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NCES 2003-161

A Study of Higher Education Instructional Expenditures: The Delaware Study of Instructional Costs and Productivity

Research and Development Report

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Research and Development Report

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June 2003

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Suggested Citation
U.S. Department of Education, National Center for Education Statistics. *A Study of Higher Education Instructional Expenditures: The Delaware Study of Instructional Costs and* Productivity. NCES 2003-161, by Michael F. Middaugh, Rosalinda Graham, and Abdus Shahid. Project Officer: C. Dennis Carroll. Washington, DC: 2003.

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Foreword

The Research and Development (R&D) series of reports at NCES has been initiated:

1. To share studies and research that are developmental in nature. The results of such studies may be revised as the work continues and additional data become available.

2. To share the results of studies that are, to some extent, on the "cutting edge" of methodological developments. Emerging analytical approaches and new computer software development often permit new and sometimes controversial analyses to be done. By participating in "frontier research," we hope to contribute to the resolution of issues and improved analysis.

3. To participate in discussions of emerging issues of interest to educational researchers, statisticians, and the federal statistical community in general. Such reports may document workshops and symposia sponsored by NCES that address methodological and analytical issues or may share and discuss issues regarding NCES practices, procedures, and standards.

The common theme in all three goals is that these reports present results or discussions that do not reach definitive conclusions at this point in time, either because the data are tentative, the methodology is new and developing, or the topic is one on which there are divergent views. Therefore, the techniques and inferences made from the data are tentative and subject to revision. To facilitate the process of closure on the issues, we invite comment, criticism, and alternatives to what we have done. Such responses should be directed to:

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Acknowledgments

Many individuals contributed in important ways to development of this report. The Delaware Study of Instructional Costs and Productivity is the data source for the analyses that comprise this study of higher education instructional expenditures. The Delaware Study would not exist were it not for the strong institutional commitment and support received from University of Delaware President David Roselle, Provost Daniel Rich, and most especially Executive Vice President David Hollowell. Larry Hotchkiss and David Kaplan, from the University of Delaware, provided critical advice and support with respect to the selection and use of statistical tests used in the analyses in this report.

Early drafts of the report benefited from extensive review and suggestions from Dennis Carroll, Associate Commissioner for Postsecondary Education, and Paula Knepper, both at the National Center for Education Statistics (NCES), and from Michael Lance, consultant with NCES. Several other individuals in Washington provided valuable feedback. They include Marilyn McMillen Seastrom, Chief Statistician for NCES; Grover J. Whitehurst, Director of the Institute of Education Sciences, U.S. Department of Education; Bernie Greene, Early Childhood, International and Crosscutting Studies Division, NCES; Ilona Berkovits, Division of Elementary, Secondary, and Longitudinal Studies, NCES; David Bergeron, Office of Postsecondary Education, U.S. Department of Education; Dan Goldenberg, Office of the Under Secretary, U.S. Department of Education; and Carol Fuller, National Association of Independent Colleges and Universities.

Finally, special thanks to the staff in the Office of Institutional Research and Planning at the University of Delaware, whose conscientious work on university institutional research projects allowed us time to pursue this project. Those individuals include Dale Trusheim, Associate Director; Karen Bauer, Assistant Director; Heather Isaacs, Institutional Research Analyst; Karen DeMonte, Institutional Research Analyst; and Maggie Brumit, Records Analyst/Coordinator.

EXECUTIVE SUMMARY

A Study of Higher Education Instructional Expenditures is an examination of higher education costs undertaken by the National Center for Education Statistics (NCES). This study of higher education costs was mandated by Congress in the 1998 Higher Education Act. The NCES response to the congressional mandate encompassed three reports: the first, *Study of College Costs and Prices, 1988–89 to 1997–98*; followed by *What Students Pay for College: Changes in Net Price of College Attendance Between 1992–93 and 1999–2000*; and culminating in this third and final report.

The first report in the congressionally mandated study drew the distinction between *sticker price*, i.e., the tuition that an institution charges for a college education, and *cost*, i.e., the fiscal resources expended by the institution to provide that education. Additionally, researchers for the first part of the study found that certain factors are associated with tuition rates. Most notable at state-supported institutions is importance of annual budget appropriations. At private not-for-profit institutions, internal budget constraints, size of endowments, and external market competition were among factors associated with sticker price. There was little evidence indicating that expenditures for instruction were a major factor in determining tuition rates.

This report focuses solely on the issue of direct instructional expenditures, and the factors associated with the comparative magnitude of those expenditures at 4-year colleges and universities in the United States. As evident in the findings and conclusions, the factors associated with instructional expenditures are different from those associated with sticker price, as identified in the first part of the congressionally mandated study. Cost and price are *not* interchangeable constructs, and a strong statistical relationship between them has not been found.

The data source for this analysis is multiple cycles of the Delaware Study of Instructional Costs and Productivity, henceforth called the Delaware Study. Begun in 1992 by the Office of Institutional Research and Planning at the University of Delaware, the study has grown into a national data-sharing consortium embracing over 300 4-year colleges and universities across the United States. The foci of data-sharing activities are detailed analyses of teaching loads by faculty category, instructional costs, and externally funded scholarly activity, all at the level of the academic discipline.

Goals and Limitations of This Study

The primary objective of this analysis of instructional expenditures is the identification of those factors that contribute to describing direct instructional costs in the colleges and universities that participate in the Delaware Study.

The study is characterized by the following factors:

- Participation in the Delaware Study is *voluntary*, and is restricted to 4-year Title IV-eligible institutions only. The fact that the data population used in this study is self-selected raises the issue of nonresponse bias. For example, institutions that participate in the Delaware Study typically have enrollments of at least 5,000 students and are organizationally complex, with discrete academic departments or programs that correspond with the four-digit codes assigned to disciplines within the NCES *Classification of Instructional Programs* (CIP) taxonomy. In contrast, single purpose institutions with smaller enrollments frequently have multiple disciplines grouped within a given organizational structure, e.g., Division of Social Sciences, or Department of Education, etc., and participate in much smaller numbers than their larger, more complex counterparts. In addition, because participation is restricted to 4-year institutions, findings cannot be extended to the 2-year college sector.

- Because the population for this study is self-selected, it is, by definition, not a random sample. Descriptive statistics are applied to data from responding institutions to describe instructional expenditures for those institutions, but the findings cannot be inferentially generalized to the larger population of all Title IV-eligible 4-year colleges and universities in the United States. However, this study's findings nonetheless yield valuable descriptive information about expenditures in those institutions that participate in the Delaware data-sharing process.

- The Delaware Study expenditure data reflect *direct* instructional expense, and therefore cannot be used for a full cost model. There are methodological pitfalls and inconsistencies in full cost modeling in higher education, especially with respect to allocating indirect costs (as described in the full report).

Within the context of these characteristics, this study yields information about factors that contribute to direct instructional costs at an institution, and these expenditures generally compose the largest portion of the operating budget at most colleges and universities.

Study Design and Methodology

This study utilized data from multiple data collection cycles of the Delaware Study, focusing primarily on data collected during 1998, 2000, and 2001. Data were collected using an established survey instrument that requests detailed information on fall semester teaching loads by faculty category, and academic and fiscal year student credit hour production and direct expenses for instruction, research, and service activity.

Direct instructional cost per student credit hour taught is the focal dependent variable examined in this study. Patterns of dispersion and difference in cost across disciplines are examined through a series of analytical lenses that are typically assumed to be major cost factors in the literature. These include institutional mission as characterized by the Carnegie institutional classification. The Delaware Study employs the 1995 Carnegie taxonomy[1]—research, doctoral, comprehensive, and baccalaureate institutions. The study also examines the impact of other variables such as highest degree offered within a discipline, and the relative emphasis on undergraduate versus graduate instruction within a discipline.

Using appropriate statistical tools, the relationship of cost to variables such as department size (measured in terms of number of faculty), proportion of faculty who are tenured, volume of student credit hours taught, and personnel expense as a percentage of total instructional costs is examined and measured. Effects of highest degree offered in the discipline, as well as Carnegie institutional classification, are also examined. Cost factors are determined by disciplines, or where more appropriate, groups of disciplines.

Findings

The key finding from analysis of multiple years of Delaware Study data is that most of the variance in instructional cost across institutions, as measured by direct expense per student credit hour taught, is associated with the disciplinary mix within an institution.

A secondary factor affecting cost is institutional mission, as related to Carnegie institutional classification. This result may be associated with different faculty responsibilities at institutions with different Carnegie classifications. For example, faculty at research universities,

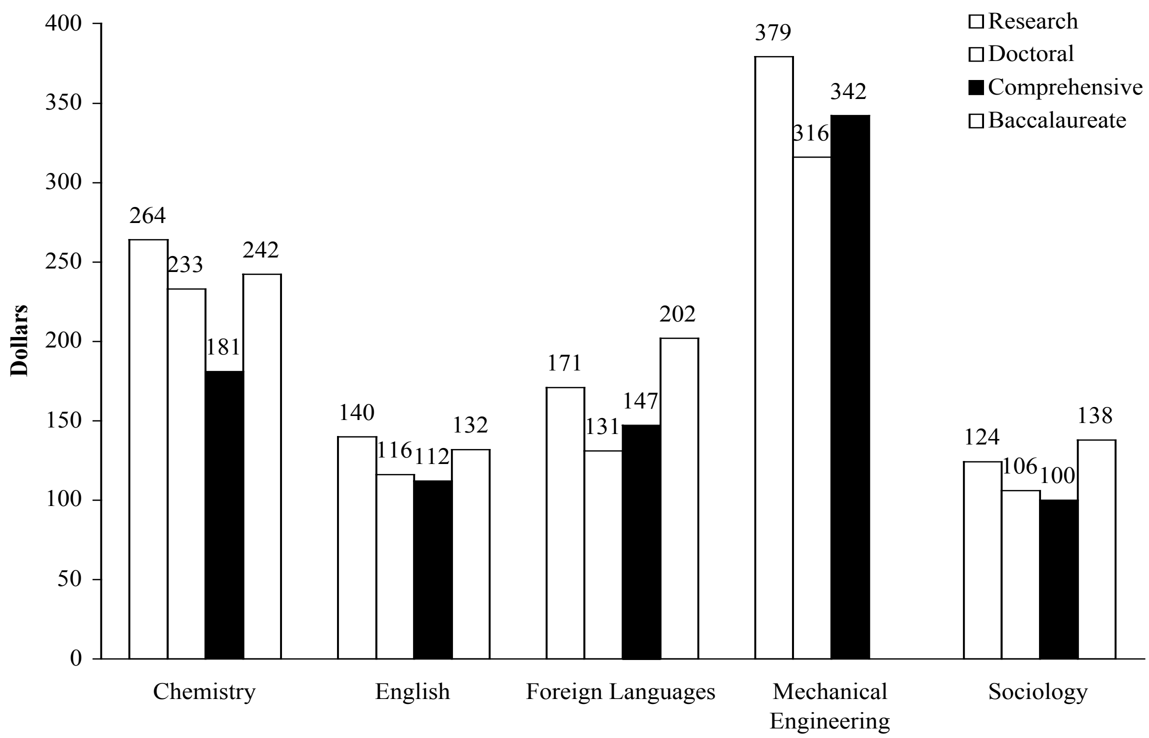
[1] The 1995 Carnegie Taxonomy is fully described in appendix C.

extensively engaged in research activity, might be expected to teach fewer student credit hours at higher costs than faculty at comprehensive institutions. However, Carnegie classification accounts for less of the cost differential between institutions than the disciplinary mix factor.

Figure A reflects actual academic year 2001 Delaware Study benchmarks[2] for 5 of the 24 disciplines analyzed in this study. The benchmarks are mean values for direct expense per student credit hour taught, as reported by participating institutions. They have been refined to correct for outliers and influential cases, and as such, are fair reflections of the average cost of instruction in those disciplines.

In chemistry, average direct expense per student credit hour taught ranged from $181 at comprehensive institutions to $264 at research universities, an $83 spread. The range in English is $28, from a low of $112 at comprehensive institutions to a high of $140 at research universities. Foreign languages range from $131 at doctoral universities to $202 at baccalaureate colleges, a $71 spread, while mechanical engineering ranges from $316 at doctoral universities to $379 at research universities, a difference of $63. And sociology ranges from $100 at comprehensive institutions to $138 at baccalaureate colleges, a spread of $38. These examples in figure A are typical of the ranges in any given Delaware Study data collection cycle.

Figure A. Direct expense per student credit hour taught: Institution type within discipline, 2001



NOTE: Data for mechanical engineering at baccalaureate institutions are not applicable.
SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

[2] The complete set of Delaware Study benchmarks for all of the disciplines analyzed in this study is found in appendix tables D-1 through D-10.

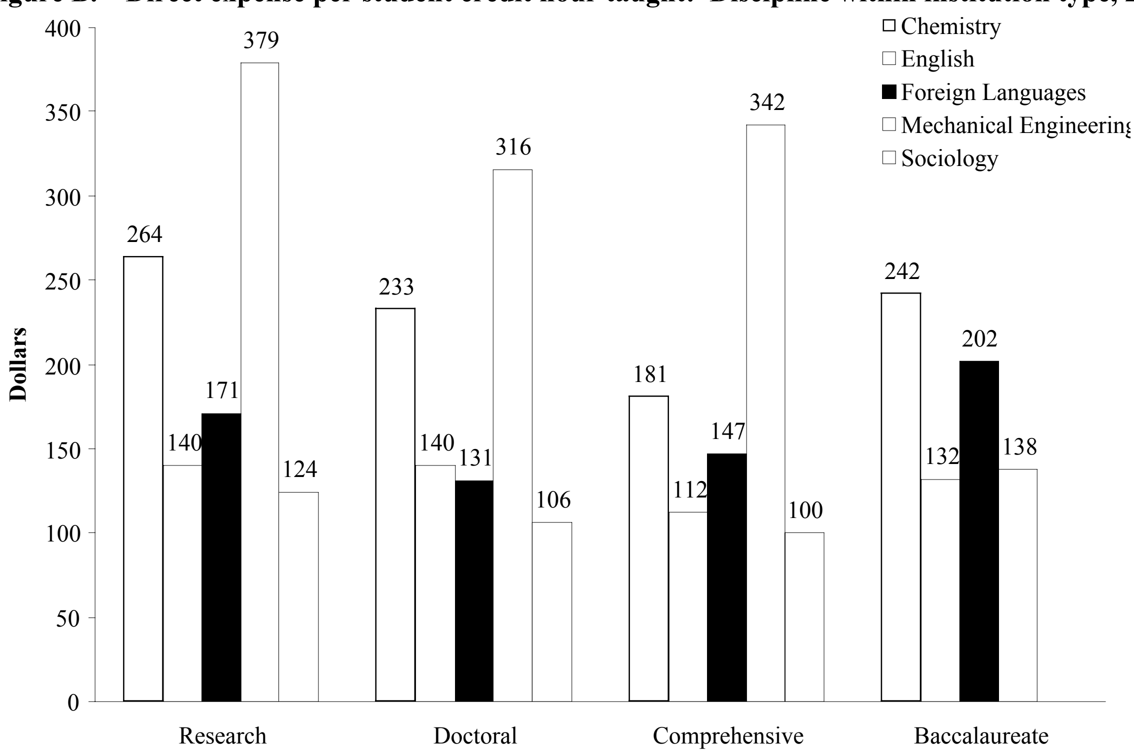
While the foregoing discussion demonstrates that there is variation within a discipline *across institution types*, figure B clearly illustrates there is also considerable variation *across the disciplines within an institution*. Using the same disciplinary examples, at a research university, the difference in direct expense per student credit hour taught between English and mechanical engineering is $239; the difference between sociology and chemistry is $140. Comparable patterns are apparent within the other Carnegie categories as well.

