engineering differential subsidy, total funds increase, and the university decides to grow engineering spending faster than other departments.

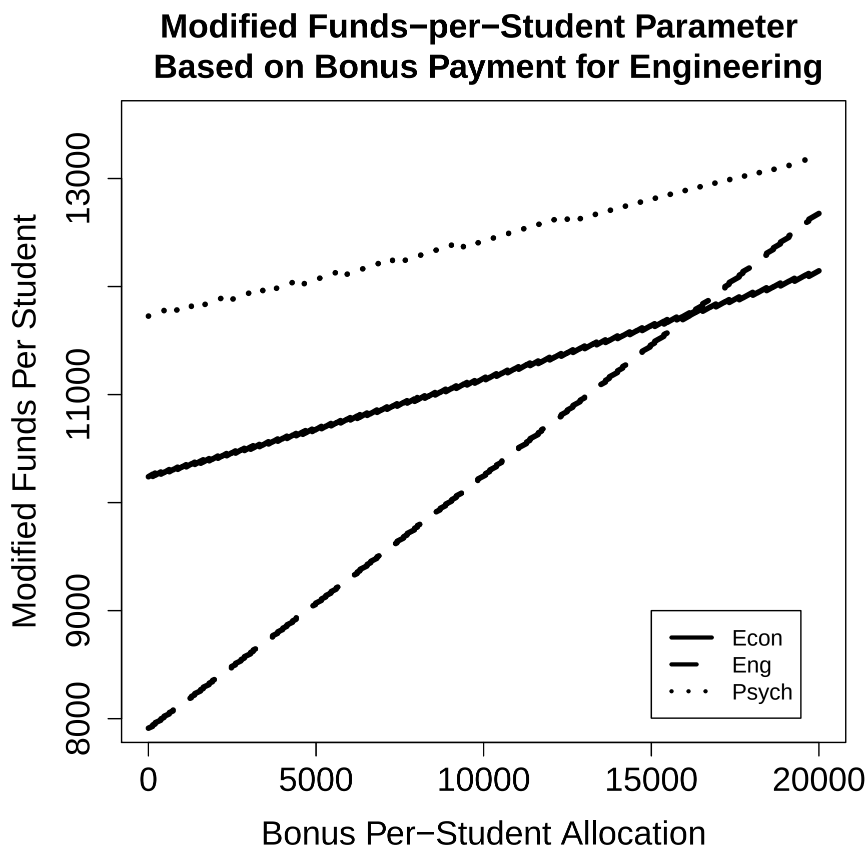

Figure 14: Simulation: Level of Funding and Total Funding Based on Per-Student State Bonus Payment for Engineering. As the state increases *b*, effective funds per student increase in *all* fields, not just engineering – although the differential is much larger in engineering.

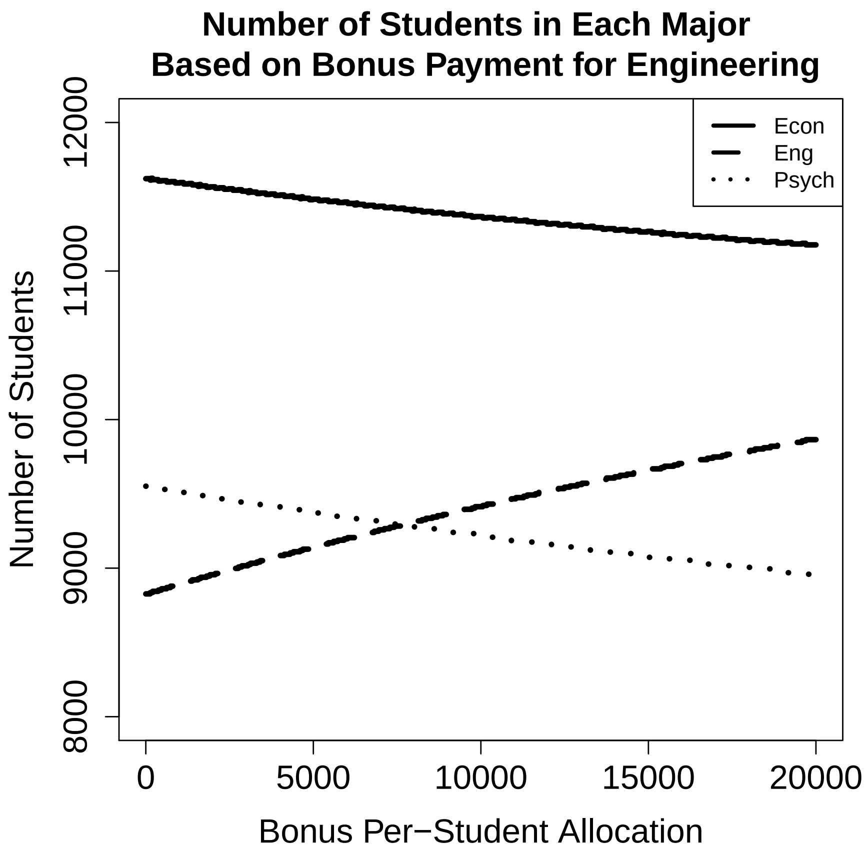

Figure 15: Simulation: Number of Students in Each Major Based on Bonus Payment for Engineering. As the state increases b, the per-engineering differential subsidy, more students fill in engineering as ρ_2 increases more differentially than other fields.

4 Education Funding Research

How does our simulation explain what is happening with actual data? Many of the impacts of increasing tuition, differential tuition, major choice, school choice, and departmental funding are already well-researched. Hoxby (1997) looks at increasing tuition throughout the latter half of the 20th century and concludes that increased competition led to higher price tags, better matched students, higher quality education, lower variance in student abilities at schools, higher variance between schools, and increased diversity in geography at schools. She made no decomposition into effects by departments.

Very few studies attempt to dissect cost into departments. One recent attempt to do this is Johnson

(2009). Johnson looks at five different ways to compute cost of a bachelors degree. The first estimates the cost of the degree if a student follows the prescribed catalog and does not fail any courses. The second looks at the actual classes that students in each major take. The third ("Full Cost Contribution") includes students who fail out of the program or waste time taking classes not attributable to their degree and transfer to a different (often, easier) field. The fourth takes IPEDS data on institutional costs and does a large regression. The final looks at the sticker price for the student. Engineering is uniformly higher than other fields in virtually all of the calculations. The Full Cost Attribution is notable because of students in the State University System of Florida who end up in Leisure Studies, only 9% started off wishing to finish in that field, dramatically decreasing the cost of the degree in the Full Cost Attribution calculation. Johnson's method finds Florida's costs per bachelors degree of $26,485 for the Catalog Cost, $31,764 for the Transcript Cost Method, and $37,757 for the Full Cost Attribution.

The question though is what to include in the calculation. What is the relevant margin? In the Johnson paper, notably, capital costs are excluded. In the IPEDS analysis, costs include funds from "contracts, grants, endowment income and gifts," which are not included in the other cost analyses, which include, "direct and indirect" costs, and not "auxiliary" activities, such as housing.

The Johnson paper is a framework for a working paper by Romano, Losinger, and Millard, who look at the cost of a community college degree. Surprisingly, the more expensive community college degrees are very expensive, even compared to four year degrees. At the upstate New York community college they looked at, Broome Community College, the Full Cost Transcript method yielded $47,968, for the Dental Hygiene Degree. Clearly, the college is losing money on these degrees; they are being subsidized by lower-cost liberal arts degrees. Another working paper by Romano and Djajalaksana actually finds it is *cheaper* per full-time equivalent to educate students at a masters-level university than it is to educate them at a community college.

Part of what may be driving low-cost masters-level university teaching is economies of scale and scope. Readily available college-level data proliferated a large number of studies on the marginal cost of activities on campus. Nelson and Hevert (1992) find that economies of scale occur if colleges decide to increase class size. It also finds laboratory courses are associated with higher cost. Dundar and Lewis (1995) are also concerned with economies of scale and scope. In the process, they discover that social science courses have the lowest cost and engineering the highest. They find economies of scale and scope in at the departmental level that differ between types of departments (i.e., social sciences) but not within type;

they also control for quality using departmental rankings. de Groot, et.al. (1991) also finds economies of scale for U.S. universities in 1983. In contrast to previous studies, Fu, et.al. (2011) finds that Taiwanese universities are too large and are experiencing *diseconomies* of scale.

Another way to compare departments is to use a multidimensional microeconomic analysis, such as data envelopment analysis. Kao and Hung (2006) does this for a Taiwanese university, and a working paper by Halkos, Tzeremes, and Kourtzidis does this for a Greek university. One fatal downfall of this approach when comparing departments is that outputs are *different* across majors. While scientists may take pride in publishing papers, art faculty may both publish papers and put on exhibits. Since all departments could have different outputs, the efficiency scores are near one, particularly at a school with few academic departments.

