DOCUMENT RESUME

ED 422 813 HE 031 571

AUTHOR Toutkoushian, Robert K.
TITLE The Value of Cost Functions for Policymaking and Institutional Research. AIR 1998 Annual Forum Paper.
PUB DATE 1998-05-00
NOTE 26p.; Paper presented at the Annual Forum of the Association for Institutional Research (38th, Minneapolis, MN, May 17-20, 1998). An earlier version of the paper was presented at the Annual Meeting of the Northeast Association for Institutional Research (Hartford, CT, November 1997).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Correlation; *Costs; Educational Administration; *Educational Finance; *Expenditure Per Student; *Expenditures; Higher Education; Institutional Characteristics; Peer Institutions; *Policy Formation; Predictive Measurement; Private Colleges; Regression (Statistics); School Demography; State Universities
IDENTIFIERS *AIR Forum; Integrated Postsecondary Education Data System

ABSTRACT

Multiple regression analysis was used to examine data from the 1994-95 Integrated Postsecondary Education Data System survey to determine the characteristics that influence institutional costs and, in the process, to identify policies that could reduce costs. The data universe consisted of 828 public and private 4-year institutions that did not have a medical school or hospital, enrolled both undergraduate and graduate students, and ranged in size from small liberal arts colleges to major research universities. The study focused on how factors such as enrollment level, institution location, research intensity, and faculty characteristics influence institutional costs. These cost functions were also used to estimate the marginal cost of undergraduate instruction and to compare actual and predicted expenditures per student across institutions. It was found that both total and average expenditures were significantly lower at public institutions than at private institutions. While economies of scale were noted, the evidence varied across types of institutions; expenditures per student appeared to be minimized at about 23,000 students. The paper includes an introduction, a literature review, a summary of data and methodology, an analysis of the results, and a summary section that reviews some of the policy implications. Five data tables are appended. (Contains 24 references.) (CH)

The Value of Cost Functions for Policymaking and Institutional Research

Robert K. Toutkoushian

Executive Director
Office of Policy Analysis
University System of New Hampshire
Myers Financial Center
27 Concord Road
Durham, NH 03824
Phone: (603) 862-0966

I am indebted to Paula Hollis for her helpful comments on earlier drafts of this paper, to IPEDS for making the data used in this study available to researchers on the World Wide Web, and to John Kraus for raising the possibility that the expenditures per student difference between public and private institutions varies by geographic region. An earlier version of this paper was presented at the annual meetings of the Northeast Association for Institutional Research, Hartford, CT, November 1997.

for Management Research, Policy Analysis, and Planning

This paper was presented at the Thirty-Eighth Annual Forum of the Association for Institutional Research held in Minneapolis, Minnesota, May 17-20, 1998.
This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of AIR Forum Papers.

Dolores Vura
Editor
AIR Forum Publications

Abstract

This study uses data from the 1994-95 Integrated Postsecondary Education Data Surveys (IPEDS) to estimate cost functions for postsecondary institutions. This paper focuses on the applications of these functions for policymaking and institutional research. The results show how factors such as enrollment levels, institution location, research intensity, and faculty characteristics influence institutional costs. Many of these relationships have direct implications for how institutions can reduce expenditures per student, and the possible consequences of such changes. The cost functions are also used to estimate the marginal costs of undergraduate instruction, and to compare actual and predicted expenditures per student across institutions. Particular emphasis is given throughout as to the policy implications of the results.

The Value of Cost Functions for Policymaking and Institutional Research

Introduction

It is well known that postsecondary institutions are focusing increased attention on the costs they incur from providing services. This emphasis on cost containment has been driven largely by declining federal and state contributions to higher education. The U.S. Department of Education (1996) reports that nationwide from 1980-81 to 1993-94, the share of current fund revenues from the federal government has fallen from 14.9% to 12.3%, and state contributions to higher education have experienced an even larger drop (from 30.7% to 23.4%). Key constituencies such as legislators and citizens have also become increasingly vocal in their demands for accountability from virtually all public sectors, including higher education. These constituents have suggested that higher education should adopt business practices used in the private sector to become more efficient, such as responsibility centered management.

As a result, institutions now routinely calculate their "expenditure per student" and use comparisons of this figure to those for other institutions to assess their relative level of cost efficiency. Such comparisons are problematic in that even within sets of similar institutions there are often differences with regard to factors that could influence costs, such as enrollment levels and mixes, geographical location, and relative emphasis on instruction and research. Failure to account for how an institution's characteristics influence costs can lead to inaccurate conclusions regarding efficiency and what could be done to become more efficient.