These cost differentials within disciplines across institutional types and between disciplines within those types lead to an overarching question. In describing the cost of instruction at higher education institutions, which is the more important factor—the designation of the institution as research, doctoral, comprehensive, or baccalaureate, or the configuration of disciplines that compose the institution?

Hierarchical linear modeling (HLM)[3] is a statistical tool that provides the capability to disaggregate total variance in cost by institution, and by discipline within the institution. HLM helps to explore and describe the dispersion of instructional costs across institutions, and to identify those factors that are associated with the dispersion. The hierarchical linear model constructed in this study demonstrates that most of the variance in cost is at the discipline level within an institution, ranging from 76.0 percent in the 1998 data collection cycle to 82.6 percent in the 2000 cycle.

It can be asserted that Carnegie institutional classification, as a proxy for institutional mission, is tied to at least some of the dispersion of costs at the aggregate institutional level. When Carnegie classification is taken into account in the hierarchical linear model, the dispersion in cost across institutions decreases, and the relative

Figure B. Direct expense per student credit hour taught: Discipline within institution type, 2001



NOTE: Data for mechanical engineering at baccalaureate institutions are not applicable.

SOURCE: University of Delaware. The Delaware Study of Instructional Costs and Productivity, 1998–2001.

[3] A complete brief discussion of the statistical techniques used in analyzing cost variance is found in the Technical Notes (appendix E).

variance due to disciplines within an institution ranges from 81.0 to 88.0 percent.

This important finding underscores that the disciplines that compose a college or university's curriculum, not its Carnegie designation, are associated with most of the dispersion of costs among institutions. This further highlights the distinction between costs, i.e., instructional expenditures, and price, i.e., tuition. Stated plainly, *price* is a constant for all undergraduates at an institution; chemistry and engineering majors pay the same tuition rate as English and sociology majors. However, the *cost* of delivering instruction in those disciplines varies widely.

Finding that most of the variation in instructional expenditures is associated with the mix of disciplines within an institution is also important in light of the issues raised in the first part of the congressionally mandated study. Researchers found no apparent relationship between the level of instructional expenditures at an institution and the tuition rate charged by that institution. Results of this analysis of direct instructional expense underscore the difficulty in relating price to cost at the level of the academic discipline. While direct instructional expense per student credit hour taught in civil engineering is three times higher than that for sociology, it is not practical for an institution to charge engineering majors a tuition rate three times that charged to sociology majors.

Indeed, the first report in the cost study found that institutional tuition rates at public institutions are determined largely by state appropriation levels, while competitive market forces shape tuition at private institutions. Neither of these external factors has anything to do with what it costs to deliver instruction in a discipline. Price (i.e., tuition) and cost (i.e., institution expenditures) are not interchangeable constructs.

While the foregoing discussion described the forces that are associated with instructional cost *within an institution*, the study also focused on those factors that impact expenditures *within a discipline*. In *The Economics of American Universities,*[4] Paul Brinkman postulated that the behavior of marginal and average costs can be associated with four dimensions: size (i.e., quantity of activity or output), scope of services offered, level of instruction (for instructional costs), and discipline (for instructional costs).

The analyses in this study determined that 60 to 75 percent of the variation in cost *within a discipline or groups of disciplines* is associated with specific cost factors consistent with those identified by Brinkman. While the association of a given variable with cost, as measured by direct expense per student credit hour taught, may vary from discipline to discipline, the following general patterns are consistently observed:

- The volume of teaching activity, as measured by total student credit hours taught, is a major cost factor. Cost decreases as volume increases.

- Department size, as measured in terms of total number of faculty, is a consistent cost indicator. The larger the department, the higher the cost.

- The proportion of faculty holding tenure is a cost factor. The higher the proportion of tenured faculty, the higher the cost.

- The presence of graduate instruction in a discipline increases costs, although the measured effect of this variable on direct expense in this study is smaller than teaching volume, department size, and faculty tenure rate.

- Similarly, the extent to which expense is associated with personnel costs, as opposed to equipment costs, has less impact on total direct instructional expenditures within a discipline than do teaching volume, department size, and tenure rate.

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[4] P.T. Brinkman, Higher Education Cost Functions, in S.A Hoenack and E.L. Collins, Eds., *The Economics of American Universities: Management, Operations and Fiscal Environment*. (Albany, NY: State University of New York Press, 1990).

Conclusions

While the first report in the congressionally mandated study of expenditures in higher education provided evidence that the price that students pay for an education is largely associated with factors external to the institution, the analyses in this report suggest that the direct cost of providing that education is more closely associated with internal institutional decisions and priorities.

The mix of disciplines that compose an institution's overall curriculum is associated with direct instructional expense at that institution and, to a smaller extent, its designation as a research, doctoral, comprehensive, or baccalaureate institution. Costs vary more substantially across disciplines within a given institution than they do across institutions within a given discipline.

Within the individual disciplines at an institution, economies of scale have the greatest impact on instructional costs. When given a faculty of fixed size, the more student credit hours taught, the lower the unit cost. Increasing the size of that faculty without a concomitant increase in student credit hour production raises instructional expense. Increasing the proportion of tenured faculty—that cadre of faculty that is better compensated and are essentially a "fixed cost"—will increase instructional expense. And to a lesser extent, introducing or increasing the level of graduate instruction raises instructional costs.

While the data analyzed in this study reflect cost patterns for those 4-year colleges and universities participating in the Delaware Study of Instructional Costs and Productivity only, they nonetheless provide a clear and measurable understanding of cost behaviors within those institutions. These are fresh data, collected at the academic discipline level of analysis, and lend themselves to descriptive statistics that illuminate and clarify cost patterns within those institutions that elect to belong to this data-sharing consortium.

A college or university's tuition rate is tied to what competing institutions charge, i.e., marketplace conditions, and what state legislatures provide as an operating subsidy. Instructional expenditures are tied to more fixed-cost factors, i.e., the mix of disciplines in place at the institution, and within those disciplines, student credit hour production, department size, and tenure rate. This study suggests that depending upon their magnitude, these variables constitute a baseline level for instructional costs within a discipline, and these costs vary less by discipline across institutions than they do among disciplines within an institution.

Most higher education institutions have multiple revenue streams, tuition being but one, to cover instructional costs. It is evident from this study that the factors that are associated with instructional costs are very different from the factors that are associated with tuition prices.

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INTRODUCTION

As a part of the Higher Education Amendments of 1998, Congress required that the National Center for Education Statistics (NCES) conduct a study of expenditures in higher education. This legislation specifically required that the study include information concerning:

- The change in tuition and fees compared with the Consumer Price Index and other appropriate measures of inflation;
- Faculty salaries and benefits;
- Administrative salaries, benefits, and expenses;
- Academic support services;
- Research;
- Operations and maintenance; and
- Institutional expenditures for construction and technology, and the potential cost of replacing instructional buildings and equipment.

The study was also to include an evaluation of expenditure patterns over time, an evaluation of the relationship of expenditures to the price charged for a college education, and the impact of tuition discounting and federal financial aid on tuition-setting policy.

NCES Response to the Congressional Mandate

NCES elected to respond to the congressional mandate for a study of higher education costs through a statistical analysis of factors that drive tuition at higher education institutions, supplemented by a series of commissioned expert papers. Both the analysis and the papers defined the conceptual framework for cost analysis, and responded to several of the key congressional concerns with respect to the relationship between the *price* charged to students for a college education and the *cost* of that education.

The commissioned papers included the following:

- *Cost Analysis and the Formulation of Public Policy*, Dennis P. Jones, National Center for Higher Education Management Systems
- *Institutional Financial Health: Tuition Discounting and Enrollment Management*, Lucie Lapovsky, Mercy College (New York)
- *Higher Education's Costs, Prices, and Subsidies: Some Economic Facts and Fundamentals*, Gordon C. Winston, Williams College (Massachusetts)
- *Issues of Cost and Price in Higher Education: Observations on Needed Data and Research*, Michael McPherson, Macalester College (Minnesota), and Morton Owen Schapiro, Williams College
- *Higher Education and Those "Out of Control Costs,"* D. Bruce Johnstone, University of Buffalo (New York)
- *An Essay on College Costs*, David W. Breneman, University of Virginia
- *Measuring Higher Education Costs: Considerations and Cautions*, Michael F. Middaugh, University of Delaware

Despite the disparate backgrounds and institutions of the authors, certain consistent themes run through the expert papers that speak specifically to questions raised by Congress with respect to the relationship between the cost and price of a college education.

1. There is not a pure cause-and-effect relationship between price and cost. While tuition revenues are associated with expenditure patterns at an institution, they are also associated with revenue streams available to that institution. Tuition rates at public institutions are clearly associated with the level of state appropriations. On the other hand, tuition rates at private institutions are associated with competitive market place as much as with expenditures.

2. While tuition discounting is an issue at colleges and universities, especially private institutions, tuition rates are to a greater extent tied to what neighboring institutions, particularly public institutions, are charging.

3. Expenditure/cost patterns represent institutional choices, values, and priorities. They reflect choices made within the constraints of available resources, i.e., revenue streams.

While Congress may have been looking for a simple relationship between the price of a higher education and the cost of delivering that education, these papers deliver compelling arguments for environmental factors that have little to do with expenditure rates as the major determinants of tuition levels. The study specifically cites declining state appropriations as the major factor associated with rising tuition rates at public institutions, while competitive market pressures and the availability of nontuition revenue streams are tied to tuition increases at private, not-for-profit institutions. That said, the issue raised by Congress as to how college and universities spend money, i.e., for what purpose and with what results, is deserving of a clear and credible response.

In attempting to formulate a response over the years, colleges and universities have developed full cost models that look at total expenditures at groups of institutions without regard to differences between and among those institutions with respect to mission and disciplinary mix—both of which have profound impacts on expenditure patterns. The dialogue is further confounded when, in attempting to distinguish between direct and indirect costs in higher education, the full cost model at one institution may use one battery of indirect cost formulas while the model at another uses an entirely different set of formulas. In each case, the formulas are dependent upon funding source and purpose of expenditure.

Full cost models of higher education expenditures attempt to describe direct expenditures—particularly those for instruction and student services—plus what are commonly referred to as indirect costs, i.e., expenditures associated with research and public service, overhead associated with administrative costs, and costs associated with the operation and maintenance of the physical plant. One of the oldest and most standard of full cost formulas was developed by Kent Halstead of Research Associates of Washington, and was used for years in their publication *Higher Education Revenues and Expenditures*. This annual volume computes, for each institution in the country, a "Full Instructional Cost per Full Time Equivalent Student," using data entirely derived from the Integrated Postsecondary Educational Data System (IPEDS) database. The formula for full instructional cost is as follows:

> Full Instructional Cost equals the sum of direct costs for instruction and student services <u>plus</u> indirect costs equal to total institutional and academic support and institutional support expenditures and plant expenditures less overhead for funded research and public service estimated at 33.3 percent of the expenditures for these two activities.

The National Commission on the Cost of Higher Education (1998), charged with responsibility for determining the relationship between higher education expenditures and tuition or "sticker price," relied heavily on the work of Gordon Winston of Williams College and the Williams Project on the Economics of Higher Education. The Winston model is predicated on the assumption that some expenditures are clearly related to instruction, while some are only partially related, and to both of these must be added a proportion of capital costs (figure 1).

Figure 1. Winston full cost model: Annotated formula for cost per student

Cost =

Clearly instruction	+ **Proportion partially instruction**	**Proportion capital costs**
Current expenditures on: *Instruction* *Student services*	Current expenditures on: *Academic support* *Institutional support* *Operation of physical plan*	Depreciation (2.5%): *Replacement value of buildings* *Replacement value of equipment* **plus** Opportunity cost (9.12%): *Replacement value of buildings* *Replacement value of equipment* *Replacement value of land*
	Where proportion equals Current expenditures on instruction and student services divided by Total current fund expenditures less: current expenditures on academic support, institutional support, operation of physical plan, scholarships and fellowships, mandatory and non-mandatory transfers	

Cost per student =
Cost divided by full-time-equivalent enrollment

SOURCE: National Commission on the Cost of Higher Education. *Straight Talk College Costs and Prices.* Phoenix, AZ: Oryx Press, 1988.

The Halstead and Winston models illustrate the difficulty in developing full cost models for higher education. The allocation of indirect costs or administrative overhead to the instructional function is an issue of judgment. Why does Halstead assume that the cost of overhead for research and service activity is 33 percent? Why not 25 percent or 40 percent? Halstead uses total expenditures for academic and institutional support plus operation and maintenance of physical plant; Winston has developed a proportional allocation for these costs. The Halstead model excludes capital costs; Winston includes them. Is one model superior to the other? Brinkman (2000, pp. 11-12) put it best:

> A problem in determining full costs is that the schemes used to allocate indirect costs are, if not arbitrary, at least imprecise. This remains stubbornly true even though the problem has been worked on for some time, including a national effort in the 1970's and early 1980's to develop appropriate procedures for full costing. Despite such efforts, making mistakes in allocating indirect costs is still easy. For example, it is a heroic assumption that library usage correlates well with student credit hour across all disciplines or that one square foot of space is necessarily worth as much as another. The analyst who does not accept these simplifying assumptions is left with having to actually measure the impact of a particular organization or activity on various support systems, a daunting and expensive task that might at some point still depend on arbitrary valuation of some facet of the production process.

The difficulty in accurately and systematically allocating indirect costs across disciplines and institution types is not a recent roadblock in developing full cost models. Jones (2000) pointed out that full cost analyses start with accounting data and rely on adjustments to, and allocations of these financial data to arrive at answers, making the analyses captives of the purposes, conventions and limitations of such data. Hoenack (1990) particularly focused on the need to develop reliable means for accurately tracking overhead associated with research and service activity as well as instruction.

The foregoing complexities in describing and allocating indirect costs have been further exacerbated by a schism within the accounting community between institutions governed by the Financial Accounting Standards Board (FASB), generally independent or privately chartered colleges and universities, and those governed by the Governmental Accounting Standards Board (GASB), generally public, state-assisted institutions. The differences in accounting standards between the two groups are so significant that IPEDS has been forced to develop separate Finance surveys for FASB and GASB institutions, and comparability of data is an issue.

In initially responding to Congress and others seeking an assessment of major cost factors in higher education, analytical vehicles should not be encumbered with descriptors that are arbitrary or imprecise. In developing the Delaware Study of Instructional Costs and Productivity, the data source used in this study, Middaugh (2001, pp. 73–74) stated:

> It is important to underscore that for each of the expenditure categories [instruction, research, and service] only *direct costs* are measured. In creating a framework for productivity analysis, it is important that the data be credible and verifiable. The standard definitions are clear and precise for identifying direct expense by institutional functional category. Measuring indirect costs, that is, administrative costs, utilities costs, capital costs, and so on, is less uniform and precise. Indeed, on any given campus there are multiple calculations for indirect costs based upon the academic disciplines for which costs are being recovered. For the sake of clarity, simplicity, and credibility, the discussion of costs [in this analysis] will in no way attempt to measure full costs, only direct expenses.

Brinkman (2000) emphasizes that, "The cost accounting data developed for the Delaware Study of Instructional Costs and Productivity is a good example of data suitable for subsequent statistical, econometric type analyses."

The Delaware Study of Instructional Costs and Productivity

The evolution of the Delaware Study of Instructional Costs and Productivity[4] is thoroughly detailed in the book, *Understanding Faculty Productivity: Standards and Benchmarks for Colleges and Universities* (Middaugh, 2001), and in articles in *Planning for Higher Education*, the official journal of the Society for College and University Planning (Middaugh 1996, 1999). The following is a capsulization of the rationale that underpins the conceptual framework for the study, as well as a brief discussion of the methodology.