5 Data Analysis

5.1 UCSD

The University of California, San Diego, is a highly-ranked "very high research activity" public university in La Jolla, CA – a northern outlying neighborhood of San Diego. There are over 23,000 students, multiple graduate program, and a medical school (*U.S. News and World Report* 2015 and Carnegie Classification of Institutions for Higher Education). UCSD is a residential university with six colleges[1] – the academic "home" of students. These colleges determine the general education requirements for the students. Any student in any college can major in any of the departments on campus, as long as they meet the requirements for that department. UCSD has strict guidelines[2] for students who want to transfer colleges, and this happens infrequently. Colleges house their own freshman writing programs, which are hybrid courses where colleges introduce their themes and students write about them.

Academic departments are divided into divisions[3]. Divisions also have budgets, which we will include in the cost per credit hour.

[1] Thurgood Marshall, Earl Warren, Eleanor Roosevelt, Revelle, Muir, Sixth
[2] See "The College System: FAQ" for more details on these requirements.
[3] Undergraduate majors are in Art, Biology, Social Sciences, Engineering, and Science

5.2 Cost Data

We download the list of all courses taken by all students in FY2008 and FY2009 (years 2007-8 and 2008-9) from the university's database. The number of students comes from the query "Campus Classlist Statistics 3rd Week" (the drop date for classes is in the third week). Since some courses have more than one credit hour option, we also find the average credit hours taken in the course by downloading the query "Campus Classlist 3rd Week." We assign the courses to the department listed, with a few exceptions, some of which are listed below, and some of which are noted in the Appendix.

Each course has both a department code and a subject code. In the administration of the university, the subject code is uniquely in a particular department. The theater department has a code "THEA," and the Dance and Movement subject within theater has a subject code "TDMV." However, some instructors teach outside of their department code (i.e., cross-listed courses), so in our calculations, some subject codes may span multiple departments.

Most undergraduate independent and lab courses are not included in the *initial* department code calculation, including many practicum courses. These are, however, included when we find the cost for each *subject code*; some subject codes are clearly only for independent study purposes and thus have cost $0. *Department code calculations do not reflect "independent" courses – these are assigned $0, but when we aggregate to subject code, these $0's are reinserted to lower the cost per credit hour for the final cost of the degree and to reflect actual cost.* We relegate the technical description of this calculation to the appendix. The calculation is done in this way because any undergraduate receiving credit for laboratory experience or independent research is contributing to the research goals of the university, which is a worthy goal but not what we are trying to calculate here. However, the calculation of the subject code will reflect the basket of research and non-research courses in that particular subject code and will be a good comparison. Furthermore, we can take this average to student-by-student data containing lower and upper division hours and subject code to compute the cost of a degree: Our data for this purpose has total hours by subject codes *including and not separating independent study courses*.

We find cross-listed courses based on similarities on the course schedule, and we assign these courses to the department of the faculty which taught the course as they are listed in the *UCSD General Catalog*. If the faculty home is not listed, we assign it to the listed department as a last resort.

Weighted Penner-ratios are a UCSD measure for student-to-faculty ratios and are adjusted for whether instructional hours are lower division undergraduate, upper division undergraduate, early graduate, or late doctoral. The factors for the weighting of the hours are, respectively, 1, 1.5, $2.5 \times (15/12)$, and $3.5 \times (15/12)$. The latter two have an adjustment for the fact that a full-time graduate student is considered 12 hours instead of 15. Since this is the university's way to adjust for the difficulty of and issues related to teaching the course, and we do not have finer data (such as total amount of time preparing for each type of course), we defer to the university approach to adjust core units. As a sidenote, the Penner-ratio, after all adjustments, is divided by a campus-wide average, so that departments with an average student-to-faculty ratio will have a ratio of 1.0.

5.3 Cost Calculation

We have four methods to compute these costs, which are highly correlated (see Table 3). The data is from UCSD Academic Affairs Resource Profiles for FY2008 and FY2009, the Office of Graduate Studies, and UCSD's Blink System. Except for Winter 2009 tuition[4], all calculations are inflated to FY2009 dollars[5]. There were a few additional quid-pro-quos to these data, which we relegate to the appendix.

We relegate the formal formulation of cost to the appendix, section 6.2.2. There are several variables added to all of the cost calculations. These are:

1. Budgeted support funds.
2. Faculty salaries.
3. Lecturer salaries.
4. Teaching assistant salaries.
5. Tutor and reader salaries.
6. Diversity awards.
7. Block grant awards.
8. OGS non-specified awards.
9. Teaching assistant tuition waivers.

[4]Tuition for each quarter is nearly the same, payments are available, so this is nearly equivalent to the FY2009 calculation.

[5]We define FY2009 dollars as the average CPI-U over months July 2008-June 2009.

Four cost measures are computed. Measure one includes no space. The first three have various amounts of space included in addition to the costs above. Measure two includes the following space at $36/year[6]:

1. Office space allocated to department.
2. Classroom space allocated.
3. Teaching labs.

Measure three includes the three space requirements measures above and the following space measures at $36/year:

1. Assembly space.
2. Research space.
3. Other space.

The fourth measure uses the same space as the second measure, but it does not do the Penner adjustment explained in Subsection 5.2.

First, a cost per credit hour is found per department by dividing the cost measure by the hours awarded in the department code in FY2008 and FY2009 (summer excluded). As described earlier in Section 5.2, independent courses are excluded and valued at $0 in the department code run, but will be bundled appropriately at the subject code level. We do this for all of the departments and separately for divisions. We then sum the money used in each subject code by computing the hours awarded times the sum of division cost plus department costs. We then divide by the hours awarded by subject code (thus independent courses are awarded some monies at the end). We then get a cost per credit hour for each subject code. All cost per credit hours are in the Appendix, Tables 1 and 2.

5.4 Cost at the University of California, San Diego

To determine the cost of an undergraduate degree, and to assign benefits to the state, the university, and the student, we first use the cost per credit hour calculations from section 5.3. Denote the set of

[6]Christopher Beliare from the real estate firm Newmark Grubb Knight Frank assisted us in lease data for the UCSD area.

courses each student S takes as $\mathbf{k}^S$, which is a vector of courses (k). The subject code of each course is $\varkappa(k)$, the number of hours for that course is h_k, and the Penner parameter of the course is P_k.

The Penner parameter is a university-assigned weight for the level of the course. Upper division courses, in this calculation are considered harder to teach and more costly per hour than lower division courses. The Penner parameters used in this calculation are 1 [Lower Division Undergraduate], 1.5 [Upper Division Graduate], 2.5 × (15/12) [Lower Graduate], and 3.5 × (15/12) [Upper Graduate].

The cost of the degree $\left(c^{\kappa(k)}\right)$ is given by $\sum_{k \in \mathbf{k}^S} c^{\kappa(k)} h_k P_k$. The cost per credit hour, by subject code, are listed in Table 2.

We begin an analysis of the cost of each degree at UCSD in the spirit of Johnson (2009). In our analysis, we look at the courses that students *take* and the degrees with which they graduate. Say a student fails out of engineering and enters economics. This throws the cost of the now non-contributing engineering courses into the economics major. We trade this bias for another bias – one where only the required courses are included. A cost measure which only looks at the required courses does not allow us to compare majors where students are likely to take non-required courses, for any particular reason.

Our student-level degree awarded data tracks non-transfer students who entered in year 2006 as freshmen, and graduated by Spring 2012. We see dropouts, and we consider those not earning their degrees at the end of this period as not earning a degree. We have lower division, upper division, and graduate hours by subject code. We do not use AP credit in the cost calculations, as these are not costs to the university.

We compute costs for summer courses as if they were during-the-year courses separately and report these. The default measure presented in the regressions in this report includes the summer-session hours. The summer session has a fundamentally different cost structure and is run by UCSD extension, not the school itself. Although not relevant to the cost calculation – the funding for the session is also different (tuition is assigned per credit hour and the funding mechanism between the university is also different). However, one can argue that the summer session utilizes the same type of instruction (with perhaps a higher lecturer percentage), the same buildings, and other resources – all for required courses which would have appeared in the degree anyways.

We do not have data on inter-school transfer hours, which are generally small at UCSD.

Each degree has a particular code, and we combine some degrees and treat them as one degree in our analysis. For instance, an econ-coded Joint Math-Econ degree is the same as a math-coded Math-Econ degree; we bundle several literature majors, etc. A listing of these majors that are bundled as one are in the appendix, Section 6.2.1. In aggregate analysis, some information is only available for departments; for instance, salary per faculty FTE will not be available for programs without faculty. For the most part, programs do not have faculty independent of departments. Much of the analysis is thus restricted to degrees in departments. The number of observations in the analysis is in each table.

A listing of the degrees and the costs are available in the appendix, Section 9. Biology at UCSD is an enormous major, in fact, taking its own division, and has many majors in this table, all of them fairly low-cost. Also of low-cost are many of the social science majors. Humanities are not on the whole cheap; there are few of these majors,.

5.4.1 Explaining Cost

Next, we use a regression framework to look at the role of factors in explaining cost. The dependent variable in these regressions is the log of costs. Independent variables include (a) the log of the salary per FTE faculty member in the department, (b) the log of the students graduating in the department in the dataset, (c) the log of the adjusted Penner Ratio [an adjusted student-faculty ratio; different from the Penner parameter[7]], (d) the log of the indirect funds per FTE faculty measure, (e) the log of the office space per FTE faculty member, and (f) the log of the number of hours[8].