Multiple regression analysis can be used to estimate how identified characteristics influence institutional costs and in the process identify policies that could be used to reduce costs. The resulting equation is referred to as a cost function. A majority of studies focus on

explaining expenditures per student, usually derived by dividing total expenditures by the number of students (headcounts or full-time equivalents). More recent studies by Cohn, Rhine and Santos (1989), deGroot, McMahon and Volkwein (1991), and Nelson and Hevert (1992) have argued that the practice of dividing total expenditures by enrollments is problematic since many institutions produce several distinct outputs in the areas of research, undergraduate instruction, and graduate instruction, and that these outputs are interrelated. These studies use total expenditures as the dependent variable and multiple output measures are included as relevant independent variables (see Cohn et al. (1989) and Baumol, Panzar and Willig (1982)). Nonetheless, since expenditures per student is a widely-used statistic, it is important to understand how this measure is also influenced by institutional characteristics.

Cost functions can provide valuable information to policymakers and institutional researchers. The relationship between enrollments and expenditures per student, for example, may indicate whether reductions in expenditures per student can be achieved through increasing enrollments (referred to as "economies of scale"). This is of particular relevance for public institutions, in that if economies of scale exist, states could deliver services to citizens at a lower cost per student through restructuring their public postsecondary system. Cost functions can also be used to test for the presence of economies of scope — that is, whether there are lower per-unit costs when institutions increase production of multiple outputs simultaneously, such as research and undergraduate education. The relationships between other independent variables and institutional costs may highlight alternative means of reducing costs. Finally, cost functions can be used to compare institutions on the basis of actual and predicted expenditures per student, thus controlling for differences due to relevant factors such as enrollments when making comparisons.

This study uses data from the 1994-95 Integrated Postsecondary Education Data Surveys (IPEDS) to estimate cost functions for postsecondary institutions. This paper focuses on the value and limitations of these functions for policymaking and institutional research. Cost functions are estimated using both total expenditures and expenditures per student for the set of all four-year postsecondary institutions engaged in teaching both undergraduate and graduate students and included in the IPEDS data. The results show how enrollment levels, institution location, research intensity, and faculty characteristics influence institutional costs, and how marginal costs vary by enrollment levels and institution type. The cost functions are then used to compare actual and predicted expenditures per student across institutions. It will be argued throughout that many of the steps an institution might take to reduce per student expenditures could have adverse consequences.

Literature Review

There is a long and rich literature on the topic of cost functions in postsecondary education (see Witmer (1971) and Brinkman (1990) for surveys). The practice of focusing attention on institutional costs, and in particular expenditures per student, can be traced to the studies conducted by Allen (1915, 1917). Reeves and Russell (1935) provide perhaps the earliest study of how selected factors influence educational expenditures, and studies by McNeely (1937) and Kilzer (1937) documented notable differences in expenditures per student across institutions.

Most studies to date have focused on whether there are economies of scale in higher education (Cohn et al., 1989; Getz, Siegfried and Zhang, 1991; Nelson and Hevert, 1992; Koshal and Koshal, 1995). Economic theory posits that economies of scale are present in an

organization when average costs per unit of output fall as output rises. Both economies and diseconomies of scale may exist when the average cost curve for an organization is U-shaped (quadratic). The quadratic function is a useful approximation for many organizations, reflecting initial gains from specialization of labor and resources at low levels of output, and eventual rising costs per unit of output from added bureaucracy as output becomes too large.

The emphasis on costs is of particular importance to firms in the for-profit world in that they can learn whether they are achieving their goal (profit maximization) through minimizing costs per unit of output since this is directly tied to their level of profits. It should be recognized, however, that postsecondary institutions are not profit maximizing enterprises. Brinkman (1990), for example, posits that higher education institutions do not attempt to minimize costs, noting that public institutions cannot generally carry over excess revenues from one year to the next, as would be required under profit maximization. Typically, the goals of higher education institutions include improving society through knowledge production due to research activities, and raising the human capital of undergraduate and graduate students by their instructional activities. The connection between cost minimization and the objectives of postsecondary institutions is more ambiguous than in the for-profit world. It is questionable, then, whether policies aimed solely at cost minimization will help institutions better achieve their goals.

In estimating higher education cost functions, the counterpart to output is typically taken to be the level of enrollments at an institution. Since many fixed costs (such as for classrooms and buildings) are not included in institutional expenditure data, higher education cost functions are more properly referred to as variable cost functions (deGroot et al., 1991). The distinction between average cost and marginal cost is also of importance. Average cost is defined as total

expenditures divided by the level of output, whereas marginal cost reflects the change in total cost due to a one-unit increase in output.