The Delaware Study is predicated on the operating principle that any meaningful analysis of costs and productivity in institutions of higher education must take place at the academic discipline level of analysis. Institutional aggregate data, while useful in making broad, general statements about higher education costs, may actually mask factors associated with expenditures and lead to erroneous conclusions when making policy related to instructional costs and productivity. For example, a commonly used measure of instructional costs is one derived by taking total direct expenditures for instruction, as reported on the IPEDS Finance survey, and dividing that total by the number of full-time-equivalent (FTE) students at the institution. FTE students is a headcount measure derived by taking the part-time headcount

[4] The Delaware Study of Instructional Costs and Productivity is a data-sharing consortium of colleges and universities throughout the United States. Access to Delaware Study data is restricted to participating institutions. Questions concerning data access should be directed to the Office of Institutional Research and Planning at the University of Delaware, 325 Hullihen Hall, Newark DE 19716.

enrollment at a college or university, dividing it by three, and adding the quotient to the full-time headcount enrollment (Taylor and Massy 1996.) While this measure of "Direct Instructional Expense per FTE Student" might quite appropriately be used to compare average instructional cost between and among research universities as a group, doctoral universities as a group, or comprehensive or baccalaureate institutions as a group, it should be used to compare individual institutions with caution and when much is known about the curricular offerings at the institutions being compared.

Specifically, only institutions with similar curricular mixes should be compared using institution-wide metrics such as Direct Instructional Expense per FTE Student. One might wish to compare two research/doctoral intensive universities, as defined under the 2000 Carnegie Institutional Classification convention. Suppose one of the institutions is heavily oriented toward the natural and physical sciences, with significant emphasis on graduate education; the other is steeped in the social sciences and humanities with lesser emphasis on graduate education. The former institution is weighted with disciplines that are typically characterized by small class instruction in equipment-intensive laboratories, while the latter more typically uses large classroom, lecture-based pedagogy in many of its classes. Any institution-wide comparison of costs without consideration of disciplines between these universities will be totally misleading.

To appreciate the impact of academic discipline on instructional cost, one need only consider faculty salaries. Table 1 contains the average faculty salary, by rank, for 24 disciplines typically found at most 4-year institutions in the United States. The data are taken from the annual survey of faculty salaries by discipline conducted by Oklahoma State University. While the data reflect average salaries for flagship university members of the National Association of State Universities and Land Grant Colleges, this resource is a frequently used benchmark for identifying marketplace salaries for hiring purposes.

While it is obvious that there is disparity between and across academic disciplines, even at the full professor rank, the important information in table 1 is at the assistant professor and new assistant professor rank. There are clear marketplace differentials between entry-level salaries for new faculty in quantitative disciplines such as mathematics, engineering, computer science, economics, and business, when compared with arts, humanities, and social sciences. The operating assumption in the Delaware Study is that instructional expenditures are largely associated with personnel costs, and that faculty salary differentials will constitute a significant cost factor across academic disciplines. This is consistent with the finding from the first part of the congressionally mandated study that instructional expenditures reflect institutional choices and priorities. Recruiting and retaining high-quality faculty in a very competitive marketplace requires competitive compensation, but the level of competition and compensation clearly varies from discipline to discipline. The differences among the disciplines is further exacerbated by the fact that programs in the sciences and engineering are more equipment-intensive than other disciplines, underscoring the need to examine instructional expenditures at an institution as a function of programmatic mix.

In order to better understand factors associated with instructional expenditures in higher education, the Office of Institutional Research and Planning at the University of Delaware was asked to analyze multiple data collection cycles from the Delaware Study. The Delaware Study is a data-sharing consortium embracing 4-year colleges and universities running the full spectrum of the 1995 Carnegie Institutional Taxonomy, i.e., research, doctoral, comprehensive, and baccalaureate.[5] The consortium shares detailed information on faculty teaching loads by instructor classification and direct expenditures for instruction, research, and public service activity. Data are collected and analyzed by academic discipline.

[5] The 1995 Carnegie Taxonomy is used throughout this report, as it is analytically more meaningful for this analysis than the current Carnegie taxonomy.

Table 1. Average faculty salary in selected disciplines,[1] by rank

Discipline	Full professor	Associate professor	Assistant professor	New assistant professor
Communications	$73,406	$54,126	$44,785	$43,458
Computer and information sciences	100,780	75,123	67,929	66,698
Education	75,564	55,669	45,420	45,614
Engineering	103,828	70,207	56,940	57,410
Foreign languages and literature	67,335	50,005	41,240	40,763
English language and literature	73,273	52,026	42,292	41,314
Biological sciences	78,506	56,951	47,279	47,900
Mathematics	80,990	57,421	47,959	45,101
Philosophy	76,890	52,734	41,812	40,369
Chemistry	89,245	58,527	49,292	46,726
Geology	77,266	56,946	48,552	47,026
Physics	85,998	60,365	53,123	50,953
Psychology	83,382	74,606	55,953	46,263
Anthropology	74,751	53,745	44,668	43,371
Economics	99,447	67,945	60,565	62,635
Geography	75,415	56,597	45,306	43,527
History	77,849	53,859	42,800	41,491
Political science	82,480	56,306	45,960	45,025
Sociology	78,900	54,793	45,753	45,294
Visual and performing arts	65,645	50,349	39,979	37,530
Nursing	77,652	60,109	48,521	49,158
Business administration	110,753	83,558	81,615	83,835
Accounting	110,424	87,610	83,553	88,854
Financial management	115,314	91,568	88,948	86,515

[1]Disciplines reflect those organizational structures at land grant universities for which faculty salary data are collected by Oklahoma State University.

SOURCE: 2000–2001 Faculty Salary Survey by Discipline, Office of Planning, Budget, and Institutional Research, Oklahoma State University.

Since its inception in 1992, nearly 350 colleges and universities have participated in the Delaware Study (see appendix A for the list of participants). A substantial portion of the participant pool submits data on an annual basis; other institutions elect to participate on an alternate-year or less regular interval cycle. It should be noted that this is a voluntary data-sharing consortium. Institutions elect to participate during any given data cycle, and the data sample for that cycle is therefore not random. The issue of a nonrandom sample and potential nonresponse bias will be addressed throughout this report.

The Delaware Study collects teaching load and financial data at the academic discipline level of analysis. The underlying assumption in this data collection strategy is that there are very real differences between and across disciplines with respect to magnitude of teaching loads and cost. To ensure comparability of data, disciplines are defined using the NCES Classification of Instructional Programs (CIP) taxonomy. Data are typically collected at the four-digit CIP level, although a number of participating institutions request benchmarking at the six-digit CIP level, and where sufficient cases exist (i.e., N equal to or greater than 5), accommodation is made.

The Delaware Study Data Collection Form comprises two parts (see appendix B). Part A is a detailed collection of information on faculty teaching loads during the fall term of the academic year under analysis. Information is collected on student credit hours and organized class sections taught by each of four discrete categories of faculty. The faculty categories include tenured/tenure eligible; faculty on recurring contracts at the institution but who are in non-tenurable lines; supplemental and adjunct faculty;

and graduate teaching assistants. While student credit hour generation is a fairly obvious measure of teaching productivity, data on the number of class sections taught is also collected, as not all instructional activity is credit-bearing. It is not uncommon to find associated with the credit-bearing lecture portion of a course, organized class sections (e.g., recitation and discussion sections, laboratory sections, etc.), which themselves are zero-credit, but which are required components of the overall course of instruction. A complete picture of total faculty teaching activity—credit hours and course sections—is essential to any discussion of a possible relationship between teaching productivity and cost.

Cost data collected in Part B reflect *direct expenditures* for instruction and separately budgeted research and public service. The decision to focus on direct costs is related to the consistency in definitions as to what constitutes instruction, research, and service expenditures. Long-standing definitions and calculation conventions for direct expenditures, as established by the National Association of College and University Business Officers (NACUBO) are used to develop information on instructional costs. These definitions are equally appropriate for, and applicable to a complex research university or a small baccalaureate liberal arts college.

The present study examines three cycles of Delaware Study data (i.e., 1998, 2000, and 2001) to identify those factors that are associated with the variation in direct instructional costs between and across academic disciplines, and to identify those cost factors that are tied to the magnitude of instructional expenditures in a given discipline. This examination takes place within the context of intervening variables such as Carnegie classification (a proxy for mission), highest degree offered in a discipline, and the relative emphasis on undergraduate versus graduate instruction in the discipline.

ANALYTICAL FRAMEWORK

Data Source: The Delaware Study of Instructional Costs and Productivity

The data analyzed in this study were collected from multiple cycles of the Delaware Study of Instructional Costs and Productivity, and reflect information for the years 1997–98, 1999–2000, and 2000–2001. Data are collected annually using the template found in appendix B. The complete set of data definitions associated with each element in the template is found in the glossary (appendix C).

The purpose of this study is to examine whether instructional costs vary across disciplines within an institution, and across disciplines when institutions are arrayed by Carnegie classification. The Delaware Study utilizes the 1995 Carnegie taxonomy, which aggregates 4-year institutions into research universities, doctoral universities, comprehensive colleges and universities, and baccalaureate colleges (see appendix C for complete definitions). An institution's classification is based upon the volume and type of degrees granted, and the volume of externally funded research activity measured in terms of federal research and development expenditures.

The study further assesses the extent to which highest degree offered within a discipline (bachelor's, master's, or doctorate) and the relative emphasis on undergraduate versus graduate instruction in a discipline impacts cost patterns.

The model developed to analyze costs in this study focuses on *direct* expenditures for instruction. The instructional function is fully described and defined in the glossary to this report, as are those cost components that constitute direct expenditures. Instructional expenditures include salaries and wages, benefits, equipment, and other support costs that are dedicated to the instructional function, which embraces teaching, departmentally supported research, and other support activity designed to enhance the teaching process. Unit cost for purposes of this study is measured in terms of direct instructional expenditures per student credit hour taught within each of the disciplines under analysis.

A number of variables are considered in this study as potential factors associated with instructional costs. Faculty are classified into four faculty categories—tenured and tenure-track faculty, other regular faculty, supplemental or adjunct faculty, and graduate teaching assistants (see the glossary). Faculty type may be a cost factor if tenured and tenure-track faculty are more expensive than non-tenurable full-time faculty and part-time adjuncts or teaching assistants. The size of an academic department or program faculty is measured by total full-time equivalency for each of the four faculty categories. The metric for calculating full-time equivalency is described in the glossary.

Teaching activity is measured by student credit hours taught—in total, and within each faculty category. Student credit hour generation is measured at the lower division and upper division levels within undergraduate instruction, and in total at the graduate level. Within each discipline, instructional activity is also characterized by the highest degree awarded. Student credit hours and other characteristics of faculty teaching load are described in the glossary.

The cost model developed for this study examines the relationship of individual variables, and combinations of variables, with direct expenditures for instruction. The techniques for transforming collected data elements into specific data variables are fully described in the Findings section of this report. Specifically, the model employs appropriate statistical tools to test the following:

- The extent to which variation in instructional costs is associated with discipline and with institutional mission, as expressed by Carnegie classification.

- The extent to which specific variables are associated with direct instructional expense. The rationale for including these variables is described in the Technical Notes (appendix E). These variables are as follows:

  1. Economies of scales as measured by the volume of student credit hours taught by a faculty of fixed size.

  2. Variation in the total size of a faculty.

  3. The proportion of total faculty who hold tenure. Tenured faculty tend to be better compensated, and are essentially "fixed costs" until retirement.

  4. The proportion of total instructional expense that is accounted for by personnel expenditures.

  5. The relative emphasis on undergraduate versus graduate instruction within a department's student credit hour production.

The apparent relationships between and across these variables are fully described in the Findings section of this report.

Bias Issues in the Data

Since its inception, participation in the Delaware Study has been restricted exclusively to 4-year colleges and universities. Although participating institutions self-select and the participant pool is not random, a general invitation to submit data is sent annually to presidents, chief academic officers, and institutional researchers through professional organizations such as the National Association of State Universities and Land Grant Colleges (NASULGC), the American Association of State Colleges and Universities (AASCU), the Association for Institutional Research (AIR), and the Society for College and University Planning (SCUP). Working relationships have also been established with the Association of American Universities Data Exchange (AAUDE), the Southern Universities Group (SUG), the Big 12 Universities, and the Higher Education Data Sharing Consortium (HEDS), the latter embracing 125 private colleges and universities across the United States. The Delaware Study is also the official data collection vehicle for several state entities, including the University of North Carolina System, the Tennessee Board of Regents, the Louisiana Board of Regents, the Mississippi Board of Regents, and the South Dakota Board of Regents, among others. Table 2 displays institutional participation for the five most recent data collection cycles.

One of the assumptions examined in this study is that expenditure patterns and faculty workloads are, at least in part, tied to the institution's mission, i.e., the range of program offerings, the extent of commitment to graduate education, and the priority given to research and public service. The 1995 Carnegie classification category that groups institutions according to these institutional characteristics became the subpopulation that the participating institutions were to represent.

Table 2 shows a steady annual participation in the Delaware Study of roughly 150 institutions per year, except in 1999 when participation was restricted to research and doctoral universities while a secure web site was tested for use for online collection of data and dissemination of benchmarks. This relatively stable participation rate persists even though invitations to submit data were sent in summer 2001 to all Title IV-eligible 4-year institutions in the United States.

This consistent group of roughly 150 institutions over the years comprises about 4 in 10 research universities and 1 in 4 doctoral universities. The proportion of comprehensive and baccalaureate institutions is lower, because the base number of those institutions in the United States is much larger than that for research and doctoral universities. The 2000 data collection cycle, for example, embraced 152 institutions and 5,140 secondary analysis units, i.e., all disciplines at the

Table 2. Number of institutions participating in the Delaware Study, by Carnegie institutional classification, by year: 1997–2001

Carnegie classification	Data collection cycle				
	1997	1998	1999[1]	2000	2001
Total	150	150	97	152	175
Research	48	48	53	48	46
Doctoral	36	27	25	27	34
Comprehensive	53	61	12	64	72
Baccalaureate	13	14	7	13	23

[1]In 1999, participation was restricted to research and doctoral institutions, except in cases where entire state higher education systems utilize the Delaware Study.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

4-digit CIP level. With the exception of a few institutions every year, there is complete enumeration of the discipline data by institution. The primary and secondary analytical units are generally similar for all data collection cycles.

Analysis of Nonresponse Bias

While numbers within the 1995 Carnegie categories vary slightly from year to year, institutional counts from the Integrated Postsecondary Education Data System (IPEDS) indicate that the following numbers reflect the total approximate size of each Carnegie grouping: 125 research universities, 110 doctoral universities, 525 comprehensive institutions, and 630 baccalaureate colleges. The counts do not include specialized 4-year institutions. The rate of participation over the years in the Delaware Study has been highest among research universities, with roughly 4 in 10 participating nationally. Approximately 1 in 4 doctoral universities participate, and 10 to 13 percent of comprehensive institutions submit data in any given year. The lowest participation rate is among baccalaureate institutions, with 2 percent participating prior to the 2000 data collection, and just over 3 percent submitting data in the most recent data collection cycle. It should be noted that data are collected at the academic discipline level of analysis, with four-digit CIP codes being the identifying marker. As a result, it is apparent that larger, more complex institutions, with discrete departments and disciplines, are more likely to participate than smaller institutions that typically have multiple-discipline organizational structures.

In any survey data collection, the risk exists that estimates derived from participating institutions may differ from those that might have been derived from nonparticipants. In such circumstances, data derived from the study participants alone could potentially be biased estimates of the overall population of institutions. This is a particular concern in instances where participation rates are low, as in the case of comprehensive and baccalaureate institutions. Moreover, as noted, participants are self-selected, and the pool of institutions is not random.