Since the definition of cost is functionally dependent in a non-linear way with adjusted hours, we also take the cost and subtract off Average Cost per Adjusted Hour $\times$ Adjusted Hours. This helps wash out the hours portion of the discrepancy and then the regressand only reflects additional cost above and beyond the hours. We regress this adjusted cost on the non-log measures in the previous paragraph. This should create confidence in the log regression if the signs are similar.

Additionally, we have indicators for a double major, one Bachelors of Science, and colleges. “Transfer” students are students who transfer from one college to another. UCSD is a residential college with six colleges[9] – the academic “home” of students. These colleges determine the general education requirements for the students. Any student in any college can major in any of the departments on campus, as long as

[7]The Penner ratio is an adjusted student-faculty ratio. We will use the term Penner ratio to contrast it with what we term the Penner parameter, which was discussed earlier in the paper. The Penner parameter is actually used in the calculation of the adjusted Penner ratio.

[8]We adjust logs by a trivial fraction of a dollar to avoid zeros and small, negative numbers. While this is a fairly controversial procedure, we also do an adjusted-mean procedure.

[9]Thurgood Marshall, Earl Warren, Eleanor Roosevelt, Revelle, Muir, Sixth

they meet the requirements for that department. UCSD has strict guidelines for students who want to transfer colleges, and this happens rarely.

Information on the data is relegated to the appendix.

The cost-regression results are consistent with the presented model and are presented in Tables 4 to 6. The student-faculty ratio, the salary, and the number of students are the only department-level significant variables when we account for hours. The coefficient on adjusted hours is not surprising; the cost is a function of hours. This paper does find a (very small) increasing return to scale – but the coefficient, while significant, is economically small. A doubling of students would yield a $<4\%$ increase in degree price. Notably, most of the returns to scale that much of the education literature finds may be occurring through lower-quality education: once we control for the Penner ratio, the cost savings elasticities in the hours regressions go from -0.07 to -0.03.

If we do not control for hours, double majors are clearly more expensive; Bachelors in Science Degrees do not appear significantly more expensive, but the signs are mostly positive and non-trivially small. Once we control for hours, however, this washes away; double majors are actually *cheaper* controlling for hours.

Removing the Penner ratio from the regression yields expected results. The percent taught by faculty, which is negatively correlated with the Penner (see Table 8), become significant. The returns to scale increase significantly. More importantly, we must include the Penner to even see the impact on FTE faculty salary. This is the most surprising result; our simulation predicts a negative coefficient: That if you do not take into account faculty per student, you should see a lower funds-per-student in higher salary departments. This in fact is true. A regression of log cost of degree on log salary (and other binary variables) is negative, not positive, and fairly large (-20.0%; see regression (14) in Table 5). However, it is not significant at the 10% level. Higher paid faculty in expensive departments teach more students to more than make up for their higher salaries.

Next, let's look at time-to-completion, shown in Table 7. While the elasticity is small, higher Penners are associated with lower time-to-degree. This has the implication that higher Penner departments are also better from a time perspective. However, we must be careful in assigning too much to the faculty-student ratio. The effects are small, and the explanatory power of virtually all relevant variables is incredibly small.

5.5 Conclusions

Universities and students face substantially different incentives in procurement of bachelor's degrees. The university, if state funds are not allocated towards majors differentially and tuition is equal, will face incentives to fund popular majors at lower levels relative to unpopular majors. This is because marginal students are a cost to the university. On the other hand, the state wants students to major in hard, heavy-return majors. Students want to balance their future potential salary against how difficult or enjoyable the major is.

Looking at UCSD, what we have shown in the model simulation seems to be what is actually happening. The major, relevant factor in the analysis is the modified student-to-faculty ratio. The paper shows that much of the so-called returns to scale in education, at least at UCSD, is actually a reduction in faculty time with students. Surprisingly, faculty salary across departments does not impact the cost of education unless we account for the amount of per-capita students the faculty member must bear; higher paid faculty deal with more students. Indeed, a lone regression on faculty salary and other binary parameters shows that higher paid fields lead to less costly degrees.

6 Appendix, Education Paper

6.1 Tables

Table 1: Cost per Credit Hour (Department Code). This is the listing of cost per credit hours for departments and programs as described in the text. Programs are highlighted in grey, and writing programs are highlighted in black. The table is sorted by Measure II and does not include division costs.

Department or Program	Measure I	II	III	IV
Basic Writing Program Admin	$12.89	$20.57	$20.57	$20.57
Making of the Modern World	$60.09	$63.48	$63.48	$63.60
Culture, Art, Technology	$67.05	$74.54	$74.85	$83.28
Dimensions of Culture	$79.09	$86.53	$86.53	$87.03
Revelle Humanities	$84.25	$92.68	$92.68	$93.91
Muir College Writing Program	$95.49	$107.25	$107.25	$111.89
Warren College Writing Program	$99.02	$115.83	$115.83	$115.83
Science, Technology, Public Affairs	$40.83	$40.83	$40.83	$46.30
Critical Gender Studies	$41.44	$41.44	$41.44	$52.96
International Studies Program	$52.80	$52.80	$52.80	$79.19
Urban Studies & Planning	$49.69	$56.08	$56.08	$78.23
Third World Studies	$55.38	$59.04	$59.04	$59.71
Earth Systems	$65.94	$70.65	$70.65	$98.41
Human Development Program	$59.87	$79.34	$79.34	$106.63
Linguistics Language Program	$86.19	$93.68	$93.68	$98.66
Academic Internship Program	$98.22	$135.64	$135.64	$203.47
Psychology	$69.93	$79.17	$93.39	$115.79
History, CAESER	$79.49	$85.82	$85.91	$121.24
Economics	$80.64	$86.02	$86.23	$126.08
Biology	$87.18	$103.95	$132.94	$166.39
Chemistry	$84.14	$108.08	$139.01	$166.27
Political Science	$102.92	$109.24	$109.24	$163.27
Educational Studies	$96.14	$110.35	$110.42	$275.86
Bioengineering	$88.21	$115.55	$142.76	$293.31
Communications	$104.53	$115.66	$115.83	$181.55
Mathematics	$107.67	$118.98	$119.55	$146.61
Sociology	$120.24	$130.75	$130.75	$204.51
Cognitive Science	$111.55	$131.95	$152.75	$193.21
Ethnic Studies	$125.22	$137.90	$137.90	$204.85
Mechanical & Aeronautical Engineerir	$123.67	$143.73	$159.98	$266.26
Structural Engineering	$120.75	$144.64	$188.81	$289.81
Computer & Science Engineering	$129.69	$159.75	$175.98	$326.19
Visual Arts	$131.54	$161.27	$196.05	$232.65
Anthropology	$148.51	$165.26	$178.61	$287.44
Music	$132.75	$167.88	$183.59	$230.82
Literature	$155.62	$170.91	$171.35	$246.72
Linguistics (not FLP)	$146.14	$172.93	$192.58	$265.22
Electrical & Computer Engineering	$149.36	$178.29	$216.39	$461.49
Theater	$143.94	$190.76	$220.86	$293.87
Physics	$163.52	$200.01	$239.55	$260.53
Philosophy	$198.75	$216.80	$216.80	$287.29
Rady School of Management	$197.24	$246.93	$249.64	$646.12

Table 2: Cost per Credit Hour (Subject Code). [includes division cost]