The results from empirical studies have been mixed with regard to whether economies of scale exist in higher education. Studies by Hanson (1964), Maynard (1971), Kress (1977), Smith (1978), Brinkman (1981), Cohn et al. (1989), deGroot et al. (1991), and Koshal and Koshal (1995) have found evidence of economies of scale in various groups of postsecondary institutions. Within these studies, however, there is much disagreement as to the enrollment range over which economies of scale are present. Other studies have concluded that no economies of scale exist or that any such economies were relatively minor (Carnegie Commission, 1972; Verry and Layard, 1975; Verry and Davies, 1976; Bowen, 1980; McLaughlin, Montgomery, Smith, Mahan and Broomall, 1980; Nelson and Hevert, 1992).

Data and Methodology

The data are taken from selected IPEDS surveys (Finance, Fall Enrollment, Salaries and Institutional Characteristics) for the 1994-95 academic year. The sample is restricted to the set of four-year institutions that (a) responded to the IPEDS surveys, (b) do not have a medical school or hospital, (c) enroll both graduate and undergraduate students, and (d) have no missing values on the variables in the model. The final sample consists of 828 institutions, encompassing both private (n=453) and public (n=375) institutions. The institutions range in size and scope, from small Liberal Arts colleges to major research universities. While this aggregation poses some challenges in the estimation of appropriate cost functions, it also provides variability that is informative in evaluating how expenditures vary according to size/scope of the institution.

Table 1 provides descriptive statistics and definitions for the variables used in the study. Institutions that are identified as being either a Research I or II institution or a Doctoral I or II institution according to the Carnegie classification system are labeled as "research" institutions (n=132), and likewise all Comprehensive I or II institutions and Liberal Arts I and II institutions are labeled as "teaching" institutions (n=696). This formulation does not rule out situations where teaching institutions are also engaged in research, and vice-versa, since the same set of teaching and research variables are used in the stratified equations.

********** **Insert Table 1 Here** **********

Of particular interest are the differences arising between public and private institutions and research versus teaching institutions. The average expenditures for all institutions in the sample is $48.83 million in the 1994-95 fiscal year, with research institutions spending more on average than teaching institutions. Expenditures per student are considerably lower in public institutions than in private institutions, and are higher in research institutions than in teaching institutions. Surprisingly, research institutions allocate a higher proportion of expenditures to instructional activities than teaching institutions. It should be noted, however, that this could be due in part to variations in how expenditures are classified by institutions.

Empirical Results

Multiple regression analysis is used to estimate several alternative cost functions using the IPEDS data. The results are shown in Table 2. Both total expenditures and expenditures per student are used as the dependent variable. Each model controls for the following factors: undergraduate enrollments, graduate enrollments, research dollars received, geographic and

urban location, student/faculty ratio, average full professor salary, percentage of faculty who are full professors, percentage of expenditures for instruction, and public versus private status. The enrollment and research output variables are entered in cubic form in the total expenditure equation and in quadratic form in the expenditure per student equation so that the resulting average and marginal cost curves would be U-shaped when the relevant parameters in the model are non-zero. Economies of scope are captured by interacting the enrollment and research output variables with each other, and dummy variables are also used to determine if there are regional differences in the public/private cost differential between institutions. Since the Park-Glesjer test revealed evidence of heteroscedasticity in the total expenditure models (but not in the expenditure per student models), weighted least squares is used to correct for heteroscedasticity in the total expenditure models. The equations were also estimated in "double log" form, where all variables were expressed in logarithms. The results were very similar to those in Table 2 and thus are not presented here.

********** **Insert Table 2 Here** **********

Table 2 shows that expenditures per student at first decline with the number of undergraduate students and then rise, giving rise to a U-shaped average variable cost curve, holding other output measures constant. The sign patterns for the research variables in Model (1) also suggest that there are U-shaped average cost curves for research, holding enrollments constant. The negative interaction terms in the expenditure per student equation for research and enrollments indicates that economies of scope are present when institutions combine research with either undergraduate or graduate instruction. On the other hand, similar economies of scope are not found with regard to combining graduate and undergraduate instruction.

These findings clearly have policy implications for institutions. Expenditures per student are minimized at enrollment levels of approximately 23,000 undergraduates. Since this figure is larger than the average enrollment levels in place at most institutions, it suggests that reductions in expenditures per student could be achieved through the expansion of institutions and the merging of smaller institutions. While these changes might be advantageous from a cost perspective, would they help institutions to better achieve their goals? One of the major features of the American postsecondary system is its diversity. Such consolidation would certainly reduce the variety of higher education institutions available to students. If students learn better in some environments than in others, then "homogenizing" the higher education market may actually inhibit learning.