To examine how different or similar the participant pools are when compared with nonparticipating institutions, selected institutional characteristics were obtained from the IPEDS database. Institutional characteristics pertaining to faculty size, enrollment levels, degrees conferred, and expenditures information are summarized in appendix tables D-1 through D-5 for each data collection cycle, 1997 through 2001 (although some institutions had incomplete IPEDS information, particularly in the area of institutional finances). The difference between the average for the selected variables for participants and nonparticipants is displayed, along with an estimate of the magnitude of bias. The difference is also presented in terms of percent, with the participant average as the base. The findings are as follows:

- Among the research universities, institutions participating in the Delaware Study are 9 to 13 percent larger than nonparticipants in terms of the number of faculty that are tenured, and are 6 to 11 percent larger in terms of total full-time faculty. Full-time-equivalent (FTE) enrollment at participating institutions is higher by 16 to 22 percent. Participants also tend to have a larger undergraduate enrollment than nonparticipants and a correspondingly larger number of baccalaureate degrees awarded. Student/faculty ratio, measured in terms of FTE enrollment per full-time faculty, is slightly higher at participating institutions. Research expenditures per FTE faculty are lower by one-third at participating institutions, but public service expenditures per FTE faculty are higher. The average scholarship and library expenditures per FTE enrollment are approximately 20 percent higher among participating institutions when averaged over the years.

- Among doctoral universities, institutions participating in the Delaware Study are larger, both in terms of the number of tenure-track and total faculty, and in terms of FTE enrollment. The student/faculty ratio, as measured in terms of FTE enrollment per full-time faculty, is similar for participating institutions and nonparticipants. Undergraduate enrollment as a percentage of total enrollment is higher among participating institutions by 12 to 16 percent. Average instructional expenditures per FTE student are higher among nonparticipants, while average scholarship expenditures per FTE enrollment are higher among participating institutions.

- Among comprehensive institutions, those that participate in the Delaware Study have about one-third more tenure-track and total full-time faculty than nonparticipants. FTE enrollment among participating institutions is larger than among nonparticipants by 25 to 34 percent, although undergraduate enrollment as a proportion of the total is higher among participating institutions by only 2 to 4 percentage points. The student/faculty ratio, as measured in terms of FTE enrollment per full-time faculty, is consistently smaller for participating institutions by two to four students per faculty. Participating institutions vary by year in terms of instructional and academic support expenditures per FTE enrollment. In 1997, participants spent 8 percent less on instruction and 13 percent less on academic support than did nonparticipants, where in subsequent years they spent more.

- Among baccalaureate institutions, those that participate in the Delaware Study are larger than nonparticipants both in terms of tenure-track faculty (17 to 53 percent) and total full-time faculty (23 to 42 percent). FTE enrollment at participating institutions is higher than at nonparticipating institutions by 23 to 33 percent, although the average student/faculty ratio, as measured by FTE enrollment per full-time faculty, is similar for both groups. The composition of the participant pool varies from year to year in terms of instructional expenditures per FTE students, with spending higher than that of nonparticipants in two of the years examined, and less in two other years. Average scholarship expenditures per FTE student at participating institutions are substantially less than at nonparticipating institutions in the earlier data collection cycles.

The findings are consistent with the general observation over the years that participants in the Delaware Study are more likely to be larger, more organizationally complex institutions that lend themselves to a structure that largely embraces discrete single CIP code academic department or program structures. Smaller institutions, with organization structures that involve high levels of interdisciplinary instruction and multiple CIP codes within a department or program (e.g., humanities department, social sciences department, etc.) find it more difficult to disaggregate teaching loads and expenditure information into recommended reporting formats and are less likely to participate. Consequently, data analyses in this study cannot be used to estimate cost patterns at the national level. However, statistics can be applied to the participant pool to describe cost patterns across disciplines, and across institutions, and to describe the association of those variables with direct instructional expenditures. These findings, while not generalizable to the larger universe of higher education institutions, do provide a thorough description of cost behaviors, by discipline, at institutions participating in the Delaware Study and yield a framework for discussion of strategic approaches to cost analysis at other institutions.

It must be underscored that comparable cost and teaching productivity data currently do not exist for 2-year colleges, proprietary schools, and the vast majority of small, interdisciplinary-oriented liberal arts colleges. Consequently, the findings from this study cannot be extended to those institutions. However, by analyzing the data available from the Delaware Study, we can draw certain conclusions about differences that exist in cost patterns at larger, complex, mostly public 4-year institutions. While the Delaware Study participant pool represents a small proportion of the universe of higher education institutions, it also represents a substantial proportion of total higher education enrollment.

Statistical Tools

This study of higher education instructional expenditures is a descriptive analysis. Because the population for the study is self-selected, any generalization to the larger universe of 4-year higher education institutions is not possible. However, application of appropriate statistical tools to the data from institutions that elect to participate in the Delaware Study can yield rich descriptive information about expenditure patterns and cost factors for those institutions.

As noted earlier, the focal variable for this study is unit cost, by academic discipline, as measured by direct instructional expense per student credit hour taught. Direct instructional expense per student credit hour taught is one of the national benchmarks produced annually. It is a calculated mean value for the data submitted by participants for two variables: total direct instructional expenditures divided by total student credit hours taught. However, as a national benchmark, this mean statistic is "refined" to correct for idiosyncratic values that may be submitted by any given institution. In analyzing the data within each data set, national benchmarks are computed through Windsorization. The initial step in the computation is the inclusion of all institutional responses with each Carnegie class for a given variable. From those total responses, an initial mean value is calculated. The responses are then further analyzed to identify those cases that are beyond two standard deviations above or below the initial mean. These cases are then defined as outliers and are excluded from the subsequent calculation of the refined mean. This conservative approach to benchmark construction was taken to ensure that no single or set of idiosyncratic responses exert undue influence on the calculation of a mean value or benchmark. The Windsorization process trims the tails of the distribution by specified percentiles. For example, in a normal distribution, a 5 percent trimmed mean excludes the smallest 5 percent and the largest 5 percent observations. Benchmarks are calculated only for those disciplines wherein a minimum of five institutional responses were submitted.

Table 3 displays the refined means for direct instructional expense per student credit hour taught for each of the academic disciplines examined in this study. The data are arrayed by Carnegie institution type for the years 1998, 2000, and 2001. The data demonstrate general stability over time within each Carnegie class in each discipline. It is evident that direct instructional expense varies across Carnegie class within each discipline, with research universities generally costing more than doctoral universities, which, in turn, are more expensive than comprehensive institutions. Baccalaureate institutions that elect to participate tend to be selective institutions that offer small classes, and this is reflected in their expense per credit hour data.

To further illuminate the dispersion of direct expenditures per student credit hour taught among participating institutions, benchmarks are produced annually that display the refined means, arrayed by quartile as well as Carnegie institution type. Table 4 illustrates the dispersion of those refined means for 2001 for the same academic disciplines as in table 3. Comparable patterns in all data collection cycles have been evident. The values displayed for the quartiles represent the point at which one-fourth, one-half, and three-

Table 3. Direct instructional expense per student credit hour taught in selected academic disciplines, by Carnegie institution type: 1998, 2000, and 2001

Discipline and institution type	1998	2000	2001
Communication			
Research	$157	$164	$164
Doctoral	132	143	130
Comprehensive	125	134	138
Baccalaureate	118	126	151
Computer science			
Research	170	203	204
Doctoral	141	165	142
Comprehensive	119	135	155
Baccalaureate	203	160	135
Education			
Research	235	269	260
Doctoral	167	184	198
Comprehensive	143	185	180
Baccalaureate	156	161	175
Civil engineering			
Research	369	401	411
Doctoral	328	367	379
Comprehensive	262	362	339
Baccalaureate	---	---	---
Electrical engineering			
Research	360	358	358
Doctoral	273	318	276
Comprehensive	255	278	301
Baccalaureate	---	---	---
Mechanical engineering			
Research	415	400	379
Doctoral	321	353	316
Comprehensive	264	333	342
Baccalaureate	---	---	---
Foreign languages			
Research	165	169	171
Doctoral	124	127	131
Comprehensive	134	139	147
Baccalaureate	186	128	202
English			
Research	122	138	140
Doctoral	111	118	116
Comprehensive	101	109	112
Baccalaureate	135	120	132
Biological sciences			
Research	261	286	276
Doctoral	167	201	191
Comprehensive	120	135	149
Baccalaureate	151	173	186
Mathematics			
Research	144	147	160
Doctoral	113	122	116
Comprehensive	104	105	106
Baccalaureate	97	111	112
Philosophy			
Research	124	134	137
Doctoral	138	130	125
Comprehensive	108	112	119
Baccalaureate	124	105	146
Chemistry			
Research	205	255	264
Doctoral	197	229	233
Comprehensive	157	168	181
Baccalaureate	189	190	242

Discipline and institution type	1998	2000	2001
Geology			
Research	$208	$223	$211
Doctoral	159	201	197
Comprehensive	143	160	144
Baccalaureate	---	---	---
Physics			
Research	249	284	263
Doctoral	178	191	203
Comprehensive	159	165	167
Baccalaureate	235	---	254
Psychology			
Research	131	150	150
Doctoral	124	135	131
Comprehensive	101	113	115
Baccalaureate	126	113	131
Anthropology			
Research	139	148	157
Doctoral	118	127	126
Comprehensive	106	106	132
Baccalaureate	---	---	---
Economics			
Research	134	145	154
Doctoral	142	139	144
Comprehensive	102	112	126
Baccalaureate	162	---	194
Geography			
Research	140	155	164
Doctoral	119	137	125
Comprehensive	95	121	103
Baccalaureate	---	---	---
History			
Research	129	142	149
Doctoral	139	125	124
Comprehensive	105	99	103
Baccalaureate	108	107	151
Political science			
Research	160	168	164
Doctoral	172	151	152
Comprehensive	120	129	131
Baccalaureate	160	---	165
Sociology			
Research	108	130	124
Doctoral	122	105	106
Comprehensive	96	99	100
Baccalaureate	130	110	138
Visual and performing arts			
Research	205	214	228
Doctoral	193	200	199
Comprehensive	175	174	180
Baccalaureate	207	174	226
Nursing			
Research	300	368	388
Doctoral	270	354	332
Comprehensive	247	316	318
Baccalaureate	---	---	---
Business			
Research	161	167	170
Doctoral	149	164	157
Comprehensive	150	151	156
Baccalaureate	138	118	119

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table 4. Direct instructional expense per student credit hour taught in selected academic disciplines, by Carnegie institution type, by quartile: 2001

Discipline and institution type	25 percent	50 percent	75 percent	Discipline and institution type	25 percent	50 percent	75 percent
Communication				**Geology**			
Research	$107	$159	$214	Research	$159	$209	$278
Doctoral	96	118	161	Doctoral	113	176	254
Comprehensive	97	137	169	Comprehensive	112	138	175
Baccalaureate	115	146	203	Baccalaureate	---	---	---
Computer Science				**Physics**			
Research	158	181	256	Research	189	254	340
Doctoral	95	140	182	Doctoral	131	199	256
Comprehensive	112	137	190	Comprehensive	115	163	208
Baccalaureate	103	120	176	Baccalaureate	127	163	436
Education				**Psychology**			
Research	181	243	322	Research	106	150	185
Doctoral	129	194	246	Doctoral	92	136	158
Comprehensive	119	161	223	Comprehensive	88	112	131
Baccalaureate	125	161	322	Baccalaureate	90	121	150
Civil engineering				**Anthropology**			
Research	273	403	485	Research	117	159	191
Doctoral	316	394	468	Doctoral	72	122	154
Comprehensive	281	336	412	Comprehensive	106	127	165
Baccalaureate	---	---	---	Baccalaureate	105	136	260
Electrical engineering				**Economics**			
Research	307	338	437	Research	112	144	192
Doctoral	204	252	334	Doctoral	112	150	170
Comprehensive	230	292	391	Comprehensive	101	127	146
Baccalaureate	---	---	---	Baccalaureate	134	199	232
Mechanical engineering				**Geography**			
Research	302	382	455	Research	122	140	229
Doctoral	224	286	405	Doctoral	97	127	148
Comprehensive	264	347	414	Comprehensive	75	110	133
Baccalaureate	---	---	---	Baccalaureate	---	---	---
Foreign languages				**History**			
Research	115	146	207	Research	113	150	188
Doctoral	97	124	149	Doctoral	81	125	163
Comprehensive	118	146	172	Comprehensive	77	101	126
Baccalaureate	124	160	256	Baccalaureate	93	114	243
English				**Political science**			
Research	109	131	169	Research	127	159	198
Doctoral	86	115	144	Doctoral	97	152	209
Comprehensive	88	105	128	Comprehensive	107	124	149
Baccalaureate	105	120	149	Baccalaureate	103	186	211
Biological Sciences				**Sociology**			
Research	194	236	333	Research	105	119	153
Doctoral	125	175	233	Doctoral	76	104	131
Comprehensive	113	148	182	Comprehensive	74	95	125
Baccalaureate	150	165	205	Baccalaureate	92	135	192
Mathematics				**Visual and performing arts**			
Research	103	137	195	Research	160	217	280
Doctoral	83	120	136	Doctoral	141	189	253
Comprehensive	83	113	128	Comprehensive	129	166	221
Baccalaureate	80	111	140	Baccalaureate	176	201	283
Philosophy				**Nursing**			
Research	93	138	180	Research	309	403	468
Doctoral	96	123	145	Doctoral	240	341	403
Comprehensive	92	122	140	Comprehensive	242	291	373
Baccalaureate	78	140	203	Baccalaureate	---	---	---
Chemistry				**Business**			
Research	208	244	324	Research	125	166	207
Doctoral	164	241	266	Doctoral	122	154	185
Comprehensive	128	171	221	Comprehensive	124	149	188
Baccalaureate	160	223	302	Baccalaureate	95	110	146

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

quarters of participating institutions, respectively, reported costs equal to or below those values.

The data in displayed table 3 indicate modest variation across Carnegie institutional categories within a discipline, but also indicate that larger and more substantial differences exist between and across the disciplines within institution types. These patterns are consistent in examining the dispersion of data points in table 4, thereby raising one of the focal questions for this study: Which is more central to understanding the variation of instructional costs in higher education—differences within disciplines examined across institutions, or differences between disciplines within institutions?

As important as describing the factors that are associated with the dispersion of instructional costs within and across institutions is an understanding of those factors that are tied to expenditures within academic disciplines. Multiple regression techniques were applied to a full range of variables that potentially are associated with the magnitude of direct instructional expenditures. Using direct expense per student credit hour taught as the dependent variable, potential cost factors, including but not limited to the following, were examined:

- Volume of teaching load as measured in terms of student credit hours taught;
- Size of instructional faculty, measured in terms of full-time equivalency;
- The proportion of total FTE faculty that are tenured or tenure track (predicated on the assumption that tenured and tenure-track faculty are better compensated than other faculty);
- The relative emphasis of departmental teaching on undergraduate versus graduate instruction; and
- The extent to which an academic discipline is personnel-intensive as compared to equipment-intensive.

The application of multiple regression techniques to the variables in this study is described in appendix E. The Findings section of this study describes the results of the application of both HLM and multiple regression statistics to the data, and clearly identifies those factors that are associated with the dispersion of instructional expenditures within and across institutions, and those factors that are associated with the magnitude of direct instructional expense in academic disciplines.

FINDINGS

Two major issues are addressed in this Study of Higher Education Instructional Expenditures. The first is whether important differences in direct instructional costs are evident between and across the disciplines within an institution and across institutions within Carnegie category. The second issue is the identification of important cost factors within the disciplines under analysis. This section of the report details findings growing out of analyses of three Delaware Study data collection cycles that speak to those issues.