	Subject Code	Measure I	Measure II	Measure III	Measure IV
Academic Internship Program	AIP	$ 98.22	$ 135.64	$ 135.64	$ 203.47
Anthropological Archeology	ANAR	$ 151.49	$ 168.54	$ 181.90	$ 292.41
Anthro/Biological Anthropology	ANBI	$ 148.12	$ 165.11	$ 179.18	$ 285.77
Anthropology/Sociocultural	ANSC	$ 151.49	$ 168.54	$ 181.90	$ 292.41
Anthropology	ANTH	$ 146.46	$ 162.94	$ 175.86	$ 284.82
Bioengineering	BENG	$ 98.83	$ 129.15	$ 155.87	$ 319.79
Biology/Biochemistry	BIBC	$ 91.37	$ 108.46	$ 137.35	$ 173.54
Biol/Genetics,Cellular&Develop	BICD	$ 91.25	$ 108.32	$ 137.32	$ 173.39
Biol/Ecology, Behavior, & Evol	BIEB	$ 91.25	$ 108.32	$ 137.32	$ 173.39
Biology/Lower Division	BILD	$ 91.11	$ 108.16	$ 137.11	$ 173.13
Biology/Molec Biol, Microbiol	BIMM	$ 91.31	$ 108.41	$ 137.39	$ 173.62
Biology/Animal Physiol&Neurosc	BIPN	$ 91.25	$ 108.32	$ 137.32	$ 173.39
Biology/Special Studies	BISP	$ 14.25	$ 16.91	$ 21.44	$ 27.07
Culture, Art, and Technology	CAT	$ 118.34	$ 142.94	$ 145.48	$ 159.87
Chemical Engineering	CENG	$ 136.88	$ 161.00	$ 177.79	$ 303.66
Critical Gender Studies	CGS	$ 47.69	$ 48.63	$ 48.64	$ 63.38
Chemistry and Biochemistry	CHEM	$ 86.99	$ 111.20	$ 141.89	$ 170.62
Chinese Studies	CHIN	$ 82.74	$ 89.69	$ 89.78	$ 126.74
Classical Studies (Hon Thesis)	CLAS	$ -	$ -	$ -	$ -
Communication and Culture	COCU	$ 107.50	$ 118.94	$ 119.12	$ 186.52
Communication/General	COGN	$ 103.56	$ 114.58	$ 114.75	$ 181.36
Cognitive Science	COGS	$ 111.63	$ 131.81	$ 152.09	$ 194.06
Communication/Human Info Proc	COHI	$ 107.50	$ 118.94	$ 119.12	$ 186.52
Communication Media Methods	COMT	$ 90.26	$ 99.86	$ 100.01	$ 156.60
Communication as Social Force	COSF	$ 107.50	$ 118.94	$ 119.12	$ 186.52
Computer Science & Engineering	CSE	$ 142.12	$ 175.95	$ 192.65	$ 362.12
Dimensions of Culture	DOC	$ 141.69	$ 165.69	$ 165.69	$ 167.96
Education Abroad Program	EAP	$ 110.63	$ 129.01	$ 142.71	$ 195.91
Electrical & Computer Engineer	ECE	$ 162.14	$ 194.96	$ 233.20	$ 495.73
Economics	ECON	$ 83.40	$ 89.09	$ 89.31	$ 130.73
Education Studies	EDS	$ 98.46	$ 112.18	$ 112.60	$ 260.31
Engineering	ENG	$ 110.63	$ 129.01	$ 142.71	$ 195.91
Environmental Studies	ENVR	$ 120.14	$ 142.62	$ 148.01	$ 161.61
Eleanor Roosevelt College	ERC	$ 77.07	$ 89.88	$ 99.42	$ 128.23
Environmental Systems	ESYS	$ 62.05	$ 68.39	$ 70.72	$ 98.24
Ethnic Studies	ETHN	$ 128.10	$ 142.23	$ 143.12	$ 209.94
Exchange Programs	EXPR	$ 110.63	$ 129.01	$ 142.71	$ 195.91
Film Studies	FILM	$ 120.37	$ 142.90	$ 148.30	$ 161.89
Family and Preventive Medicine	FPM	$ -	$ -	$ -	$ -
Human Development Program	HDP	$ 59.60	$ 77.18	$ 77.20	$ 106.15
History of Africa	HIAF	$ 82.80	$ 89.76	$ 89.85	$ 126.81
History of East Asia	HIEA	$ 82.76	$ 89.71	$ 89.80	$ 126.74
History of Europe	HIEU	$ 82.76	$ 89.71	$ 89.80	$ 126.74
History of Latin America	HILA	$ 82.80	$ 89.76	$ 89.85	$ 126.81
History, Lower Division	HILD	$ 82.80	$ 89.76	$ 89.85	$ 126.81

Table 2. Cost per Credit Hour (Subject Code), *continued.*

	Subject Code	Measure I	Measure II	Measure III	Measure IV
History of the Near East	HINE	$ 82.57	$ 89.50	$ 89.60	$ 126.45
History of Science	HISC	$ 82.69	$ 89.64	$ 89.73	$ 126.64
History Topics	HITO	$ 69.40	$ 75.23	$ 75.31	$ 107.00
History of the United States	HIUS	$ 82.98	$ 90.31	$ 90.40	$ 127.04
Human Rights	HMNR	$ 132.17	$ 146.38	$ 156.01	$ 245.84
Humanities	HUM	$ 157.84	$ 183.60	$ 184.67	$ 186.03
Computing and the Arts	ICAM	$ 129.11	$ 157.92	$ 184.61	$ 226.25
International Studies	INTL	$ 55.05	$ 55.35	$ 55.36	$ 83.08
Japanese Studies	JAPN	$ 82.64	$ 89.59	$ 89.68	$ 126.64
Judaic Studies	JUDA	$ 80.64	$ 87.41	$ 87.51	$ 124.31
Latin American Studies	LATI	$ 107.10	$ 124.91	$ 138.17	$ 191.57
Law and Society	LAWS	$ 110.63	$ 129.01	$ 142.71	$ 195.91
Linguistics/Arabic	LIAB	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics - Directed Study	LIDS	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics/French	LIFR	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics/German	LIGM	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics/General	LIGN	$ 146.44	$ 172.93	$ 192.07	$ 265.75
Linguistics/Heritage Languages	LIHL	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics/Italian	LIIT	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics/Portuguese	LIPO	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics/Amer Sign Language	LISL	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Linguistics/Spanish	LISP	$ 89.16	$ 96.96	$ 96.97	$ 103.63
Literature of Africa	LTAF	$ 158.94	$ 174.85	$ 175.29	$ 252.28
Literature of the Americas	LTAM	$ 158.94	$ 174.85	$ 175.29	$ 252.28
Literature of China	LTCH	$ 158.94	$ 174.85	$ 175.29	$ 252.28
Literature/Cultural Studies	LTCS	$ 158.46	$ 174.33	$ 174.77	$ 251.63
East Asian Literature	LTEA	$ 158.35	$ 174.20	$ 174.64	$ 251.35
Literatures in English	LTEN	$ 157.45	$ 173.45	$ 174.06	$ 250.47
Literature/European & Eurasian	LTEU	$ 136.98	$ 150.37	$ 150.72	$ 217.07
Literature/French	LTFR	$ 158.94	$ 174.85	$ 175.29	$ 252.28
Literature/Greek	LTGK	$ 131.14	$ 143.83	$ 144.15	$ 217.95
Literature/German	LTGM	$ 121.74	$ 133.28	$ 133.55	$ 203.47
Literature/Italian	LTIT	$ 125.34	$ 137.30	$ 137.59	$ 208.71
Literature/Korean	LTKO	$ 158.94	$ 174.85	$ 175.29	$ 252.28
Literature/Latin	LTLA	$ 86.36	$ 93.74	$ 93.85	$ 131.27
Literature / Portuguese	LTPR	$ 158.94	$ 174.85	$ 175.29	$ 252.28
Literature/Russian	LTRU	$ 82.56	$ 89.49	$ 89.59	$ 126.51
Literature/Spanish	LTSP	$ 158.43	$ 174.29	$ 174.72	$ 251.71
Literature/Theory	LTTH	$ 100.26	$ 109.27	$ 109.44	$ 155.58
Literatures of the World	LTWL	$ 146.73	$ 161.21	$ 161.60	$ 233.57
Literature/Writing	LTWR	$ 150.80	$ 165.90	$ 166.32	$ 241.22
Mechanical & Aerospace Engin	MAE	$ 137.73	$ 162.09	$ 179.64	$ 305.78
Mathematics	MATH	$ 111.11	$ 122.87	$ 123.43	$ 151.98
Muir College Writing Program	MCWP	$ 174.41	$ 208.71	$ 214.11	$ 220.81
Medicine	MED	$ -	$ -	$ -	$ -