The results for other variables in the model are equally relevant from a policymaking and institutional research perspective. Beginning with the student/faculty ratio, Model (3) suggests that an institution can reduce its expenditures per student by nearly $170 through increasing the student/faculty ratio by one, achieved by either reducing the number of faculty or increasing the number of students. Increasing class sizes, however, may raise concerns about the possible negative consequences on student learning. Likewise, reducing faculty numbers would limit both the total research accomplishments of the institution and the breadth of knowledge represented in fields where reductions occur. The coefficient for average full professor salaries shows that an extra $100 in average faculty compensation leads to a $20 increase in per-student costs, and is a major reason why expenditures per student are higher at some institutions than at others. While reducing the growth in faculty salaries would reduce expenditures per student, such reductions could make an institution less effective at attracting and retaining higher quality faculty.

The models suggest that similar gains could be achieved through less reliance on full professors. As the age distribution of faculty shifts to the right due to the progression of the baby boomers through academe, the models would predict that this will place some upward pressure on expenditures per student. Although the tenure system limits an institution's short-term flexibility in reducing the proportion of faculty who are at the full professor rank, this can be accomplished over time through not filling permanent positions when senior faculty retire and using non-regular faculty such as adjuncts to handle the additional teaching load. Policymakers should be aware, however, that such a move could have a negative impact on an institution's research reputation, faculty morale, and quality of instruction.

Expenditures per student are lower at institutions that devote a higher proportion of expenditures to instruction and hence a lower proportion to all other activities. While dedicating a higher percentage of spending to direct instructional activities would reduce expenditures per student, such a policy is also not without probable costs. Reallocating more spending towards instruction would mean less money for things such as facility improvements and student services, two changes which could make the institution less attractive to students. Reducing the relative spending on support personnel and administrative functions can also have a negative impact on many areas including faculty productivity, student satisfaction, and institutional efficiency.

Other results that do not have obvious policy implications are nonetheless interesting. Public institutions are found to have expenditures per student that are over $2,000 lower than for private institutions with the same measured characteristics. The geographical variables suggest that expenditures per student are higher in the New England and Far West regions of the country after taking into account the other regressors in the model. Finally, the interaction variables for

geographic region and public/private status show that the gap between expenditures per student in public and private institutions is larger in New England and smaller in the Great Lakes region.

The cost functions in Table 2 aggregate many different types of institutions. This raises the possibility that the cost function is quite different from those for smaller subsets of institutions. In Table 3, the cost function using expenditure per student as the dependent variable is estimated separately for public and private institutions, and research and teaching institutions.

********** **Insert Table 3 Here** **********

The Chow tests reveal that the cost equations for public versus private, and for research versus teaching institutions, are significantly different from each other (calculated F-statistics are 12.24 and 11.44 respectively). At the same time, most of the key results for each separate group of institutions are very similar to the results found for the pooled sample. The student/faculty ratio, average full professor salary, percentage expenditures for instruction, percentage faculty who are full professors, research dollars and undergraduate enrollments all have similar sign and significance patterns across these groups. The difference in expenditures per student between public and private institutions is also of similar magnitude for research and teaching institutions.

Among the notable differences across groups are (i) the positive effect of the percentage of faculty who are full professors on expenditures per student is isolated to private and/or teaching institutions, (ii) economies of scope between research and graduate enrollments is mainly concentrated in research institutions, and (iii) the effect of graduate enrollments on expenditures per student in public institutions is quite different from other institutions. These differences notwithstanding, the comparability of findings across strata suggest that the aggregate cost function is a reasonable representation for the postsecondary institutions in the sample.

The cost function can also be used to estimate the marginal costs for undergraduate students. Marginal costs are important for determining how much total expenditures would be expected to rise from enrolling additional students, and then deciding whether the net additional revenue from tuition and other sources would be sufficient to cover these costs. The marginal cost is obtained by differentiating the cost function (with total expenditures as the dependent variable) with respect to the output variable of interest. Table 4 provides estimates of the marginal costs for undergraduates evaluated at selected enrollment levels. As enrollments rise, marginal costs are calculated assuming that additional faculty are hired to keep the student/faculty ratio constant.

********** **Insert Table 4 Here** **********

Table 4 illustrates that there are wide variations across institution type with regard to the marginal cost associated with increases in undergraduate enrollments. At undergraduate enrollment levels of 5,000, for example, the marginal cost associated with an additional undergraduate student ranges from $5,000 to over $10,000. Generally, public institutions are found to have much lower marginal costs for undergraduate students than private institutions.