Variation in Cost Across and Within Institutions

To establish the variance components of cost through hierarchical linear modeling (HLM), disciplines are considered the level 1 units and institutions the level 2 units. Without taking into account any institutional or discipline-related variables, the hierarchical linear model is equivalent to one-way ANOVA with random effects. This approach provides information on how much of the variation in cost lies across or within institutions, a test of whether the institutional average costs are the same, and a measure of each institution's calculated average cost.

Results from the model are presented in table 5 for three data collection cycles. The data indicate that most of the variation occurs at the discipline level. In the 1998 data collection cycle, disciplines within institutions were tied to 76 percent of the total variance. In 2000, disciplines were associated with 82.6 percent of the variance. In 2001, disciplines within institutions were tied to 81.3 percent of the total variance, while institutions were linked to 18.7 percent. The results also show that there are mean differences in cost by institution in all three data sets.

The last column in the table refers to reliability of average cost by institution. If the data set used in this study were a random sample, these numbers would indicate whether or not the average cost for each institution is reliable estimates of true average cost. Since the data are not random, all that can be said about these reliability estimates is that the average cost of instruction estimated by the hierarchical linear model for the three data cycles can be deemed reliable for the participating institutions. Within that context, the reliability estimates are high, ranging from 86.3 percent in the 1998 data set to 80.7 percent in 2000, and 81.3 percent in the 2001 data set.

The second panel in table 5 presents Delaware Study results from the hierarchical linear model after accounting for the Carnegie classification of the institution (level 2). If it is assumed that Carnegie classification is tied to some of the variations in cost at the institutional level, then incorporating it at level 2 of the model will reduce the variance in cost due to institutions. As the table indicates, Carnegie classification is tied to some of the variation in cost at the institutional level. While the one-way ANOVA model with random effect indicated that in the 2001 data collection cycle, institutions were tied to 18.7 percent of the variance, this second model reduces this to 14.2 percent, meaning that the variance in cost among schools within the same Carnegie classification is 14.2 percent. This is equivalent to a 28 percent reduction in the variance among institutions after accounting for the Carnegie groupings of those institutions. There is a 35.2 percent and 25.5 percent variance reduction in the 2000 and 1998 data collection cycles, respectively. As the result of the variance reduction across institutions, the variance within institutions in relative terms increased from 81.0 percent in 1998 to 88.0 percent in 2000, and 85.8 percent in 2001.

Table 5. Study of variance components of cost per student credit hour based on hierarchical linear modeling: 1998, 2000, and 2001

Data collection model	Random effect	Variance component	df	Chi-square	P value	Variance component (percent)	Reliability of institution average cost (percent)
I. One-way ANOVA model							
1998	Institution	2,144	126	1,031	*	24.0	86.3
	Discipline within institution	6,807				76.0	
2000	Institution	1,787	133	779	*	17.4	80.7
	Discipline within institution	8,460				82.6	
2001	Institution	1,737	157	969	*	18.7	81.3
	Discipline within institution	7,540				81.3	
II. With fixed effect of Carnegie classification of institution							
1998	Institution	1,597	123	783	*	19.0	82.6
	Discipline within institution	6,810				81.0	
2000	Institution	1,158	130	560	*	12.0	73.5
	Discipline within institution	8,459				88.0	
2001	Institution	1,251	154	748	*	14.2	76.1
	Discipline within institution	7,540				85.8	
III. With fixed effect of Carnegie class of institution and fixed effect of the discipline groupings							
1998	Institution	1,788	123	1,484	*	32.8	90.6
	Discipline within institution	3,669				67.2	
2000	Institution	1,352	130	1,094	*	23.7	85.7
	Discipline within institution	4,361				76.3	
2001	Institution	1,569	154	1,478	*	28.5	87.9
	Discipline within institution	3,939				71.5	

* $p < 0.05$.

NOTE: Degrees of freedom for the variance component of discipline within institution are not generated from output for hierarchical linear modeling. Similarly, since discipline within institution variance is the error term, there should be no entries in the Chi-square and p value columns.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Examining cost by discipline over the three data collection cycles consistently showed that there is a general and reasonable grouping of disciplines according to cost levels. Service departments such as English and mathematics are among those with the lowest instructional costs, and their costs are comparable with those on the social sciences. Instructional costs in the physical sciences are in the next highest level and are comparable to those in education, business, and art. Costs are highest in engineering and nursing. These three groupings were used as indicator variables for disciplines (level 1) in the hierarchical linear model to understand how much reduction in the variance across disciplines is evident. In this model, the fixed effect of Carnegie classification is retained. The results are summarized in the bottom panel of table 5.

Inclusion of the discipline grouping reduced the variance among disciplines by 48 percent in the 2001 and 2000 data cycles, and by 46 percent in the 1998 data set. In spite of the reduction, however, the resulting variance among disciplines in relative terms remained at high levels of over 70 percent in the 2001 and 2000 data cycles, and 67 percent in the 1998 data set.

While there are numerous variables that can be considered in the model to reduce the variance among disciplines (level 1), analysis was restricted to the aforementioned discipline groupings. Relationships between cost and other variables that may be tied to expenditures are discussed in a subsequent section of these Findings.

Differences in Costs Between and Across Disciplines

Preliminary examination of the data suggested the necessity of combining the data from comprehensive and baccalaureate institutions, owing to very small participation rates for baccalaureate colleges within the disciplines and to eliminate the possibility of having unbalanced factors. While differences in average cost between comprehensive and baccalaureate institutions may exist for some disciplines, it can be argued from a purely practical approach, this combination of institutions is consistent with real-world practice at colleges and universities. While some level of graduate instruction is present in a few selected disciplines at comprehensive institutions, the vast majority of teaching activity and student credit hour generation occurs at the undergraduate level. It is, therefore, reasonable to group comprehensive and baccalaureate institutions, given their common primary undergraduate teaching mission.

Because of the nature of the data, there is large variation in the number of cases in each of the cells (i.e., combination of discipline and Carnegie classification). Costs for some of the disciplines are estimated from fewer than 10 courses, which can result in failure to find differences in means when differences, in fact, exist. In addition, the Levene test, which is the standard test of homogeneity of variance, indicated that the variances among the cells are not equal. After careful examination of the variances, the cost data were transformed to logarithm for the ANOVA. Although the variances remained unequal even after the transformation, the Levene test indicated that the inequality of the variances was substantially reduced. Therefore, ANOVA was used on the logarithm of cost.

The ANOVA showed that there are differences in costs among the 25 disciplines under examination, and among the now-three institutional groupings—research universities, doctoral universities, and comprehensive/baccalaureate institutions. Because there is strong interaction between discipline and Carnegie classification, the differences in cost across the disciplines are examined separately by Carnegie classification, and vice versa.

It should be noted that before ANOVA was applied to the data, outliers were identified in each of the cells, e.g., discipline by Carnegie classification. Outliers were defined as data points that lie beyond two standard deviations from the mean for the cell, and were subsequently omitted. The summary of the ANOVA to test for differences in average cost of instruction by discipline, and by Carnegie classification, by highest degree offered, and by undergraduate/graduate program mix in discipline for the 2001, 2000, and 1998 data collection cycles is found in appendix table D-6.

The results of the ANOVA by discipline and Carnegie classification are presented in appendix table D-7 for the 2001 data collection cycle, appendix table D-8 for the 2000 data collection cycle, and appendix table D-9 for the 1998 data collection cycle. The results of the pair-wise multiple comparisons are based on the Bonferroni procedure at the 5 percent level of significance. In the tables, the disciplines are sorted in ascending order of cost within each Carnegie classification. Then, groupings of disciplines are presented according to similarity in cost based on results from the pair-wise multiple comparisons. Disciplines that are defined as belonging to a group are assigned similar letters. For example, for research institutions in appendix table D-7, sociology through business are members of the "a" group. As such, there are no two disciplines in this group, regarding average cost of instruction, where differences were detected through ANOVA, even though the absolute values of those average costs range from $124 to $177. Business belongs to the "b" group as well, meaning that with respect to the cost of instruction, differences were not found between business and the other disciplines in group "b." Business, as a member of group "c," also shows no differences between its cost and the other disciplines in "c" group. Since business does not belong to the "d" group, cost in business is lower than that in education and the remaining disciplines listed below education.

The strong interaction between discipline and Carnegie groups, as expected, produced somewhat different discipline groupings for each category. The general findings are as follows:

- Among research institutions, differences were not detected between and among "service" departments such as English and mathematics, as well as disciplines in the social sciences, with respect to direct instructional expense per student credit hour taught. It costs as much to teach art (with small studio courses and individualized instruction) as it does to teach education (with a clinical teacher education component) and disciplines in the physical sciences (with emphasis on equipment intensive laboratory instruction). The high cost of teaching nursing puts it at the same levels as the engineering disciplines that have the highest unit costs. In the two more recent data sets, biology and physics have costs comparable to nursing and the engineering disciplines, with the exception of chemical engineering. It should be noted that costs in the engineering disciplines have the highest variability among reporting institutions.

- Cost of instruction in service departments and in the social sciences at doctoral universities tends to be at the same levels. Differences were not detected in the cost of instruction in the physical sciences compared with several of the social science disciplines. As at research universities, art groups with the physical sciences in cost, while nursing groups with engineering. This is likely associated with more expensive pedagogical delivery systems in art and nursing.

- Instructional costs at comprehensive/ baccalaureate institutions generally follow the patterns seen in the research and doctoral universities. Nursing groups with engineering with respect to instructional cost; education, art, and foreign languages group with the physical sciences. Again, this is likely tied to more costly pedagogical delivery systems in art, education, and nursing. English and mathematics, the two large service disciplines, group with the social sciences as the least expensive disciplines from an instructional cost perspective.

- Using the results from the same ANOVA, differences in costs were not detected among Carnegie groups for many disciplines. There are, however, a few disciplines, notably biology and education, wherein cost in research universities is higher than in doctoral and comprehensive institutions for all three data sets, and in mathematics and physics for the two more recent data sets. Costs in research universities are also found to be higher in the most recent data set in art, chemistry, computer science, and geography.

The analysis was extended to summarize variation in costs among the disciplines by highest degree offered within the discipline. As was the case with the preceding discipline analysis by Carnegie institution type, ANOVA was used on the logarithm of cost per student credit hour taught in order to reduce inequality of variance among the cells.

The results of the pair-wise multiple comparison of average instructional cost by discipline, within each highest degree offered category, are displayed in appendix tables D-10 to D-12 for the three data sets. Since the interaction between discipline and degree level is substantial, discipline groupings according to cost level are shown independently by highest degree offered. The results are as follows:

- Regardless of the highest degree offered, costs of instruction are lowest among service departments such as mathematics and English and all disciplines in the social sciences. Costs in art and education tend to be at similar levels as those in the physical sciences.

- In general, physical science disciplines have higher instructional costs than the social sciences in those instances where the Ph.D. is the highest degree offered. Where the master's or bachelor's is the highest degree offered, no differences in instructional costs were detected between the physical sciences and social sciences disciplines.

- Differences were not found between the cost of instruction in business and the social sciences for programs where the Ph.D. is the highest degree offered, whereas instructional costs in business are more comparable to costs in the physical sciences at the master's and bachelor's programs.

- Generally, all disciplines in engineering and nursing have higher costs than all other disciplines for all three degree-granting levels.

- In biology, cost of instruction is different at each of the three degree-granting levels, and the pattern remains consistent in each of the three data sets examined. Differences in cost, by degree level, are also found in all three data sets in education, art, and geology, and in two data sets in mathematics and psychology.

The relative undergraduate/graduate program mix is measured by the number of bachelor's degrees awarded in a discipline as a proportion of total degrees awarded. The Delaware Study national benchmarks are reported by 25-percentile ranges for undergraduate/graduate program mix, as defined. In the 2001 data collection cycle, those institutions where the proportion of undergraduate degrees is 75 percent or more of total degrees awarded account for 60 percent of the sample. With another 19 percent of the sample comprised of institutions granting 50 to 75 percent of all degrees at the undergraduate level, the sample sizes for institutions granting fewer than 50 percent of total degrees at the undergraduate level—in other words, predominantly graduate institutions—is very small. As a result, the sample size for many disciplines with predominantly graduate programs is small, and within that group, several disciplines were not represented at all. This distribution is very similar for the two earlier data collection cycles. Consequently, the entire sample was grouped into only two categories: 1) undergraduate degrees equivalent to 75 to 100 percent of total, and (2) undergraduate degrees equivalent to 0 to less than 75 percent of total.

The interaction between the program mix categories and discipline is both strong and important. The pair-wise multiple comparisons by discipline are, therefore, examined independently for the two groups, the results of which are presented in appendix Tables D-13 to D-15 for the three data sets. The ranking and grouping of instructional costs for these two groups follows the general patterns seen in the analyses by Carnegie institutional classification, and by highest degree offered within the discipline.

- For both program mix categories, service departments such as English and mathematics have the lowest instructional costs, and these costs are comparable to those in the social science disciplines.

- Differences in instructional costs were not detected between the physical sciences and several disciplines in the social science for both program mix categories.

- For the predominantly undergraduate programs, instructional costs for nursing are comparable to those in the engineering disciplines, and all have costs higher than other disciplines. Cost for biology at institutions with larger graduate programs is comparable to those in engineering disciplines.

Worth noting is the variation in cost among subdisciplines in education. The cost per student credit hour in the foregoing analysis is that for all education subdisciplines combined. A more in-depth examination of cost within education showed that there are indeed variations between and among its subdisciplines (not shown in tables). Based on the 2000 dataset, direct expense per student credit hour taught ranged from $149 in teacher education to $307 in educational administration and supervision. Tests showed that instructional costs were lowest in discipline-based teacher education (e.g., social studies education, mathematics education, science education, etc.), while general teacher education and curriculum and instruction cost more, at an average of $186 per student credit hour taught. As a group, teacher education costs are lower than the instructional cost for special education ($205), and general education, educational research/evaluation/ statistics, educational psychology, student counseling, and instructional media design—all of which average $270 per student credit hour taught. Educational administration and supervision at $307 is more expensive than most other subdisciplines. It should be noted that educational administration and supervision is typically a graduate-level discipline, often with a doctoral component.

Cost Factors

The initial analytical step in A Study of Higher Education Instructional Expenditures was to identify factors associated with instructional expenditures within each of these 25 academic disciplines under examination. In examining the 25 disciplines within any given data collection cycle, it is imperative to ensure that sufficient data points are available to allow for reliable use of the multiple regression methodology. In certain instances, e.g., engineering, it is necessary to collapse disciplines into larger, naturally affiliated groupings in order to achieve sufficient data points.

Appendix table D-16 displays cost factors for 20 disciplines or groups of disciplines under examination from the 2001 data collection cycle. Four of those disciplines—chemical, civil, electrical, and mechanical engineering—have been collapsed into a single larger "engineering" grouping. Three disciplines—anthropology, geography, and political science—had insufficient data points for discrete analysis, and since all three are social science disciplines, they lend themselves to a larger grouping called "other social sciences." Similar groupings were done for the 2000 and the 1998 data collection cycles, the results of which are presented in appendix tables D-17 and D-18, respectively.

Cost factors, as listed in appendix table D-16, were examined for modeling purposes, and fall basically into four broad categories. The first category is measures of department size. Size is described in terms of the total FTE faculty, total FTE tenured and tenure-track faculty, and FTE instructional faculty (which adjusts for contractual buyouts of faculty time for research and service activity). The size of the tenured/tenure-track faculty as a proportion of total faculty is also considered as a cost indicator. Extensive use of adjunct, part-time faculty, who tend to be paid less well than regular faculty, may actually reduce total instructional expense. Another aspect of department size is the extent of the teaching activity in the department, as measured in terms of the academic year student credit hours taught at the undergraduate level and graduate level combined. The number of graduate student credit hours taught and as proportion as of the total student credit hours are also examined, as it is generally assumed that graduate instruction is more expensive than teaching undergraduates.