Table 2. Cost per Credit Hour (Subject Code), *continued.*

	Subject Code	Measure I	Measure II	Measure III	Measure IV
Rady School of Management	MGT	$ 197.24	$ 246.93	$ 249.64	$ 646.12
Making of the Modern World	MMW	$ 96.35	$ 123.34	$ 126.14	$ 123.62
Muir College	MUIR	$ 102.76	$ 119.84	$ 132.57	$ 181.17
Music	MUS	$ 134.06	$ 168.85	$ 184.04	$ 233.47
Neurosciences	NEU	$ -	$ -	$ -	$ -
Ophthalmology	OPTH	$ -	$ -	$ -	$ -
Orthopaedics	ORTH	$ -	$ -	$ -	$ -
Pathology	PATH	$ -	$ -	$ -	$ -
Pediatrics	PEDS	$ -	$ -	$ -	$ -
Pharmacology	PHAR	$ -	$ -	$ -	$ -
Philosophy	PHIL	$ 172.89	$ 188.58	$ 188.60	$ 258.42
Physics	PHYS	$ 166.74	$ 203.62	$ 243.09	$ 265.68
Political Science	POLI	$ 103.34	$ 110.13	$ 110.15	$ 164.40
Psychiatry	PSY	$ -	$ -	$ -	$ -
Psychology	PSYC	$ 69.77	$ 78.90	$ 92.51	$ 115.96
Radiology	RAD	$ -	$ -	$ -	$ -
Religion, Study of	RELI	$ 99.18	$ 112.97	$ 121.23	$ 169.96
Revelle College	REV	$ 107.93	$ 125.87	$ 139.23	$ 191.13
Reproductive Medicine	RMED	$ -	$ -	$ -	$ -
San Diego Community College	SDCC	$ 16.20	$ 24.51	$ 24.51	$ 26.13
Structural Engineering	SE	$ 135.13	$ 162.96	$ 205.76	$ 327.70
Scripps Inst of Oceanography	SIO	$ 108.25	$ 126.24	$ 139.64	$ 192.74
Soc/Theory & Methods	SOCA	$ 119.85	$ 130.34	$ 130.36	$ 202.59
Soc/Cult, Lang, & Soc Interact	SOCB	$ 124.43	$ 136.48	$ 137.86	$ 215.45
Soc/Soc Organiz & Institutions	SOCC	$ 123.02	$ 133.85	$ 133.86	$ 209.20
Soc/Comparative & Historical	SOCD	$ 116.10	$ 126.24	$ 126.27	$ 194.93
Soc/Ind Research & Honors Prog	SOCE	$ 61.98	$ 67.42	$ 67.42	$ 105.37
Soc/Lower Division	SOCL	$ 123.21	$ 134.03	$ 134.04	$ 209.48
Sci, Technology&Public Affairs	STPA	$ 186.05	$ 223.92	$ 229.17	$ 231.09
Surgery	SURG	$ -	$ -	$ -	$ -
Theatre / Acting	TDAC	$ 146.82	$ 194.13	$ 224.15	$ 298.72
Dance/Choreography	TDCH	$ 147.25	$ 194.70	$ 224.80	$ 299.44
Theatre / Design	TDDE	$ 146.65	$ 193.91	$ 223.89	$ 298.46
Theatre / Directing&Stage Mgmt	TDDR	$ 139.35	$ 184.25	$ 212.74	$ 283.37
Theatre / General	TDGE	$ 145.87	$ 192.88	$ 222.70	$ 297.43
Dance/History	TDHD	$ 97.36	$ 113.79	$ 120.94	$ 166.50
Theatre / History & Theory	TDHT	$ 131.83	$ 169.59	$ 192.51	$ 266.50
Dance/Movement	TDMV	$ 147.25	$ 194.70	$ 224.80	$ 299.44
Dance/Performance	TDPF	$ 147.25	$ 194.70	$ 224.80	$ 299.44
Theatre Dance/Practicum	TDPR	$ 140.67	$ 186.00	$ 214.76	$ 289.61
Theatre / Playwriting	TDPW	$ 144.56	$ 191.14	$ 220.70	$ 295.16
Dance/Theory	TDTR	$ 147.25	$ 194.70	$ 224.80	$ 299.44
Thurgood Marshall College	TMC	$ 109.32	$ 127.49	$ 141.02	$ 193.98
Third World Studies	TWS	$ 58.70	$ 62.98	$ 62.98	$ 65.27
Urban Studies & Planning	USP	$ 61.70	$ 68.87	$ 68.88	$ 97.41

Table 2. Cost per Credit Hour (Subject Code), *continued.*

	Subject Code	Measure I	Measure II	Measure III	Measure IV
Visual Arts	VIS	$ 129.91	$ 158.28	$ 190.14	$ 229.61
Warren College	WARR	$ 100.07	$ 116.71	$ 129.10	$ 181.34
Warren College Writing Program	WCWP	$ 244.24	$ 298.92	$ 304.17	$ 300.62

Table 3: Correlation Between Measures.

Department	I	II	III	IV
I	1.0000			
II	0.9867	1.0000		
III	0.9509	0.9786	1.0000	
IV	0.8432	0.8698	0.8463	1.0000

Subject	I	II	III	IV
I	1.0000			
II	0.9875	1.0000		
III	0.9573	0.9864	1.0000	
IV	0.8773	0.8989	0.9095	1.0000

Table 4: Regression of Log Cost, Including Adjusted Hours as a Variable.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(Adjusted Penner Ratio)	-0.407***	-0.460***		-0.484***	-0.487***		
	(0.0582)	(0.0503)		(0.0426)	(0.0420)		
Log(Indirect Funds per FTE)	0.00475*	0.00442	-0.00305	0.00490*	0.00594***	-0.0110*	
	(0.00267)	(0.00259)	(0.00390)	(0.00248)	(0.00184)	(0.00564)	
Log(Office Space per FTE)	0.0130	0.0315	0.0125	0.0255			
	(0.0418)	(0.0436)	(0.0542)	(0.0393)			
Log(Percent Taught by Faculty)	0.0388	0.0360	0.220***				
	(0.0503)	(0.0523)	(0.0627)				
Log(Salary Per FTE)	0.268***	0.306***	0.0989	0.301***	0.280***	-0.0698	-0.0363
	(0.0658)	(0.0723)	(0.0867)	(0.0685)	(0.0668)	(0.180)	(0.0765)
Log(Adjusted Hours)	1.011***	1.016***	1.014***	1.018***	1.023***	1.097***	1.019***
	(0.0254)	(0.0244)	(0.0353)	(0.0250)	(0.0241)	(0.0530)	(0.0405)
Log(Students Graduating in Dept)	-0.0168*		-0.0567***				-0.0769***
	(0.00875)		(0.0106)				(0.0116)
Double Major	-0.0570***	-0.0584***	-0.0483***	-0.0588***	-0.0591***	-0.0498***	-0.0479***
	(0.00788)	(0.00675)	(0.0118)	(0.00687)	(0.00700)	(0.0134)	(0.0142)
One B.S.	-0.000355	-0.0177	0.0519	-0.0160	-0.00931	0.0593	0.0585**
	(0.0184)	(0.0190)	(0.0313)	(0.0189)	(0.0176)	(0.0414)	(0.0269)
Muir College	0.0287***	0.0267***	0.0370***	0.0259***	0.0273***	0.0299***	0.0311***
(ERC is the base.)	(0.00486)	(0.00490)	(0.00679)	(0.00485)	(0.00454)	(0.00658)	(0.00662)
Revelle College	0.0364***	0.0347***	0.0405***	0.0342***	0.0361***	0.0318***	0.0317***
	(0.00680)	(0.00692)	(0.00786)	(0.00704)	(0.00660)	(0.00780)	(0.00940)
Sixth College	0.0499***	0.0482***	0.0655***	0.0473***	0.0482***	0.0719***	0.0643***
	(0.00421)	(0.00417)	(0.0101)	(0.00429)	(0.00425)	(0.0138)	(0.00937)
Thurgood Marshall College	0.0279***	0.0270***	0.0322***	0.0266***	0.0277***	0.0297***	0.0274***
	(0.00538)	(0.00556)	(0.00643)	(0.00560)	(0.00504)	(0.00769)	(0.00696)
Transfer	0.0505***	0.0480***	0.0671***	0.0484***	0.0485***	0.0864***	0.0792***
	(0.0113)	(0.0112)	(0.0140)	(0.0112)	(0.0110)	(0.0236)	(0.0164)
Warren College	0.0574***	0.0557***	0.0715***	0.0558***	0.0578***	0.0927***	0.0750***
	(0.00753)	(0.00745)	(0.0118)	(0.00761)	(0.00804)	(0.0186)	(0.0147)
Constant	1.785*	1.143	3.955***	1.213	1.582**	5.151**	5.530***
	(0.919)	(0.903)	(1.166)	(0.830)	(0.711)	(2.061)	(0.918)
Observations	3,616	3,616	3,616	3,616	3,616	3,616	3,616
R-squared	0.890	0.887	0.840	0.886	0.886	0.707	0.802

Standard errors clustered by department.
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Regression of Log Cost without Hours.