Finally, the cost functions can also be used to compare institutions on the basis of actual and predicted expenditures per student. Such a procedure allows the analyst to compare costs per student after controlling for differences across institutions in the factors included in the model, and may help explain why an institution appears to spend a high amount per student when compared to other institutions. Table 5 uses a set of ten institutions (labeled A through J) that have been identified as "comparators" by the administration for one of the institutions and shows their actual and predicted expenditures per student and the difference between the two measures:

********** Insert Table 5 Here **********

Several interesting observations arise from the comparisons in Table 5. In general, institutions with higher levels of expenditures per student also have higher predicted expenditures per student based on their characteristics. This reinforces the notion that an institution's expenditures per student are in part attributed to the factors in the model, and that high expenditures per student are not solely due to inefficiency. At the same time, there are instances where an institution's actual expenditures per student differ considerably from its predicted level. For example, Institution D should have the lowest expenditures per student based on the variables in the model, but its actual per student expenditures are nearly 59% higher than its predicted level. Other institutions, such as A, B, F and G, have actual expenditures per student that are lower than their predicted levels. While these should not be interpreted as proof of either inefficiency (when the difference is positive) or efficiency (when negative), since the residual will be affected by factors not in the model as well as random error, comparing predicted to actual expenditures per student can provide better information to policymakers than is true when only looking at actual expenditures per student.

Summary

The results of this study are important in several respects. First, they verify the findings from previous research that there are a number of factors that influence institutional spending. The observation that expenditures (total and average) are significantly lower at public versus private institutions is certainly encouraging news for administrators in the public sector, and should be of use to public officials and other constituencies interested in how tax dollars given to

public higher education are being spent. While the results show that there are economies of scale, the evidence varies across types of institutions. Expenditures per student appear to be minimized at about 23,000 students total, which is notably greater than is found in most higher education institutions today. This implies that cost savings could be achieved by creating public postsecondary systems consisting of a few larger institutions in each state. Further cost savings are possible through changes in faculty composition, workload, and compensation, and reducing expenditures on non-instruction items in the budget.

While institutions have a responsibility to spend their money wisely, hopefully this study has emphasized that the pursuit of cost minimization alone does not guarantee that postsecondary institutions will be better able to achieve their ultimate goals of producing and transmitting knowledge. When asking how should their higher education system be designed, policymakers should take into account how prescribed changes will affect other desired outcomes from their postsecondary system, such as the value-added from instruction and the contributions of faculty research to society. Institutions spend money to provide these services; hence, reducing expenditures implies that some current services and benefits may be foregone. The goals of postsecondary institutions to maximize the value added to society from instruction and knowledge production may, unfortunately, often be in conflict with the principles of cost minimization advocated in the for-profit world. This conflict limits the potential effectiveness of popular business practices to the academic organizational setting. It is this trade-off between cost minimization and higher education goals that policymakers need to address when making decisions on ways to cut costs, and it is the responsibility of institutional researchers to remind policymakers of these trade-offs when necessary.

References

Allen, W. (1915). Self-Surveys by Colleges and Universities. Yonkers-on-Hudson, New York: World.

Allen, W. et al. (1917). Report Upon the Survey of the University of Wisconsin, Findings of the Board of Public Affairs and its Report to the Legislature. Madison, WI: The Board of Public Affairs.

Baumol, W., J. Panzar, and D.Willig (1982). Contestable Markets and the Theory of Industrial Structure. New York, NY: Harcourt Brace Jovanovich.

Bowen, H. (1980). The Cost of Higher Education. San Francisco: Jossey-Bass.

Brinkman, Paul (1981). Factors affecting instructional costs at major research universities. Journal of Higher Education 52(3): pp. 265-79.

Brinkman, Paul (1990). Higher education cost functions. In S. Hoenack and E. Collins (Eds.), The Economics of American Universities: Management, Operations, and Fiscal Environment. New York: State University of New York Press.

Carnegie Commission on Higher Education (1972). The More Effective Use of Resources. New York, NY: McGraw-Hill.

Cohn, E., S. Rhine, and M. Santos (1989). Institutions of higher education as multi-product firms: economies of scale and scope. The Review of Economics and Statistics 71(2): pp. 284-90.

deGroot, H., W. McMahon, and J.Volkwein (1991). The cost structure of American research universities. The Review of Economics and Statistics 73(3): pp. 424-31.

Getz, M., J. Siegfried, and H. Zhang (1991). Estimating economies of scale in higher education. Economics Letters 37: pp. 203-08.

Hanson, N. (1964). Economy of scale as a cost factor in financing public schools. National Tax Journal 17(1): pp. 92-95.

Kilzer, L. (1937). How local public junior colleges are financed. School Record 45(January): pp. 686-94.

Koshal, R. and M. Koshal (1995). Quality and economies of scale in higher education. Applied Economics 27(8): pp. 773-78.