The second group of factors relate to teaching workload. Workload is described in terms of the average number of student credit hours taught per FTE instructional faculty at the undergraduate level and at the combined undergraduate and graduate levels. Workload for tenured and tenure-track faculty is also examined in terms of student credit hours at each of the course levels as well as in terms of the proportion of student credit hours taught by them.

The proportion of total direct expenditures for instruction that is attributable to personnel costs is the third category of cost factors, while the fourth comprises variables that further describe the department in terms of highest degree offered in the discipline. The 1995 Carnegie classification is used to delineate types of institutions. Highest degree offered and the institution's Carnegie classification are transformed into categorical (dummy) variables for the analysis.

As described earlier, the analytical process for each of the disciplines was kept as consistent as possible. To recapitulate, the following protocols were adopted for all equations:

- Cost per student credit hour taught is the dependent variable. Cost is transformed to logarithm in the analysis.

- Data points wherein unit cost is beyond two standard deviations from the mean are omitted at the onset of the analysis.

- Outliers are defined as those cases in which the absolute value of the standardized residual is three or higher, and are subsequently omitted.

- Influential cases are identified as those with relatively high values of Cook's Distance and/or Mahalanobis Distance statistics. These cases are omitted in the final analysis.

- The quadratic terms of all continuous variables are tested for inclusion in the model to account for possible nonlinear relationships with cost.

- Interaction terms between selected continuous variables and categorical variables (highest degree offered and Carnegie institutional classification) were tested for inclusion in the model. *Note, however, that no interaction terms were important cost predictors in all three data sets, hence they are not listed in the summary.*

- For disciplines that are a two-digit CIP aggregate (e.g., Communication, 09.XX), data points belonging to a four-digit subdiscipline with two or fewer institutions reporting were eliminated from the aggregation.

The tables display regression coefficients and their corresponding standardized values (Beta coefficients). Since the dependent variable was transformed to logarithm, each regression coefficient is the equivalent percent increase in cost for every unit change in the corresponding variable. The Beta coefficients allow direct comparison of the relative contribution of each variable in predicting cost. The adjusted R^2 is the proportion of the variation in cost that is associated with the variables included in the equation, and is a measure of the goodness of fit of the equation. Some general observations are apparent from the three sets of analyses:

- Across almost all disciplines, the level of the department's teaching activity, as measured by total undergraduate and graduate student credit hours taught, is always associated with direct instructional expense. In the majority of disciplines, it has the highest or second highest contribution in predicting cost. Cost decreases as the volume of teaching increases. For many disciplines with a strong quadratic term, cost decreases at a faster rate at lower division levels of instruction. For engineering, art, business, and the combined political science/ anthropology/geography group, cost increases as the proportion of student credit hours that are offered at the graduate level increases.

- Departmental size (measured in terms of total number of faculty, total number of tenured/tenure-track faculty, or total number of instructional tenured/tenure-track faculty) is consistently associated with expense across disciplines. The larger the faculty size, the higher the cost. Its high explanatory power in predicting cost is evident in almost all disciplines.

- The proportion of faculty who are tenured or who are on tenure track among all instructional faculty, or among total faculty, is associated with cost, but to a lesser extent than the number of faculty. The higher this proportion, the higher the cost.

- Among the variables that measure faculty workload, the average student credit hours taught per FTE faculty is the most common cost factor among disciplines. The larger the number of credit hours taught, the lower the cost. Its relative contribution in describing cost variation is very high, if not the highest, in several disciplines. For some disciplines, regardless of magnitude of faculty workload, decrease in cost is constant. However, for many disciplines with a strong quadratic term, cost decreases at a faster rate when the teaching load is at lower levels than at higher levels.

- Personnel expenditure as percent of total instructional expenditure is a cost factor in the majority of disciplines. The higher the percentage, the lower the cost. Its contribution in describing cost, however, is relatively low in equipment-intensive disciplines, such as engineering and the physical sciences, where there is a large added cost of instruction due to nonpersonnel expenses.

- For many disciplines, cost differentials exist depending on whether or not graduate degrees are offered in the program. With the faculty size and faculty workload being tied to much of the variation in cost, most often the relative contributions of the indicator variables for highest degree are relatively small. It is worth noting that in all three data collection cycles, doctoral instruction in biology, chemistry, and physics substantially increases cost by nearly 10 percent on average, which is not surprising for disciplines in the physical sciences, given the emphasis on small group laboratory and research activity at the Ph.D. level. Interestingly, doctoral instruction in philosophy also increased cost by 10 percent, likely associated with the faculty-intensive nature of small group instruction at the Ph.D. level, and because the other variables that measure the contrast between undergraduate and graduate instructional faculty workload did not directly affect cost. Average increase in cost for English is about 5 percent.

- The cost differential due to Carnegie classification of the institution is usually more evident in disciplines when the highest degree offered is not a cost factor. In business, Carnegie classification is a consistent cost indicator with its effects being stronger than in any other discipline. For example in the 2001 data collection cycle, costs are higher by 21 percent among research institutions, 18 percent higher among doctoral institutions, and 12 percent higher among comprehensive institutions than in baccalaureate institutions. Costs in nursing in research institutions are higher by almost 10 percent, on average, than in any other group of institutions; in the discipline of education, costs are higher by almost 6 percent on average than in any other group.

Summary

Two issues consistently emerge as the most crucial findings in this analysis of multiple cycles of Delaware Study data:

- Most of the variance in instructional costs across institutions, as measured by direct expense per student credit hour taught, is associated with the disciplinary mix within an institution. While there are differences in instructional costs within a discipline when examining cost per student credit hour taught across Carnegie classification, they are less important than the difference in instructional costs between and across the disciplines that compose the curriculum within an institution.

- The magnitude of instructional costs within a discipline can be predicted based upon the degree of presence or absence of certain identifiable cost factors, specifically, volume of teaching load as measured by student credit hours taught is negatively associated with cost, while size of a departmental faculty, tenure rate within that faculty, and to a lesser extent, the presence of graduate instruction are positively associated with cost.

CONCLUSIONS AND DISCUSSION

Conclusions

Two central threads emerge from the analysis of data from the Delaware Study. First, there are real and important differences between instructional expenditures within the disciplines at a given institution. Second, it is possible to identify major factors that are tied to instructional expenditures across those disciplines.

Of foremost importance is the recognition that there are differences in cost between and across disciplines within an institution, and that these differences are associated with most of the variation when instructional costs are examined across institutions. The Delaware Study data collections have consistently revealed expenditure differences between and across disciplines ranging from a cost per student credit hour taught in the low $100s in the social sciences to in excess of $400 in engineering and certain physical sciences. The following discussion will focus on the identification of factors that are tied to important differences among disciplines.

With certain exceptions, direct instructional expenditures do not vary substantially within a given discipline when viewed across Carnegie institutional types. It is the differential in expenditures between and across the disciplines within an institution that is substantial—and important. The data consistently demonstrate that on average, whether it is a major research university or a small baccalaureate college, certain disciplines are less costly than other disciplines at the same institutions. Service departments, i.e., those that satisfy general education requirements, such as English, mathematics, and the social sciences, are generally the least costly. Because they satisfy general education requirements, service departments are in high demand and tend to be major student credit hour producers, one of the primary factors associated with reducing instructional expenditures.

Other disciplines have consistently higher costs. Physical sciences and biology, especially where the doctorate is offered, are expensive disciplines. This also is not surprising, given the equipment-intensive nature of these disciplines and the need to offer small group laboratory sections. However, at nondoctoral institutions, some physical science disciplines are only marginally more expensive than social science departments. This is likely associated with introductory, non-major sections of chemistry and biology that frequently satisfy students' science requirements, and are typically offered in large lecture format, i.e., they are major student credit hour producers.

Three disciplines—art, nursing, and education—are consistently comparable to the physical sciences in terms of instructional expenditures. These disciplines, by nature, require intense individualized instruction, in addition to lectures. Art courses often contain a studio component with a faculty mentor guiding a small number of students. Education and nursing both have a practicum associated with instruction wherein students are placed in apprentice roles at clinical sites as part of their curriculum. This type of instruction is typically more expensive than the traditional large group lecture format found in social sciences and humanities programs.

The important disciplinary differences are between and across departments at an institution, regardless of Carnegie institutional category. The differential patterns generally hold, whether at a research university or a liberal arts college. However, certain disciplines, most notably business, display distinctly different cost patterns depending upon highest degree offered. At institutions that grant the Ph.D., instructional expenditures in business tend to group with the less expensive social sciences, while grouping with the more expensive physical sciences at the master's and bachelor's degree levels. Economies of scale may well be tied to this phenomenon, as doctorate-granting institutions in the Delaware Study tend to be large, high-volume student credit hour programs.

The second important issue clarified by this study is that within an academic discipline, there are clear and measurable variables that are associated with instructional expense. Brinkman (1990) postulated that the behavior of marginal and average costs can be associated with four dimensions that are subsequently measured in the Delaware Study. Those dimensions are size (i.e., quantity of activity or output), scope of services offered, level of instruction (for instructional costs), and discipline (for instructional costs). While Brinkman ascribed two of these dimensions specifically to instructional expenditures, all four, as discussed below, are applicable.

Economies of scale are very much in evidence in examining instructional expenditures across the disciplines among institutions participating in the Delaware Study. Student credit hour production, magnitude of faculty workload, and faculty size are the most important predictors of instructional costs. Where faculty size is held relatively constant, increasing student credit hour production substantially reduces instructional expense. A proxy variable, i.e., student credit hours taught per FTE faculty, arrives at the same conclusion: increase individual faculty workloads and costs are reduced.

The data also suggest that increasing faculty size is tied to increased instructional costs, even in instances where less well paid, nontenurable full-time faculty and adjuncts are used to increase teaching activity. This finding is consistent with the manner in which costs track Carnegie institutional classification and highest degree offered in a program. In general, research and doctoral institutions tend to have the highest instructional expenditures, as do programs that offer the doctorate. Because research and public service activity are expected of faculty at research and doctoral institutions, and are components of any reputable doctoral program, it is reasonable to assume that faculty, particularly tenured and tenure track, in these institutions and programs will have research and public service obligations as part of their administered workload. Because they do things other than teach (i.e., increased scope of services offered), additional faculty must be secured to meet instructional demand, thereby increasing instructional costs. It is also noteworthy that in instances where the proportion of tenured and tenure-track faculty is higher, costs are higher.

Other variables are clearly tied to instructional costs, but less so than credit hour production, faculty workload, and faculty size. The presence of a graduate component in the department adds to instructional expenditures. This is not surprising; it is generally accepted that graduate education is more costly, given the small classes and high degree of individual instruction associated with graduate teaching. The relative contribution of this variable is small, compared with the three aforementioned variables. However, it is worth noting that over all three data collection cycles, departments offering the doctorate in biology, chemistry, physics, and philosophy increased costs by an average of 10 percent, while English departments offering the Ph.D. were, on average, 5 percent more expensive than non-doctorate-granting departments.

Discussion

The data analyzed from three discrete cycles of the Delaware Study of Instructional Costs and Productivity lead to a number of clear and consistent conclusions with respect to direct instructional expenditures in higher education.

Foremost is that the disciplinary mix at an institution has a profound impact on the overall level of instructional expenditures at an institution. Analysis of three cycles of Delaware Study data consistently demonstrates that there are real and substantial differences between and across disciplines at an institution. With few exceptions, the differences between the disciplines appear to be more important than the Carnegie classification of an institution. Simply put, it is possible to examine two research universities, one with a heavy curricular emphasis on physical sciences and engineering, the other with emphasis on the social sciences and humanities, and find substantial differences between overall instructional costs at the two institutions owing to the disciplinary mix at each. Similarly, it is possible to examine a research university and a baccalaureate college, each focused on the social sciences and humanities, and find no difference in overall unit instructional costs, again owing to disciplinary mix.

Finding that most of the variation in instructional expenditures is associated with the mix of disciplines within an institution is important in light of the issues raised in the first part of the congressionally mandated study. Researchers found no apparent relationship between the level of instructional expenditures at an institution and the tuition rate charged by that institution. The findings from this analysis of direct instructional expense underscore the difficulty in relating price to cost at the level of the academic discipline. While direct instructional expense per student credit hour taught in civil engineering is three times more than that for sociology, it is not practical for an institution to charge engineering majors a tuition rate three times that charged to sociology majors. Indeed, researchers for the first report in the congressionally mandated study found that institutional tuition rates at public institutions are largely tied to state appropriation levels, while competitive market forces are associated with tuition levels at private institutions. Neither of these external factors has anything remotely to do with what it costs to deliver instruction in a discipline. Price and cost are not interchangeable constructs.

There are important factors that are associated with direct expense at the academic discipline level of analysis. Higher education is no different from any other enterprise with respect to economies of scale—the larger the volume of unit output from a fixed workforce, the lower the unit cost of production. Increasing the size of the workforce in any substantial way without concurrently adjusting productivity is tied to rises in costs. The scope of services offered by a department or program, i.e., the extent to which it moves beyond instruction into areas of research and public service, is tied to increases in direct instructional expense for that unit. And finally, the introduction of graduate education into a department, while not as important a predictor of cost as productivity and faculty size, nonetheless is associated with increased instructional costs of a unit. It must again be emphasized that these internal *cost* factors are very different from the external factors tied to price (i.e., state appropriations, market forces, etc.) These are non-interchangeable constructs for which no strong statistical relationship has been found.