	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Log(Adjusted Penner Ratio)	-0.417***	-0.514***		-0.565***	-0.582***			
	(0.0862)	(0.0858)		(0.0881)	(0.0827)			
Log(Indirect Funds per FTE)	0.00392	0.00331	-0.00407	0.00436	0.00946**	-0.0108		
	(0.00393)	(0.00391)	(0.00490)	(0.00404)	(0.00388)	(0.00754)		
Log(Office Space per FTE)	0.102	0.136**	0.102	0.124**				
	(0.0595)	(0.0623)	(0.0733)	(0.0561)				
Log(Percent Taught by Faculty)	0.0821	0.0774	0.268***					
	(0.0757)	(0.0848)	(0.0863)					
Log(Salary Per FTE)	0.368***	0.436***	0.195	0.426***	0.325**	-0.0947	-0.202	-0.0143
	(0.108)	(0.125)	(0.121)	(0.119)	(0.127)	(0.237)	(0.149)	(0.107)
Log(Students Graduating in Dept)	-0.0303**		-0.0712***					-0.0998***
	(0.0115)		(0.0138)					(0.0150)
Double Major	0.102***	0.101***	0.112***	0.101***	0.103***	0.129***	0.126***	0.116***
	(0.0194)	(0.0182)	(0.0225)	(0.0181)	(0.0188)	(0.0264)	(0.0257)	(0.0241)
One B.S.	0.0565	0.0256	0.110**	0.0293	0.0639	0.153**	0.0946	0.163***
	(0.0367)	(0.0348)	(0.0513)	(0.0355)	(0.0398)	(0.0661)	(0.0604)	(0.0368)
Muir College	0.0131	0.00932	0.0216	0.00771	0.0138	0.0158	0.0113	0.0202
(ERC is the base.)	(0.0143)	(0.0145)	(0.0165)	(0.0145)	(0.0159)	(0.0170)	(0.0174)	(0.0169)
Revelle College	0.0218	0.0185	0.0259	0.0174	0.0266	0.0205	0.0115	0.0244
	(0.0182)	(0.0187)	(0.0189)	(0.0187)	(0.0214)	(0.0203)	(0.0205)	(0.0206)
Sixth College	0.0763***	0.0735***	0.0924***	0.0717***	0.0770***	0.108***	0.109***	0.0948***
	(0.0158)	(0.0161)	(0.0208)	(0.0158)	(0.0163)	(0.0261)	(0.0262)	(0.0206)
Thurgood Marshall College	0.0282	0.0265	0.0326	0.0256	0.0309	0.0336	0.0292	0.0318
	(0.0193)	(0.0196)	(0.0204)	(0.0196)	(0.0203)	(0.0223)	(0.0220)	(0.0203)
Transfer	0.0835*	0.0793*	0.101**	0.0802*	0.0814*	0.130**	0.133***	0.116**
	(0.0437)	(0.0436)	(0.0448)	(0.0434)	(0.0442)	(0.0475)	(0.0465)	(0.0459)
Warren College	0.0722***	0.0693***	0.0867***	0.0696***	0.0795***	0.124***	0.121***	0.0989***
	(0.0116)	(0.0112)	(0.0130)	(0.0113)	(0.0149)	(0.0181)	(0.0168)	(0.0189)
Constant	5.665***	4.536***	7.899***	4.697***	6.613***	11.38***	12.57***	10.91***
	(1.359)	(1.510)	(1.556)	(1.395)	(1.456)	(2.726)	(1.734)	(1.222)
Observations	3,616	3,616	3,616	3,616	3,616	3,616	3,616	3,616
R-squared	0.428	0.419	0.375	0.416	0.400	0.141	0.116	0.325

Standard errors clustered by department.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6: Regression of Mean-Hour Adjusted Cost on Variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Adjusted Penner Ratio	-8,326***	-8,169***		-9,286***	-10,085***		
	(1,663)	(1,800)		(1,589)	(1,629)		
Indirect Research Funds ($ per FTE)	0.00904	-0.0230*	-0.0382	-0.0199	-0.00161	-0.0390*	
	(0.0211)	(0.0118)	(0.0336)	(0.0119)	(0.00739)	(0.0203)	
Office Space	-0.976	4.478*	4.976	4.023			
(Assigned Square ft. per FTE)	(3.522)	(2.362)	(5.608)	(2.365)			
Percentage Taught by Faculty	2,003	3,873	14,293***				
	(3,631)	(3,370)	(3,703)				
Salary per FTE	0.0792***	0.0698**	-0.0160	0.0749**	0.0876***	-0.0734**	-0.0411
	(0.0256)	(0.0294)	(0.0279)	(0.0298)	(0.0286)	(0.0279)	(0.0308)
Number of Students in Dept.	-3.158**		-2.528				
	(1.405)		(2.393)				
Double Major	-1,594***	-1,637***	-1,219***	-1,667***	-1,667***	-965.6**	-1,092**
	(255.1)	(253.6)	(324.0)	(254.8)	(257.7)	(427.8)	(435.0)
One B.S.	1,130	871.7	2,608*	788.3	635.4	3,396	261.1
	(936.9)	(936.3)	(1,316)	(928.1)	(787.2)	(2,002)	(1,571)
Muir	1,095***	1,053***	1,257***	998.3***	1,021***	1,075***	794.7***
(ERC is omitted)	(194.2)	(199.3)	(226.2)	(190.3)	(180.6)	(241.7)	(196.8)
Revelle	1,387***	1,420***	1,519***	1,370***	1,378***	1,331***	697.0***
	(254.7)	(258.2)	(266.3)	(256.8)	(244.3)	(262.2)	(222.7)
Sixth	1,843***	1,864***	2,313***	1,805***	1,835***	2,584***	2,533***
	(256.8)	(261.1)	(406.4)	(253.6)	(262.0)	(511.8)	(576.1)
Thurgood Marshall	1,020***	1,046***	1,130***	1,014***	1,034***	1,093***	814.9**
	(177.4)	(181.4)	(222.8)	(179.8)	(173.3)	(297.7)	(301.4)
Transfer	1,409***	1,544***	1,971***	1,536***	1,524***	2,737***	2,865***
	(395.4)	(392.3)	(455.9)	(394.9)	(389.1)	(674.7)	(908.0)
Warren	1,878***	1,916***	2,408***	1,896***	1,981***	3,275***	2,902***
	(287.7)	(287.2)	(440.6)	(288.0)	(300.5)	(625.2)	(574.0)
Constant	2,282	-997.5	-8,806**	2,430	3,929*	7,318**	3,359
	(4,023)	(3,841)	(4,254)	(2,548)	(2,033)	(3,439)	(3,646)
Observations	3,616	3,616	3,616	3,616	3,616	3,616	3,616
R-squared	0.667	0.653	0.522	0.647	0.631	0.208	0.091

Standard errors are clustered by department.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7: Regression of Log Time in Years.

	(TIME 1)	(TIME 2)	(TIME 3)	(TIME 4)
Log(Adjusted Penner Ratio)	-0.0493	-0.0554**	-0.0413**	
	(0.0289)	(0.0261)	(0.0175)	
Log(Indirect Funds per FTE)	0.000643			
	(0.00198)			
Log(Office Space per FTE)	0.0365			
	(0.0287)			
Log(Percent Taught by Faculty)	0.00633	-0.00295		
	(0.0274)	(0.0299)		
Log(Salary Per FTE)	0.0573	0.0373		-0.0199
	(0.0372)	(0.0403)		(0.0331)
Log(Students Graduating in Dept)	-0.00365			
	(0.00428)			
Double Major	0.0412***	0.0430***	0.0434***	0.0450***
	(0.00983)	(0.00985)	(0.00965)	(0.00983)
One B.S.	0.0173	0.0369**	0.0372**	0.0349**
	(0.0204)	(0.0139)	(0.0146)	(0.0136)
COLLEGE FIXED EFFECTS	YES	YES	YES	YES
Constant	0.566	0.997**	1.428***	1.644***
	(0.532)	(0.467)	(0.0116)	(0.388)
Observations	3,596	3,596	3,596	3,596
R-squared	0.038	0.031	0.030	0.023

Standard errors clustered by department.
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Regression of Log Penner Ratio on Other Variables.

	(1)	(2)
Log(Percent Taught by Faculty)		-0.898***
		(0.150)
Log(Students Graduating in Department)	0.174***	
	(0.0477)	
Constant	-0.575**	-0.178*
	(0.237)	(0.0952)
Observations	3,616	3,616
R-squared	0.477	0.520

Standard errors are clustered by department. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9: Cost per Degree.