Kress, S. (1977). Economies of scale and the form of expenditure functions in education: an econometric study of the California community colleges. Unpublished Ph.D. dissertation, University of California at Berkeley.

Maynard, J. (1971). Some Microeconomics of Higher Education: Economies of Scale. Lincoln, NE: University of Nebraska Press.

McLaughlin, G., J. Montgomery, A. Smith, B. Mahan, and L. Broomall (1980). Size and efficiency. Research in Higher Education 12: pp. 53-66.

McNeely, J. (1937). University Unit Costs. Bulletin No. 21. Washington, DC: United States Office of Education.

Nelson, R. and K. Hevert (1992). Effect of class size on economies of scale and marginal costs in higher education. Applied Economics 24: pp. 473-82.

Reeves, R. and J. Russell (1935). The Evaluation of Higher Institutions, Finance, 7. Chicago, IL: University of Chicago Press.

Smith, N. (1978). An Economic Analysis of the Costs of Instruction in the Michigan System of Higher Education. Unpublished Ph.D. dissertation, Michigan State University.

U.S. Department of Education. National Center for Education Statistics. Digest of Education Statistics 1996, NCES 96-133, by Thomas D. Snyder. Production Manager, Charlene M. Hoffman. Program Analyst, Claire M. Geddes. Washington, DC: 1996.

Verry, D. and B. Davies (1976). University Costs and Outputs. Amsterdam: Elsevier.

Verry, D. and P. Layard (1975). Cost functions for university teaching and research. The Economic Journal 85: pp. 55-74.

Witmer, D. (1971). Cost studies in higher education. Review of Educational Research 42(1): pp. 99-127.

Table 1. Descriptive Statistics: IPEDS Survey Data 1994-95

Variable	All Institutions	Public Institutions	Private Institutions	Research & Doctoral Institutions	Comprehensive & Liberal Arts Institutions
Total Expenditures (millions $)	$48.83 (57.7)	$68.62 (65.8)	$32.45 (43.8)	$133.0 (91.5)	$32.86 (27.9)
Expenditures Per Student	$10,450 (4823)	$8,465 (2460)	$12,093 (5619)	$12,885 (7877)	$9,988 (3827)
Number of Undergraduates	4,200 (4338)	6,841 (4881)	2,013 (2034)	9,309 (6350)	3,231 (2983)
Number of Graduates	735 (1098)	1,022 (1302)	498 (824)	2,365 (1671)	426 (555)
Research Dollars (millions)	$10.20 (22.65)	$15.62 (25.37)	$5.71 (19.02)	$36.95 (46.5)	$5.13 (6.46)
Student/Faculty Ratio	20.69 (6.90)	21.96 (4.38)	19.64 (8.29)	20.16 (4.87)	20.79 (7.22)
Average Full Professor Salary	$52,437 (12902)	$56,258 (9911)	$49,274 (14183)	$66,531 (11612)	$49,764 (11304)
% Expenditures on Instruction	46.2%	51.1%	42.1%	51.1%	45.3%
% Faculty Full Professors	31.8%	33.3%	30.4%	38.4%	30.5%
Public Institutions (1=public)	45.3%	n/a	n/a	65.2%	41.5%
Large Urban Area	50.6%	46.9%	53.6%	67.4%	47.4%
Small Urban Area	19.7%	16.0%	22.7%	13.6%	20.8%
Sample size	828	375	453	132	696

Notes: Standard deviations are shown in parentheses. Total expenditures includes current funds expenditures for instruction, academic support, student services, institutional support, operation & maintenance of plant, and mandatory and nonmandatory transfers (restricted and unrestricted). Research dollars = current funds revenues from federal grants and contracts, state grants and contracts, and local grants and contracts. Undergraduate = full-time undergraduate headcount plus 1/3rd part-time undergraduate headcount. Graduate = full-time graduate headcount plus 1/3rd part-time graduate headcount. Number of full-time faculty includes full professors, associate professors, assistant professors, instructors, lecturers, and other faculty. Student/Faculty ratio = sum of undergraduate and graduate enrollments divided by the number of faculty. Large urban area equals 1 if college or university is located in either a large central city of a CMSA of MSA (population greater than 250,000) or a mid-size central city of a CMSA or MSA (population less than 250,000). Small urban area equals 1 if college or university is located on the urban fringe of either a large central city or a small central city.