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Appendix A

Delaware Study Institutional Participant List

Delaware Study Institutional Participant List

Appalachian State University
Arizona State University
Arizona State University - West
Arkansas State University
Asbury College
Auburn University - Main Campus
Auburn University - Montgomery
Augusta College
Averett College
Ball State University
Baylor University
Belmont University
Black Hills State University
Bloomsburg University of Pennsylvania
Blufton College
Boston University
Bowling Green State University
Bradley University
Bridgewater State College
Brigham Young University
Butler University
Caldwell College
California State University - Fresno
California State University - Long Beach
California State University - San Marcos
Carleton College
Catholic University of America
Centenary College of Louisiana
Central Connecticut State University
Central Michigan University
Charleston Southern University
Christopher Newport University
Clarion University
Clarkson University
Clemson University
Cleveland State University
Coastal Carolina University
College of Charleston
College of Mount St. Joseph
College of New Rochelle
College of St. Mary
College of St. Elizabeth
College of the Holy Cross
Creighton University
Daemen College
Dakota State University
Davidson College
Delta State University
De Paul University
De Pauw University
Drew University
Drexel University
Drury University
Duquesne University
East Carolina University
East Tennessee University
Eastern Mennonite University
Eastern Michigan University
Eastern New Mexico University
Eastern Washington University
Edinboro University of Pennsylvania
Elizabeth City State University
Fayetteville State University
Florida Institute of Technology
Florida International University
Florida State University
Furman University
George Washington University
Georgetown University
Georgia Institute of Technology
Georgia Southern University
Georgia State University
Georgian Court College
Gonzaga University
Goshen College
Grambling State University
Grand Valley State University
Grinnell College
Gwynedd-Mercy College
Hartwick College
Indiana State University
Indiana University–Purdue University at Indianapolis
Indiana University–South Bend
Indiana University
Iowa State University
Ithaca College
Jackson State University
Jacksonville State University
James Madison University
Kansas State University
Keene State College

Kennesaw State College
Kent State University
La Salle University
Lake Superior State University
Lander University
Lebanon Valley College
Longwood College
Louisiana State University–Baton Rouge
Louisiana State University–Shreveport
Louisiana Tech University
Loyola Marymount University
Lynchburg College
Marist College
Marshall University
Marygrove College
Marywood University
McNeese State University
Mercer University
Mesa State College
Miami University
Michigan State University
Michigan Technological University
Millikin University
Mississippi State University
Mississippi University For Women
Mississippi Valley State University
Montana State University - Billings
Montana State University - Bozeman
Montclair State University
Moravian College
Mount Saint Mary's College (Maryland)
Muhlenberg College
Nazareth College of Rochester
New York State College of Ceramics
Niagara University
Nicholls State University
North Carolina A&T State University
North Carolina Central University
North Carolina State University
North Dakota State University
Northeastern University
Northern Arizona University
Northern Illinois University
Northern Kentucky University
Northern State University
Northwestern State University of Louisiana
Oakland University
Oberlin College
Ohio Northern University
Ohio State University
Oklahoma City University
Oklahoma State University
Old Dominion University
Oregon State University
Pacific Lutheran University
Park University
Portland State University
Prairie View A & M University
Presbyterian College
Purdue University Calumet
Radford University
Ramapo College of New Jersey
Rhode Island College
Rider University
Rockhurst University
Rollins College
Rowan University
Saint Edward's University
Saint Louis University
St. Michael’s College
Saint Norbert College
St. Paul’s College
Salisbury State University
Samford University
San Jose State University
Seattle University
Siena College
Slippery Rock University
Sonoma State University
South Dakota School of Mine & Technology
South Dakota State University
Southeast Missouri State University
Southeastern Louisiana University
Southern Illinois University–Carbondale
Southern Methodist University
Southern University and A&M College
Southern University – Baton Rouge
Southern Utah University
Southwest Missouri State University
Southwest Texas University
St. Bonaventure University
St. Mary's University
State University of West Georgia
SUNY–Albany
SUNY–Binghamton
SUNY–Brockport
SUNY–Cortland
SUNY–Geneseo
SUNY–Institute of Technology–Utica
SUNY–New Paltz
SUNY–Oneonta
SUNY–Oswego

SUNY–Plattsburgh
SUNY–Potsdam
SUNY–Purchase College
SUNY–Stony Brook
SUNY – University at Buffalo
SUNY – College at Fredonia
Sweet Briar College
Taylor University – Fort Wayne
Taylor University – Upland
Teachers College at Columbia University
Temple University
Tennessee State University
Tennessee Technological University
Texas A & M University–Main Campus
Texas Tech University
Towson State University
Trinity College
Troy State University
Tulane University
University of Akron
University of Alabama–Birmingham
University of Alabama–Huntsville
University of Alabama–Tuscaloosa
University of Alaska–Anchorage
University of Alaska – Fairbanks
University of Alaska–Southeast
University of Arizona
University of Arkansas–Little Rock
University of Arkansas–Fayetteville
University of California–Irvine
University of Central Florida
University of Charleston
University of Colorado–Boulder
University of Colorado at Colorado Springs
University of Colorado at Denver
University of Connecticut
University of Dallas
University of Dayton
University of Delaware
University of Florida
University of Georgia
University of Guam
University of Hartford
University of Hawaii at Manoa
University of Houston–Clear Lake
University of Houston–Main Campus
University of Houston–Victoria
University of Idaho
University of Iowa
University of Kansas
University of Louisiana at Lafayette
University of Louisiana at Monroe
University of Maine
University of Maine at Machias
University of Maryland – Baltimore County
University of Maryland–College Park
University of Massachusetts–Amherst
University of Miami
University of Minnesota–Duluth
University of Minnesota – Morris
University of Minnesota – Twin Cities
University of Mississippi
University of Missouri–Columbia
University of Missouri–Kansas City
University of Missouri–Rolla
University of Missouri–St. Louis
University of Montana
University of Montevallo
University of Nebraska–Kearney
University of Nebraska–Lincoln
University of Nevada–Las Vegas
University of New Hampshire
University of New Haven
University of New Orleans
University of North Carolina – Asheville
University of North Carolina–Chapel Hill
University of North Carolina–Charlotte
University of North Carolina–Greensboro
University of North Carolina–Pembroke
University of North Carolina–Wilmington
University of Northern Colorado
University of Northern Iowa
University of Notre Dame
University of Oklahoma
University of Oregon
University of Pittsburgh
University of Pittsburgh–Bradford
University of Scranton
University of South Alabama
University of South Carolina–Columbia
University of South Dakota
University of South Florida
University of Southern Indiana
University of Southern Mississippi
University of Tennessee–Chattanooga
University of Tennessee–Knoxville
University of Texas – Austin
University of Texas–Brownsville
University of Texas–El Paso
University of the Rio Grande–Ohio
University of Utah
University of Vermont

University of Virginia–Charlottesville
University of Washington
University of West Alabama
University of West Florida
University of Wisconsin – Madison
University of Wisconsin–Milwaukee
University of Wisconsin–Whitewater
University of Wyoming
Utah State University
Virginia Commonwealth University
Virginia Polytechnic Institute and State University
Wake Forest University
Washburn University
Washington College
Webster University
West Chester University
West Virginia University
Western Carolina University
Western Kentucky University
Western Michigan University
Western Washington University
Wichita State University
Wilkes University
William Paterson University
Winston-Salem State University
Wright State University
Xavier University of Louisiana
Youngstown State University

Appendix B

Data Collection Form

Data Collection Form

2002-03 Delaware Study of Instructional Cost and Productivity

Institution:

Department/Discipline:

Associated CIP Identifier:

Please indicate the average number of degrees awarded in this discipline at each degree level over the three year period from 1998-99 through 2000-01.

Bachelor's:
Master's :
Doctorate:
Professional:

Place an 'X' in the box below if this discipline is non-degree granting.

Place an "X" in the box below that describes your academic calendar:

Semester
Quarter

A. INSTRUCTIONAL COURSELOAD: FALL SEMESTER, 2001

Please complete the following matrix, displaying student credit hours and organized class sections taught, by type of faculty, and by level of instruction. Be sure to consult definitions before proceeding. Do not input data in shaded cells except for those mentioned in the important note below that pertains to (G) and (J).

Faculty				Student Credit Hours								Organized Class Sections				
Classification	FTE Faculty (A) Total	(B) Separately Budgeted	(C) Instructional	(D) Lower Div. OC*[1]	(E) Upper Div. OC*[1]	(F) Undergrad Indv. Instruct.	(G) Total Undergrad SCH	(H) Grad. OC*[1]	(I) Graduate Indv. Instruct.	(J) Total Graduate SCH	(K) Total Student Credit Hours	(L) Lab/Dsc/ Rec. Sections	Other Section Types (Lecture, Seminar, etc.) (M) Lower Div.	(N) Upper Div.	(O) Graduate	(P) Total
Regular faculty: -Tenured/Tenure Eligible																
- Other Regular Faculty																
Supplemental Faculty		NA														
Teaching Assistants: - Credit Bearing Courses		NA														
- Non-Credit Bearing Activity		NA		NA	NA	NA	NA	NA	NA	NA	NA					
TOTAL																

B. COST DATA: ACADEMIC AND FISCAL YEAR 2001-02

1. In the boxes below, enter the total number of student credit hours that were generated during Academic Year 2001-02 during terms that were supported by the department's instructional budget. (NOTE: Semester calendar institutions will typically report fall and spring student credit hours; quarter calendar institutions will usually report fall, winter, and spring student credit[2] hours.)

A. Undergraduate
B. Graduate

2. In the boxes below, enter total ***direct*** expenditures for instruction in FY 2001-02

A. Salaries — Are the benefits included in the number reported for salaries (Y/N)?

B. Benefits — If the dollar value is not available, what percent of salary do benefits constitute at your institution?

C. Other than personnel expenditures.

D. Total

3. In the box below, enter total ***direct*** expenditures for separately budgeted research activity in FY 2001-02

4. In the box below, enter total ***direct*** expenditures for separately budgeted public service activity in FY 2001-02

[1]OC = organized classes
[2]Summer semesters and quarters are not generally supported by the department's instructional budget.

Appendix C

Glossary

Glossary

Institution Type

The Delaware Study collects data on teaching loads, instructional costs, and externally funded scholarly activity from public and private 4-year institutions throughout the United States. Data are collected using the template in appendix B. The data from these colleges and universities are analyzed within the framework of the 1995 Carnegie Classification of Institutions of Higher Education. The institution types are as follows:

- *Research Universities:* Includes Research I and Research II institutions. The minimum criteria for inclusion in the research university category are a full range of baccalaureate programs, commitment to graduate education through the doctorate, and a high priority given to research. They award 50 or more doctoral degrees each year. In addition, they receive at least $15.5 million in federal support.

- *Doctoral Universities:* Includes Doctoral I and Doctoral II institutions. The minimum criteria for inclusion in the doctoral university category are a full range of baccalaureate programs, and a commitment to graduate education through the doctorate. They award annually at least 10 doctorates in 3 or more disciplines, or 20 or more doctoral degrees in 1 or more disciplines.

- *Comprehensive Colleges and Universities:* Includes Comprehensive I and Comprehensive II institutions. The minimum criteria for inclusion in comprehensive college and university category are a full range of baccalaureate programs, and a commitment to graduate education through the master's degree. They award 20 or more master's degrees in 1 or more disciplines.

- *Baccalaureate Colleges:* Includes Baccalaureate I and Baccalaureate II institutions. The minimum criteria for inclusion in the baccalaureate college category are that they award less than 40 percent of their baccalaureate degrees in liberal arts fields.

Academic Department/Discipline

The disciplines selected for benchmarking in the Delaware Study are found in the *Classification of Instructional Programs Taxonomy*, developed by the National Center for Education Statistics. The data are typically benchmarked at the four-digit CIP code level. Specifically, the Delaware Study examines discrete disciplines within a broad curricular field. For example, in Engineering (CIP code 14.XX), data are collected for those engineering disciplines at a given institution, e.g., 14.03 (Agricultural Engineering), 14.07 (Chemical Engineering), 14.08 (Civil Engineering), 14.10 (Electrical Engineering), 14.19 (Mechanical Engineering), and so on. Institutions with different engineering departments would report data for the appropriate four-digit CIP code. The pattern would be repeated across other curricular areas, e.g., Education (CIP code 13.XX), Physical Sciences (CIP code 40.XX), Social Sciences (CIP code 45.XX), Visual and Performing Arts (CIP code 50.XX), Business Management (CIP code 52.XX), etc.

Faculty

The Delaware Study collects detailed data on teaching loads, arrayed by category of faculty. Four discrete categories are examined:

- *Tenured and Tenure-track Faculty:* Those individuals who either hold tenure at the institution, or for whom tenure is an expected outcome.

- *Nontenure-track Faculty:* Those individuals who teach on a recurring contractual basis at the institution, but whose academic title or budget line render them ineligible for academic tenure.

- *Supplemental Faculty:* Supplemental faculty are characteristically paid from a pool of temporary funds. Their appointment is nonrecurring, although the same individual might receive a temporary appointment in successive terms. The key point is that funding is temporary, and there is no expectation of continuing appointment. This category includes adjunct faculty, administrators or professional personnel at the institution who teach but whose primary job responsibility is nonfaculty, contributed service personnel, etc.

- *Graduate Teaching Assistants:* Teaching assistants are those students at the institution who receive a stipend strictly for teaching activity. Includes teaching assistants who are instructors of record, but also includes teaching assistants who function as discussion or recitation section leaders, laboratory section leaders, and other types of organized class sections in which instruction takes place, but which may not carry credit and for which there is no formal instructor of record. Graduate research assistants are not included in this category.

Faculty Full-Time Equivalency (FTE)

The Delaware Study develops benchmark data for teaching loads (student credit hours taught per FTE faculty, FTE students taught per FTE faculty) and cost measures (direct research expenditures per FTE faculty). In converting full- and part-time faculty to FTE faculty, the following conventions are used:

- *Tenured/Tenure-track and Nontenure-track Faculty*: The definition of full-time equivalency begins with the total FTE value for filled faculty positions as they appear in the fall personnel file at an institution. A full-time faculty member is 1.0 FTE. An individual who works three-quarters time and is paid accordingly is 0.75 FTE. Filled positions are those that have salaries associated with them. This includes paid leaves such as sabbaticals wherein the individual is receiving a salary, but excludes unpaid leaves of absence. Institutions are asked to subtract from the total FTE those portions of faculty time that are externally funded and contractually obligated for activity other than teaching, e.g., research or service. The remainder is instructional FTE, the value used in teaching load benchmarks. For example, suppose Professor Jones is a full-time member of the Chemistry faculty. He would initially be reported as 1.0 FTE. Professor Jones has a research grant that contractually obligates him to spend one-third of his time in research. The externally supported portion of his position is 0.33 FTE, which would be subtracted from the total FTE. As a result, 0.66 FTE is the instructional portion of Professor Jones' full-time equivalency that is used in developing Delaware Study teaching load benchmarks.

- *Supplemental Faculty:* Full-time equivalency for supplemental faculty is calculated by taking the total teaching credit hours (which are generally equivalent to the credit value of the course(s) taught) for each supplemental faculty, and dividing by 12. Twelve hours is a broadly accepted standard for a full-time teaching load.

- *Teaching Assistants*: Full-time equivalency for teaching assistants is either defined as the value for the budget line on the institution's personnel file, or is calculated using the same convention as with supplemental faculty.

Faculty Teaching Load

Teaching loads are measured in terms of student credit hours and organized class sections taught in both regularly scheduled and individualized instruction courses. Courses are arrayed by lower division and upper division levels within undergraduate instruction, and by graduate level.

- *Course:* An instructional activity, identified by academic discipline and number, in which students enroll, typically to earn academic credit applicable to a degree objective. Excludes noncredit courses, but includes zero credit course sections which are requirements of or prerequisites to degree programs, and that are scheduled, and consume institutional or departmental resources in the same manner as credit courses. Zero-credit course sections are typically supplements to the credit-bearing lecture portion of a course. Zero-credit sections are frequently listed as laboratory, discussion, or recitation sections in conjunction with the credit-bearing lecture portion of a course.

- *Organized Class Course:* A course that is provided principally by means of regularly scheduled classes meeting in classrooms or similar facilities at stated times.

- *Individual Instruction Course:* A course in which instruction is not conducted in regularly scheduled class meetings. Includes readings or special topics courses, problems or research courses, including dissertation/thesis research, and individual lesson courses (typically in music and fine arts).

- *Course Section:* A unique group of students that meets with one or more instructors.

- *Course Credit:* The academic credit value of a course; the value recorded for a student who successfully completes the course.

- *Lower Division Instruction:* Courses typically associated with the first and second year of college study.

- *Upper Division Instruction:* Courses typically associated with the third and fourth year of college study.

- *Graduate Level Instruction:* Courses typically associated with post-baccalaureate study.

- *Student Credit Hours:* The credit value of a course (typically three or four credits) multiplied by the enrollment in the course.

Fiscal Data

The Delaware Study collects total *direct* expenditure data in certain functional areas, i.e., instruction, research, and public service. Direct expenditure data reflect costs incurred for personnel compensation, supplies, and services used in the conduct of each of these functional areas. They include acquisition costs of capital assets such as equipment and library books to the extent that funds are budgeted for and used by operating departments for instruction, research, and public service. In developing the cost models used in this study, direct expenditures for instruction are the focus of analysis. It is therefore important to have a clear understanding of what is meant by "instruction," and the components that constitute instructional expenditures.