Major(s)	N	Cost (Academic Year)	Cost (Summer)	Full Cost	Time to Degree (yrs)
Did not graduate.	635	$16,448.77	$1,199.78	$17,648.55	2.81
History	45	$23,874.82	$819.04	$24,693.86	3.92
International Studies-Econ	53	$23,380.92	$1,544.56	$24,925.48	4.07
Joint Math-Econ	17	$24,371.09	$1,130.17	$25,501.27	3.87
International Studies-History	17	$24,001.92	$1,929.34	$25,931.26	4.25
Urban Studies and Planning	31	$24,179.09	$1,835.81	$26,014.90	4.25
Psychology	207	$24,719.81	$1,566.09	$26,285.90	4.30
Psychology	83	$24,696.48	$1,735.07	$26,431.54	4.11
International Studies-Poli Sci	63	$25,475.86	$1,088.10	$26,563.96	4.15
Human Development	90	$25,813.61	$1,265.64	$27,079.25	4.12
Economics	216	$25,385.83	$1,817.36	$27,203.20	4.20
Management Science	213	$25,650.79	$1,613.07	$27,263.87	4.19
Political Science and Specialties	256	$26,122.42	$1,274.13	$27,396.55	4.07
Microbiology	9	$26,269.37	$1,492.50	$27,761.87	4.14
History & Political Science and Specialties	7	$26,004.42	$1,850.23	$27,854.65	4.25
Economics & Political Science and Specialties	15	$25,614.44	$2,589.98	$28,204.42	4.27
International Studies-Sociol	31	$27,213.99	$1,104.28	$28,318.27	4.27
International Studies-Linguist	5	$27,153.27	$1,328.75	$28,482.02	4.20
Molecular Biology	40	$26,943.91	$1,547.18	$28,491.09	4.21
Human Biology	305	$27,039.56	$1,682.87	$28,722.44	4.23
Mathematics (Applied)	10	$27,828.17	$1,195.19	$29,023.36	3.98
Environmental Systems and Specialties	5	$27,935.87	$1,227.98	$29,163.86	4.70
General Biology	252	$27,223.66	$2,057.29	$29,280.96	4.35
Communications	148	$27,932.40	$1,368.70	$29,301.11	4.08
Mathematics	14	$27,852.94	$1,596.73	$29,449.67	3.96
Communications & Political Science and Specialties	7	$27,998.80	$1,508.89	$29,507.68	4.07
Physiology & Neuroscience	114	$27,762.95	$1,756.51	$29,519.46	4.27
Biochemistry and Cell Biology	257	$27,642.97	$2,049.69	$29,692.66	4.29
Ecology, Behavior & Evolution	29	$28,600.88	$1,294.61	$29,895.49	4.44
Biochemistry/Chemistry	45	$28,073.75	$1,954.66	$30,028.41	4.21
Environmental Systems and Specialties	40	$28,234.96	$1,957.20	$30,192.16	4.35
Sociology and Specialties	58	$29,117.89	$1,226.02	$30,343.91	4.25
Pharmacological Chemistry	52	$28,837.81	$2,244.80	$31,082.60	4.39
Chemistry	20	$30,494.16	$1,225.09	$31,719.25	4.39
International Studies-Anthro	7	$29,122.59	$2,673.74	$31,796.33	4.43
Political Science and Specialties & Sociology and Specialties	8	$30,778.45	$1,866.02	$32,644.47	4.19
Anthropology and Specialties	23	$31,124.18	$1,689.37	$32,813.55	4.13
Cognitive Science and Specialties	80	$30,943.50	$1,909.21	$32,852.71	4.35
Joint Math-Econ	9	$29,670.18	$3,590.83	$33,261.01	4.94
Probability & Statistics	7	$30,705.91	$2,918.23	$33,624.14	4.25
Visual Arts (Media)	37	$32,367.08	$1,281.13	$33,648.21	4.18
Ethnic Studies	28	$32,034.24	$1,935.84	$33,970.08	4.74
Literature (French, Spanish, English, World), Lit/Writing, or Lit Cultural	74	$32,604.37	$1,519.13	$34,123.50	4.18
Linguistics and Specialties, except Language Studies	13	$33,856.66	$941.75	$34,798.42	4.23
Visual Arts (Studio)	11	$32,399.66	$2,511.31	$34,910.97	4.57
Bioengineering and Specialties	114	$33,549.85	$1,553.45	$35,103.30	4.31
Visual Arts(Art Hist/Criticsm)	15	$34,021.72	$1,340.12	$35,361.84	4.37
Cognitive Science and Specialties	10	$33,112.10	$2,520.93	$35,633.03	4.56
Philosophy	16	$34,706.30	$2,341.40	$37,047.70	4.55
Interdisc Computing & the Arts	16	$35,893.48	$1,518.77	$37,412.24	4.52
Mathematics	8	$36,592.74	$1,864.12	$38,456.86	4.88
Chemical Engineering	40	$36,273.87	$2,338.92	$38,612.79	4.39
Computer Science	91	$36,719.21	$2,043.44	$38,762.65	4.46
Interdisc Computing & the Arts	14	$38,091.79	$823.80	$38,915.59	4.45
Theatre	16	$37,984.48	$1,392.05	$39,376.52	4.34
Structural Engineering	72	$39,483.88	$2,268.06	$41,751.94	4.60
Environmental Engineering	9	$37,309.38	$4,515.03	$41,824.41	4.56
Physics and Specialties	16	$41,146.91	$917.95	$42,064.86	4.05
Aerospace Engineering	55	$39,382.63	$3,015.68	$42,398.31	4.41
Mechanical Engineering	126	$39,127.46	$3,292.05	$42,419.51	4.65
Computer Engineering	14	$41,698.22	$1,058.53	$42,756.76	4.38
Electrical Engineering	59	$41,756.24	$1,514.85	$43,271.09	4.53
Music	8	$42,221.32	$1,872.81	$44,094.13	4.50

6.2 Technical Appendix

6.2.1 Bundled Majors

This listing reflects majors that we bundled into one major. Some majors have the same title but are under different codes – for instance, some Math-Econ majors are classified under math, whereas others are classified under Economics. Additionally, some specialized majors have very small enrollments – instead of showing the actual cost of a small number of students, these students were included along with other majors in their department.

1. Anthropology, Anthropology(Conc in Bio Anth), Anthropology(Conc in Archaeol), Anth (Conc Sociocultural Anth)
2. Bioengineering, Bioengineering: Pre-Medical, Bioengineering (Biotechnology), Bioengineering: Bioinformatics
3. Cognitive Science, Cogn Sci w/Specializ Human Cog, Cogn Sci w/Specializ Neurosci, Cogn Sci w/Spec Hum Comp Inter, Cogn Sci w/Spec Clin Asp Cogn
4. Two differently coded Computer Engineering Degrees
5. Joint Major Mathematics & Econ (Home: Econ Dept), Joint Major Mathematics & Econ (Home: Math Dept)
6. Environ Sys (Earth Sciences), Environ Sys (Ecol,Behav&Evol), Environ Sys(Environ Chemistry), Environ Sys (Environ Policy)
7. Linguistics, Linguistics(Spec Lang&Society), Linguistics(Spec Cogn & Lang)
8. French Literature, Spanish Literature, Literature/Writing, Literatures in English, Literatures of the World, Literature/Cultural Studies
9. Political Science, Political Sci/Amer Politics, Political Sci/Compar Politics, Political Sci/Intntl Relations, Political Sci/Political Theory, Political Sci/Public Law, Political Sci/Public Policy
10. Two differently coded Communication Degrees

11. Physics-Biophysics, Physics, Physics w/Specializ Mtrls Phys, Phys w/Spec Computational Phys, Physics w/Specializ Astrophys

12. Sociology, Sociology-American Studies, Sociology-Culture/Communic, Sociology-Economy and Society, Sociology-International Stu, Sociology-Law and Society, Sociology-Social Inequality

13. Two differently coded Computer Science Degrees

6.2.2 Technical Description of Cost Calculation

In order to compute the cost, we use the following variables:

$1(k)$	Identity function equal to 1 if course k is *not* a graduate teaching course or an undergraduate independent study course.
$1(k,m)$	Identity function equal to 1 if course k is taught by department m.
BG_m	Block grant awards for department m (FY2008-9).
C_m^q	Budget of department or division m, measure q.
$c_{m,q}$	Cost per credit hour for major m, measure q.
$c^{\kappa,q}$	Cost per credit hour for subject code κ, measure q.
${}_{d,q}c$	Cost per credit hour for division d, measure q.
$D(m)$	Division of major m.
DIV_m	Diversity awards for graduates in department m.
F_m^1	Office space allocated to department m (assigned ft^2 FY2008-9).
F_m^2	Classroom space allocated to department m (assigned ft^2 FY2008-9).
F_m^3	Teaching labs allocated to department m (assigned ft^2 FY2008-9).
F_m^4	Assembly space allocated to department m (assigned ft^2 FY2008-9).
F_m^5	Research space allocated to department m (assigned ft^2 FY2008-9).
F_m^6	Other space allocated to department m (assigned ft^2 FY2008-9).

h_k	Non-adjusted average credit hour taken for course k.
k	Course
$\mathbf{k}_\kappa$	Set of courses in subject code κ.
$\mathbf{k}_m$	Set of courses in major m.
κ	Subject code
$\boldsymbol{\kappa}_m$	Set of subject codes in department m.
LEC_m	Lecturer salaries in department m.
m	Department
$M(k)$	Function returning departmental home of course k.
OGS_m	OGS non-specified awards for department m.
P_k	Penner measure for course k.
S_k	Number of students in a course k.
SF_m	Budgeted support funds for department m (FY2008-9).
SAL_m	Faculty salaries for department m (FY2008-9).
TA_m	Teaching assistant salaries for department m (FY2008-9).
TAT_m	Teaching assistant tuition waivers for department m (FY2008-9).
TU_m	Tutor and reader salaries (FY2008-9).