Table 2. Cost Functions for Higher Education Institutions: IPEDS Survey Data 1994-95

	Total Expenditures ($1000s)		Expenditures Per Student ($)	
Variable	(1)	(2)	(3)	(4)
Number of Undergraduates	9.534**	10.287**	-0.732**	-0.885**
	(17.12)	(19.44)	(8.17)	(9.76)
(Undergraduates)^2	-0.0004**	-0.0005**	1.5e-05**	3.6e-05**
	(5.02)	(5.88)	(3.88)	(5.79)
(Undergraduates)^3	1.3e-08**	1.8e-08**	-----	-----
	(3.82)	(5.44)		
Number of Graduates	8.641**	7.311**	0.138	-0.830**
	(6.53)	(5.71)	(0.57)	(3.30)
(Graduates)^2	0.0027**	0.0033**	-8.9e-05**	2.6e-04**
	(4.36)	(5.49)	(2.64)	(3.49)
(Graduates)^3	-2.3e-07**	-5.4e-07**	-----	-----
	(3.09)	(7.09)		
Research Dollars	853.9**	653.9**	111.36**	171.31**
	(8.60)	(6.77)	(8.03)	(12.30)
(Research $)^2	-3.660**	0.444	-0.149*	0.165
	(3.12)	(0.37)	(2.32)	(1.61)
(Research)^3	0.0158**	-0.0203**	-----	-----
	(4.62)	(3.91)		
Research x Undergrads	-----	-0.069**	-----	-0.006**
		(5.88)		(7.16)
Research x Graduates	-----	0.440**	-----	-0.018**
		(8.68)		(3.65)
Undergraduates x Graduates	-----	-0.0002	-----	-8.7e-06
		(0.89)		(0.27)
Student/Faculty Ratio	-185.5**	-163.5**	-168.1**	-168.3**
	(6.54)	(5.97)	(11.13)	(12.16)
Average Full Professor Salary	0.274**	0.290**	0.201**	0.191**
	(10.76)	(11.95)	(17.27)	(17.55)
% Expenditures for Instruction	-101.2**	-117.6**	-84.41**	-93.46**
	(3.49)	(4.26)	(5.85)	(7.13)
% Faculty Full Professors	58.18**	53.89**	30.05**	32.63**
	(5.07)	(4.97)	(3.47)	(3.99)
Public Institution	-5281**	-8707**	-2318**	-2075**
	(6.98)	(6.82)	(8.19)	(5.14)

Variable	Total Expenditures ($1000s) (1)	(2)	Expenditures Per Student ($) (3)	(4)
New England Region	4570**	4090**	1138**	1953**
	(5.92)	(5.36)	(2.90)	(4.25)
Mid East Region	1656*	443.3	203.7	535.4
	(2.39)	(0.65)	(0.65)	(1.46)
Great Lakes Region	1218	66.45	549.4	-34.26
	(1.74)	(0.09)	(1.77)	(0.09)
Plains Region	-264.5	-428.4	-277.8	-392.0
	(0.33)	(0.53)	(0.76)	(0.87)
Southwest Region	2854**	1303	634.7	-170.2
	(3.07)	(1.26)	(1.68)	(0.32)
Rocky Mountain Region	-123.1	-161.8	-29.90	-441.9
	(0.08)	(0.09)	(0.05)	(0.47)
Far West Region	2312**	1712*	1430**	1549**
	(3.06)	(2.31)	(3.88)	(3.53)
Public x New England	-----	156.3	-----	-2189**
		(0.07)		(3.04)
Public x Mid East	-----	7161**	-----	-348.2
		(3.87)		(0.65)
Public x Great Lakes	-----	6481**	-----	1318*
		(3.39)		(2.32)
Public x Plains	-----	-133.3	-----	418.2
		(0.06)		(0.63)
Public x Southwest	-----	5977**	-----	1298
		(3.10)		(1.87)
Public x Rocky Mountain	-----	2048	-----	642.0
		(0.70)		(0.57)
Public x Far West	-----	6630*	-----	-281.7
		(2.56)		(0.43)
Intercept	-5467**	-5265**	8753**	9621**
	(3.41)	(3.40)	(10.44)	(12.25)
R-squared	0.93	0.94	0.70	0.75

Notes: Calculated t-statistics (absolute value) are shown in parentheses. Sample size = 828. ** p < .01, * p < .05 (two-tailed test). Equations (1) and (2) are estimated using weighted least squares to control for heteroscedasticity, using undergraduate enrollments as the weighting variable. All models also include two dummy variables for whether an institution is located in a large urban area or a suburban area.

Table 3. **Expenditure Per Student Equations by Type of Institution: IPEDS Survey Data 1994-95**

Variable	All Institutions	Public Institutions	Private Institutions	Research & Doctoral Institutions	Comprehensive & Liberal Arts Institutions
Undergraduates	-0.881**	-0.661**	-1.565**	-0.864**	-1.175**
	(9.76)	(7.91)	(7.31)	(3.79)	(7.71)
(Undergrads)^2	3.6e-05**	3.9e-05**	4.8e-05**	2.7e-05*	9.3e-05**
	(5.94)	(5.10)	(4.84)	(2.58)	(6.13)
Graduates	-0.834**	0.889**	-1.599**	-1.135	-0.511
	(3.28)	(3.59)	(2.91)	(1.91)	(1.14)
(Graduates)^2	2.6e-04**	3.2e-05	3.2e-04*	1.8e-04	3.4e-04*
	(3.42)	(0.35)	(2.43)	(1.28)	(2.17)
Research $	167.31**	78.22**	285.73**	127.22**	158.42**
	(11.96)	(6.15)	(7.23)	(4.95)	(3.10)
(Research $)^2	0.210*	-0.072	-0.006	0.252	2.666**
	(2.05)	(0.74)	(0.02)	(1.60)	(2.77)
Research x Undergrads	-0.006**	-0.005**	-0.016*	-0.005**	-0.023**
	(7.60)	(5.12)	(2.39)	(4.05)	(3.15)
Research x Graduates	-0.019**	0.011**	-0.028	-0.017*	-0.046
	(3.79)	(2.74)	(1.72)	(2.25)	(1.36)
Undergraduates x Graduates	-3.7e-07	-8.3e-05	1.5e-04	4.0e-05	-7.4e-05
	(0.01)	(1.96)	(1.80)	(0.74)	(1.03)
Student/Faculty Ratio	-166.10**	-185.61**	-140.87**	-211.65**	-167.06**
	(11.87)	(10.53)	(7.27)	(2.81)	(11.86)
Average Full Professor Salary	0.192**	0.111**	0.236**	0.254**	0.187**
	(17.94)	(9.09)	(13.78)	(7.09)	(15.85)
% Expenditures for Instruction	-89.27**	-91.01**	-101.48**	-1.48	-92.54**
	(6.75)	(7.13)	(5.38)	(0.03)	(7.06)
% Faculty Full Professors	27.05**	-0.663	28.41*	55.19	17.39*
	(3.40)	(0.08)	(2.39)	(1.77)	(2.17)
Public Institutions	-2025.11**	n/a	n/a	-2057.96*	-1895.55**
	(7.75)			(2.15)	(7.13)
Intercept	9478.80**	11763.92**	8596.90**	3070.74	10489.55**
	(12.27)	(12.54)	(7.68)	(0.80)	(13.06)
R-squared	0.746	0.715	0.771	0.868	0.668
Sample size	828	375	453	132	696

Notes: Calculated t-statistics (absolute value) are shown in parentheses. ** $p < .01$, * $p < .05$ (two-tailed test).

Table 4: Estimates of Marginal Cost Per Undergraduate Student by Institution Type at Selected Enrollment Levels: IPEDS Survey Data 1994-95

	Undergraduate Enrollments Equal:			
	5,000	10,000	15,000	20,000
All Institutions	$5,861	$5,051	$6,881	$11,351
Public Only	$5,369	$5,369	$5,369	$5,369
Private Only	$10,226	$10,226	$10,226	$10,226
Research & Doctorate	$10,502	$14,169	$20,282	$28,839
Comprehensive & Liberal Arts Only	$5,179	$4,474	$7,219	$13,414

Notes: Marginal costs are derived by the first partial derivatives of the cost function, i.e, $MC_U = \partial C/\partial U$. Only those coefficients that were found to be statistically significant were used in the MC calculations. The means for the interaction variables were used in the MC formulas when included. Faculty are assumed to hired in constant proportion to students.

Table 5. Actual and Predicted Expenditures Per Student for Ten Institutions

College/University	Actual Expenditures Per Student	Rank	Predicted Expenditures Per Student	Rank	Actual Minus Predicted	Rank
Institution A	$8,961	1	$11,327	6	-$2,366	3
Institution B	$9,541	2	$10,981	4	-$1,440	4
Institution C	$9,635	3	$10,203	3	-$568	5
Institution D	$10,329	4	$6,508	1	$3,822	10
Institution E	$10,598	5	$10,181	2	$417	7
Institution F	$10,831	6	$20,235	10	-$9,404	1
Institution G	$11,613	7	$14,518	9	-$2,904	2
Institution H	$11,879	8	$11,399	7	$480	8
Institution I	$13,453	9	$13,415	8	$38	6
Institution J	$14,305	10	$11,143	5	$3,162	9

Notes: Rankings for actual and predicted expenditures per student are from lowest (1) to highest (10). Predicted expenditures per student are derived from regression model (3) in Table 2.

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

NOTICE

REPRODUCTION BASIS

☒ This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

☐ This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").