The cost per credit hour calculation is given by:

$$C_m^1 = SF_m + SAL_m + LEC_m + TA_m + TU_m + DIV_m + BG_m + OGS_m + TAT_m \tag{6}$$

$$C_m^2 = C_m^4 = C_m^1 + 36\sum_{t=1}^{3} F_m^t$$

$$C_m^3 = C_m^1 + 36\sum_{t=1}^{6} F_m^t$$

$$c_{m,q} = \begin{cases} q \neq 4 & \dfrac{C_m^q}{\sum_{\kappa\in\boldsymbol{\kappa}_m}\sum_{k\in\mathbf{k}_\kappa} S_k h_k P_k \times 1(k,m)1(k)} \\ q = 4 & \dfrac{C_m^q}{\sum_{\kappa\in\boldsymbol{\kappa}_m}\sum_{k\in\mathbf{k}_\kappa} S_k h_k \times 1(k,m)1(k)} \end{cases} \qquad (7)$$

$${}_{d,q}c = \begin{cases} q \neq 4 & \dfrac{C_d^q}{\sum_{\kappa\in\boldsymbol{\kappa}_d}\sum_{k\in\mathbf{k}_\kappa} S_k h_k P_k \times 1(k,d)1(k)} \\ q = 4 & \dfrac{C_d^q}{\sum_{\kappa\in\boldsymbol{\kappa}_d}\sum_{k\in\mathbf{k}_\kappa} S_k h_k \times 1(k,d)1(k)} \end{cases}$$

$$c^{\kappa,m} = \begin{cases} q \neq 4 & \dfrac{\sum_{k\in\mathbf{k}_\kappa} 1(k)\times S_k h_k P_k \left(c_{M(k),q} + {}_{d(k),q}c\right)}{\sum_{k\in\mathbf{k}_\kappa} S_k h_k P_k} \\ q = 4 & \dfrac{\sum_{k\in\mathbf{k}_\kappa} 1(k)\times S_k h_k \left(c_{M(k),q} + {}_{d(k),q}c\right)}{\sum_{k\in\mathbf{k}_\kappa} S_k h_k} \end{cases}$$

6.2.3 Student Utility Problem

We take the ratio of students as implied by a logit utility function as given instead of idiosyncratic. The utility function is $U_{ms} = b_1 \log \widetilde{\gamma}_m + b_2 \log \rho_m + b_3 \log \frac{w_m}{\bar{w}} + \epsilon_{ms}$. The ratio of the students is given by:

$$
\begin{aligned}
\frac{S_i|\mathrm{f}}{S_j|\mathrm{f}} &= \frac{\exp\left(b_1 \log \tilde{\gamma}_i + b_3 \log \frac{w_i}{\bar{w}}\right) \exp\left(b_2 \log \rho_i\right)}{\exp\left(b_1 \log \tilde{\gamma}_j + b_3 \log \frac{w_j}{\bar{w}}\right) \exp\left(b_2 \log \rho_j\right)} \\
&= \exp\left(b_1 \left[\log \widetilde{\gamma}_i - \log \widetilde{\gamma}_j\right]\right) \exp\left(b_2 \left[\log \rho_i - \log \rho_j\right]\right) \\
&\times \exp\left(b_3 \left[\log \frac{w_i}{\bar{w}} - \log \frac{w_j}{\bar{w}}\right]\right) \\
&= \left[\frac{\widetilde{\gamma}_i}{\widetilde{\gamma}_j}\right]^{b_1} \left[\frac{\frac{w_i}{\bar{w}}}{\frac{w_j}{\bar{w}}}\right]^{b_3} \left[\frac{\rho_i}{\rho_j}\right]^{b_2} \\
&= \left[\frac{\widetilde{\gamma}_i}{\widetilde{\gamma}_j}\right]^{b_1} \left[\frac{w_i}{w_j}\right]^{b_3} \left[\frac{\frac{f_i}{\sigma_i S_i}}{\frac{f_j}{\sigma_j S_j}}\right]^{b_2} \\
&= \left[\frac{\widetilde{\gamma}_i}{\widetilde{\gamma}_j}\right]^{b_1} \left[\frac{w_i}{w_j}\right]^{b_3} \left[\frac{f_i}{f_j} \frac{\sigma_j S_j}{\sigma_i S_i}\right]^{b_2} \\
&= \left[\frac{\widetilde{\gamma}_i}{\widetilde{\gamma}_j}\right]^{b_1} \left[\frac{w_i}{w_j}\right]^{b_3} \left[\frac{f_i}{f_j}\right]^{b_2} \left[\frac{\sigma_i}{\sigma_j}\right]^{-b_2} \left[\frac{S_i}{S_j}\right]^{-b_2} \\
\left[\frac{S_i|\mathrm{f}}{S_j|\mathrm{f}}\right]^{1+b_2} &= \left[\frac{\widetilde{\gamma}_i}{\widetilde{\gamma}_j}\right]^{b_1} \left[\frac{w_i}{w_j}\right]^{b_3} \left[\frac{f_i}{f_j}\right]^{b_2} \left[\frac{\sigma_i}{\sigma_j}\right]^{-b_2} \\
\frac{S_i|\mathrm{f}}{S_j|\mathrm{f}} &= \left[\frac{\widetilde{\gamma}_i}{\widetilde{\gamma}_j}\right]^{\frac{b_1}{1+b_2}} \left[\frac{w_i}{w_j}\right]^{\frac{b_3}{1+b_2}} \left[\frac{f_i}{f_j}\right]^{\frac{b_2}{1+b_2}} \left[\frac{\sigma_i}{\sigma_j}\right]^{-\frac{b_2}{1+b_2}}
\end{aligned}
\tag{8}
$$

6.2.4 Some Additional Remarks Concerning Treatment

Cost calculation: TAT_m in Section 6.2.2 should be assigned to the department offering the stipend, but the data feed is based on where the student is located. For instance, if a student in Economics is a teaching assistant for Culture, Art, and Technology, we see lines related to ECON, but we only see the line for CAT where the CAT program budget specifically funds the student. Many of the other lines are from general funds, even though the CAT program has initiated these expenses. To assign costs to the proper department, we take this group of perhaps one or more students and assign the tuition and fee waiver to the departments in proportion to the instructional stipend paid by each department. We do not include the stipend in TAT_m, as this is included in TU_m and/or TA_m.

Student-level data for TAT_m is unavailable for FY2008[10]; for FY2008, we regress (without a constant) the FY2009 stipend on FY2009 TA salaries, and then we use the inflation-adjusted TA salary for FY2008 to estimate the FY2009 tuition waiver.

For SAL_m, we were unable to obtain non-salary benefits package summaries for departments at UCSD until late in the research. In actuality, these costs are assigned department-to-department by a formula which has little relevance to the benefits actually received or to the burden implied by any particular faculty or staff member.

Variables BG_m, DIV_m, and OGS_m come from a data feed from the Office of Graduate Studies. Block grants are a department-by-department sum of money allocated by OGS; for more information on BG_m, see Arovas, et.al. (2010). The Material Science and Bioinformatics programs receive an allocation of BG_m, DIV_m, and OGS_m; we reassign these costs across relevant departments based on the course makeup of the graduate students in those departments.

On occasion, the department m is ambiguous. Firstly, the History Department is combined with the CAESER Program. This is because the CAESER Program, which includes majors such as Classical Studies, Russian & Soviet Studies, and others, is administered by the History Department. Secondly, we have separated out the Linguistics Department, which is a true academic department, from the Linguistics Language Program, which teaches undergraduate foreign language courses. While they are administered in the same department, they have separate budgets, and so many students take courses in the language

[10]We received this data, but the student-level data for FY2008 does not match the summary statistics for FY2008 by a large margin, whereas a check for a few departments on the FY2009 data against summary statistics match within rounding, so we are certain FY2009 is accurate.

program that it is worth separating. Next, the Nanoengineering department is created in the middle of the dataset. Thus, we combine it with a similar department that taught many of the courses prior to its founding, the Mechanical and Aerospace Engineering Department.

We do not have data for some departments. For instance, the Scripps Institute of Oceanography is a part of UCSD but is assigned a completely different budget process. These department codes, usually located in specialty departments, are assigned the average cost per credit hour[11].

The $36 figure comes from lease information on office and research space for similar buildings in the nearby Torrey Pines area in San Diego; this information was provided by Newark Grubb Night Frank.

Provost and division calculations are meant to include administrative costs, but often include courses taught by those provosts and divisions as well. We do have information to properly separate several of these departments (i.e., writing programs, Muir Interdisciplinary and Critical Gender Studies), but for some specific courses, there is no information. Unfortunately, this biases both courses taught by those departments *and* the divisional administrative cost. In a degree aggregation, these costs will aggregate properly as long as the student taking these college-specific courses is in the college. Secondly, some division-unidentifiable courses were assigned the average divisional cost.

Information on Right-Hand Side Variables: Most right-hand side data is from Academic Affairs' Resource Profiles and averaged across two years (we do not average the averages; we take the numerator as the sum of the figures and the denominator as the sum of the faculty over both years). However, the percentage of courses taught by faculty is taken from "Teaching Statistics for the UCSD General Campus Academic Year 2007-2008, Excluding Summer Sessions." Since many programs have 0 FTE Faculty Members, many students graduating in these programs are not included in the regression. Mechanical Engineering and Nanoengineering are combined into one department. History is combined with CAESER for the cost-per credit hour calculation (and for location of degree to determine department size), but for most right-hand side variables, we use only History funds. This is because there are no FTE faculty in CAESER, so adding extra office space in the numerator for a large, linked, but technically different, operation would make the combined History-CAESER department a strange outlier. A similar rationale works for Linguistics and the Linguistics Language Program.

A note on inflation: All data from FY2008 is inflated by 1.0140 (using an average of July-June CPI

[11]Department codes ERTH, LAWS, LATI, RELI, SOE, SIO, and UNAF. Code ERTH is different than ESYS; we do have data for ESYS. We use average adjusted undergraduate hours to weight these parameters, except in measure 4, which we use average unadjusted undergraduate hours.

for both years). We refer to this figure as FY2009 dollars.

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