The instruction function, for purposes of this study, includes general academic instruction, occupational and vocational instruction, community education, preparatory and adult basic education, and remedial and tutorial instruction conducted by the teaching faculty for the institution's students. Departmental research and service **that are not separately budgeted** are included under instruction. In other words, research that is externally funded is *excluded* from instructional expenditures, as are any departmental funds that are expended for the purpose of matching external research funds as part of a contractual or grant obligation. Also excluded are expenditures for academic administration where the primary function is administration. For example, deans would be excluded, but department chairs, whose primary function is instructional support, would be included.

Direct instructional expenditures are disaggregated into three categories:

1. *Salaries*: All wages paid to support the instructional function in a given department or program during the fiscal year. While these will largely be faculty salaries, they also include those for clerical (e.g., department secretary), professional (e.g., lab technicians), graduate student (stipends but not tuition waivers), and any other

personnel who support the teaching function and whose salaries and wages are paid from the department's/program's instructional budget.

2. *Benefits:* Expenditures for benefits associated with the personnel for whom salaries and wages were reported on the previous entry. Institutions that book benefits centrally are asked to provide, in concert with their business office, a reasonable estimate for departmental benefits. Where that cannot be done, the University of Delaware imputes a cost factor based upon the current benefit rate for the institution, as published in the annual salary issue of *Academe*. If no rate is available, a default value of 28 percent is used.

3. *Other Than Personnel Costs*: This category includes nonpersonnel items such as travel, supplies and expense, noncapital equipment purchases, etc., that are typically part of a department or program's cost of doing business. *Excluded* from this category are items such as central computing costs, centrally allocated computing labs, graduate student tuition remission and fee waivers, etc.

Appendix D

Tables

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Table of Contents—Continued

Table D-1. Nonresponse bias for 2001 Delaware Study, by institution's Carnegie classification

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference	Magni-tude of	Percent
	N_1	Avg (Y_1)	N_2	Avg (Y_2)	(Y_1-Y_2)	bias[1]	difference
Research							
Total tenure-track faculty	46	688	80	626	61	39	8.9
Total full-time faculty	46	1,008	80	944	65	41	6.4
Tenure-track faculty as percent of total full-time faculty	46	68	80	66	2	1	2.2
Total full-time-equivalent (FTE) enrollment	46	20,877	80	17,465	3,412	2,167	16.3
Undergraduate enrollment as percent of total	46	78	80	68	10	6	12.8
FTE enrollment per full-time faculty	46	21	80	18	3	2	12.4
Bachelor's degrees awarded as percent of total	46	66	80	58	8	5	12.5
Master's degrees awarded as percent of total	46	24	80	28	-4	-3	-16.6
Doctor's degrees awarded as percent of total	46	10	80	14	-4	-3	-44.9
Instructional expenditure per FTE enrollment	42	7,230	43	8,700	-1,470	-744	-20.3
Research exp per tenured and tenure-track faculty	42	136,842	43	189,807	-52,965	-26,794	-38.7
Public service exp per tenured and tenure-track faculty	42	53,559	43	54,554	-995	-503	-1.9
Academic support expenditure per FTE enrollment	42	1,807	43	3,458	-1,651	-835	-91.4
Average scholarship per FTE enrollment	42	1,504	43	1,771	-267	-135	-17.8
Library expenditure per FTE enrollment	42	605	43	699	-94	-47	-15.5
Doctoral							
Total tenure-track faculty	33	310	77	254	56	39	18.0
Total full-time faculty	33	500	77	412	88	61	17.5
Tenure-track faculty as percent of total full-time faculty	33	63	77	60	3	2	4.7
Total full-time-equivalent (FTE) enrollment	33	11,033	77	8,391	2,642	1,849	23.9
Undergraduate enrollment as percent of total	33	82	77	69	14	9	16.4
FTE enrollment per full-time faculty	33	22	77	20	2	1	7.3
Bachelor's degrees awarded as percent of total	33	68	77	56	12	9	18.1
Master's degrees awarded as percent of total	33	27	77	33	-6	-4	-22.7
Doctor's degrees awarded as percent of total	33	5	77	11	-6	-4	-130.2
Instructional expenditure per FTE enrollment	28	5,152	36	5,981	-829	-466	-16.1
Research exp per tenured and tenure-track faculty	28	46,500	36	62,394	-15,894	-8,940	-34.2
Public service exp per tenured and tenure-track faculty	28	22,829	36	20,376	2,452	1,379	10.7
Academic support expenditure per FTE enrollment	28	1,401	36	1,430	-29	-16	-2.1
Average scholarship per FTE enrollment	28	1,292	36	1,253	39	22	3.0
Library expenditure per FTE enrollment	28	506	36	475	31	17	6.1

See notes at the end of the table.

Table D-1. Nonresponse bias for 2001 Delaware Study, by institution's Carnegie classification—Continued

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference	Magni-tude of	Percent
	N_1	Avg (Y_1)	N_2	Avg (Y_2)	(Y_1-Y_2)	bias[1]	difference
Comprehensive							
Total tenure-track faculty	72	176	457	122	53	46	30.3
Total full-time faculty	72	291	459	200	91	79	31.2
Tenure-track faculty as percent of total full-time faculty	72	59	458	55	5	4	8.0
Total full-time-equivalent (FTE) enrollment	72	6,257	459	4,454	1,803	1,559	28.8
Undergraduate enrollment as percent of total	72	86	459	84	2	1	2.0
FTE enrollment per full-time faculty	72	23	457	25	-2	-1	-7.1
Bachelor's degrees awarded as percent of total	72	75	459	72	3	3	4.2
Master's degrees awarded as percent of total	72	23	459	27	-3	-3	-13.8
Doctor's degrees awarded as percent of total	72	2	459	2	0	0	6.4
Instructional expenditure per FTE enrollment	54	4,420	221	4,357	63	51	1.4
Research exp per tenured and tenure-track faculty	54	11,893	220	11,974	-81	-65	-0.7
Public service exp per tenured and tenure-track faculty	54	12,876	220	13,721	-845	-679	-6.6
Academic support expenditure per FTE enrollment	54	1,060	221	977	82	66	7.8
Average scholarship per FTE enrollment	54	1,279	221	1,286	-7	-6	-0.6
Library expenditure per FTE enrollment	54	354	221	363	-9	-7	-2.6
Baccalaureate							
Total tenure-track faculty	19	63	596	41	22	21	34.4
Total full-time faculty	19	111	606	77	34	33	30.8
Tenure-track faculty as percent of total full-time faculty	19	53	603	48	5	5	9.8
Total full-time-equivalent (FTE) enrollment	19	1,898	612	1,453	446	432	23.5
Undergraduate enrollment as percent of total	19	96	612	96	0	0	-0.3
FTE enrollment per full-time faculty	19	18	602	20	-3	-3	-15.9
Bachelor's degrees awarded as percent of total	19	96	607	94	2	2	2.1
Master's degrees awarded as percent of total	19	2	607	5	-4	-4	-240.1
Instructional expenditure per FTE enrollment	7	4,126	76	3,759	366	335	8.9
Research exp per tenured and tenure-track faculty	7	6,076	74	6,918	-842	-769	-13.9
Public service exp per tenured and tenure-track faculty	7	18,487	74	15,560	2,928	2,675	15.8
Academic support expenditure per FTE enrollment	7	1,014	76	888	126	115	12.4
Average scholarship per FTE enrollment	7	1,529	76	1,528	1	1	0.1
Library expenditure per FTE enrollment	7	418	76	322	96	88	23.1

[1]Calculated as $(Y_1-Y_2) * (N_2/(N_1+N_2))$.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1997–2001; U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), *Institutional Characteristics Surveys*, 1997–2001.

Table D-2. Nonresponse bias for 2000 Delaware Study, by institution's Carnegie classification

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference (Y_1-Y_2)	Magnitude of bias[1]	Percent difference
	N_1	Avg (Y_1)	N_2	Avg (Y_2)			
Research							
Total tenure-track faculty	48	697	78	619	78	48	11.2
Total full-time faculty	48	1,029	78	929	100	62	9.7
Tenure-track faculty as percent of total full-time faculty	48	67	78	67	0	0	0.5
Total full-time-equivalent (FTE) enrollment	48	21,657	78	16,898	4,759	2,946	22.0
Undergraduate enrollment as percent of total	48	79	78	68	11	7	13.8
FTE enrollment per full-time faculty	48	21	78	18	3	2	14.6
Bachelor's degrees awarded as percent of total	48	66	78	58	9	5	13.2
Master's degrees awarded as percent of total	48	24	78	29	-5	-3	-19.5
Doctor's degrees awarded as percent of total	48	10	78	14	-4	-3	-42.8
Instructional expenditure per FTE enrollment	43	7,123	42	8,845	-1,722	-851	-24.2
Research exp per tenured and tenure-track faculty	43	139,892	42	187,945	-48,053	-23,744	-34.3
Public service exp per tenured and tenure-track faculty	43	55,552	42	52,538	3,014	1,489	5.4
Academic support expenditure per FTE enrollment	43	1,784	42	3,521	-1,737	-858	-97.4
Average scholarship per FTE enrollment	43	1,484	42	1,798	-314	-155	-21.1
Library expenditure per FTE enrollment	43	591	42	715	-124	-61	-20.9
Doctoral							
Total tenure-track faculty	26	306	84	260	46	35	15.0
Total full-time faculty	26	494	84	421	72	55	14.7
Tenure-track faculty as percent of total full-time faculty	26	63	84	60	3	2	4.4
Total full-time-equivalent (FTE) enrollment	26	10,917	84	8,647	2,270	1,734	20.8
Undergraduate enrollment as percent of total	26	82	84	70	12	9	14.8
FTE enrollment per full-time faculty	26	22	84	20	1	1	5.7
Bachelor's degrees awarded as percent of total	26	68	84	57	11	8	16.4
Master's degrees awarded as percent of total	26	26	84	33	-7	-5	-26.2
Doctor's degrees awarded as percent of total	26	6	84	10	-4	-3	-72.7
Instructional expenditure per FTE enrollment	23	5,655	41	5,598	58	37	1.0
Research exp per tenured and tenure-track faculty	23	64,282	41	50,481	13,802	8,842	21.5
Public service exp per tenured and tenure-track faculty	23	26,859	41	18,414	8,445	5,410	31.4
Academic support expenditure per FTE enrollment	23	1,527	41	1,356	170	109	11.2
Average scholarship per FTE enrollment	23	1,331	41	1,236	95	61	7.1
Library expenditure per FTE enrollment	23	553	41	452	100	64	18.1

See notes at the end of the table.

Table D-2. Nonresponse bias for 2000 Delaware Study, by institution's Carnegie classification—Continued

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference (Y_1-Y_2)	Magnitude of bias[1]	Percent difference
	N_1	Avg (Y_1)	N_2	Avg (Y_2)			
Comprehensive							
Total tenure-track faculty	66	185	463	122	63	55	34.2
Total full-time faculty	66	304	465	200	105	92	34.4
Tenure-track faculty as percent of total full-time faculty	66	59	464	55	5	4	8.0
Total full-time-equivalent (FTE) enrollment	66	6,691	465	4,416	2,275	1,992	34.0
Undergraduate enrollment as percent of total	66	88	465	84	4	3	4.3
FTE enrollment per full-time faculty	66	22	463	25	-3	-3	-13.6
Bachelor's degrees awarded as percent of total	66	76	465	72	4	4	5.4
Master's degrees awarded as percent of total	66	23	465	27	-3	-3	-14.9
Doctor's degrees awarded as percent of total	66	1	465	2	-1	-1	-60.0
Instructional expenditure per FTE enrollment	57	4,462	218	4,345	116	92	2.6
Research exp per tenured and tenure-track faculty	57	14,951	217	11,171	3,780	2,994	25.3
Public service exp per tenured and tenure-track faculty	57	16,416	217	12,803	3,613	2,861	22.0
Academic support expenditure per FTE enrollment	57	1,047	218	979	67	53	6.4
Average scholarship per FTE enrollment	57	1,145	218	1,321	-176	-139	-15.3
Library expenditure per FTE enrollment	57	383	218	356	27	21	7.0
Baccalaureate							
Total tenure-track faculty	14	51	601	42	9	9	17.3
Total full-time faculty	14	100	611	77	23	23	23.1
Tenure-track faculty as percent of total full-time faculty	14	51	608	48	3	3	5.5
Total full-time-equivalent (FTE) enrollment	14	1,933	617	1,456	478	467	24.7
Undergraduate enrollment as percent of total	14	97	617	96	1	1	1.4
FTE enrollment per full-time faculty	14	19	607	20	-1	-1	-5.5
Bachelor's degrees awarded as percent of total	14	98	612	94	4	4	4.4
Master's degrees awarded as percent of total	14	2	612	5	-3	-3	-185.3
Instructional expenditure per FTE enrollment	9	3,648	74	3,808	-159	-142	-4.4
Research exp per tenured and tenure-track faculty	9	4,729	72	7,110	-2,381	-2,117	-50.4
Public service exp per tenured and tenure-track faculty	9	16,768	72	15,693	1,075	955	6.4
Academic support expenditure per FTE enrollment	9	856	74	904	-48	-43	-5.6
Average scholarship per FTE enrollment	9	1,302	74	1,556	-253	-226	-19.5
Library expenditure per FTE enrollment	9	350	74	327	23	21	6.6

[1]Calculated as $(Y_1-Y_2) * (N_2/(N_1+N_2))$.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1997–2001; U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), *Institutional Characteristics Surveys*, 1997–2001.

Table D-3. Nonresponse bias for 1999 Delaware Study, by institution's Carnegie classification

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference (Y_1-Y_2)	Magnitude of bias[1]	Percent difference
	N_1	Avg (Y_1)	N_2	Avg (Y_2)			
Research							
Total tenure-track faculty	53	694	73	616	78	45	11.2
Total full-time faculty	53	1,022	73	928	94	55	9.2
Tenure-track faculty as percent of total full-time faculty	53	68	73	67	1	0	1.2
Total full-time-equivalent (FTE) enrollment	53	21,179	73	16,919	4,260	2,468	20.1
Undergraduate enrollment as percent of total	53	78	73	68	10	6	13.1
FTE enrollment per full-time faculty	53	21	73	18	3	2	14.7
Bachelor's degrees awarded as percent of total	53	65	73	58	8	5	11.9
Master's degrees awarded as percent of total	53	25	73	28	-3	-2	-13.6
Doctor's degrees awarded as percent of total	53	10	73	14	-4	-3	-45.4
Instructional expenditure per FTE enrollment	47	7,187	38	8,947	-1,760	-787	-24.5
Research exp per tenured and tenure-track faculty	47	144,026	38	187,891	-43,865	-19,610	-30.5
Public service exp per tenured and tenure-track faculty	47	55,352	38	52,469	2,883	1,289	5.2
Academic support expenditure per FTE enrollment	47	1,826	38	3,653	-1,827	-817	-100.1
Average scholarship per FTE enrollment	47	1,479	38	1,837	-359	-160	-24.3
Library expenditure per FTE enrollment	47	605	38	712	-107	-48	-17.7
Doctoral							
Total tenure-track faculty	24	298	86	263	36	28	12.0
Total full-time faculty	24	476	86	428	48	37	10.1
Tenure-track faculty as percent of total full-time faculty	24	64	86	60	4	3	6.6
Total full-time-equivalent (FTE) enrollment	24	9,979	86	8,962	1,017	795	10.2
Undergraduate enrollment as percent of total	24	81	86	71	10	8	12.8
FTE enrollment per full-time faculty	24	20	86	21	0	0	-1.6
Bachelor's degrees awarded as percent of total	24	67	86	57	10	8	15.1
Master's degrees awarded as percent of total	24	27	86	33	-6	-4	-20.9
Doctor's degrees awarded as percent of total	24	6	86	10	-5	-4	-81.8
Instructional expenditure per FTE enrollment	20	5,575	44	5,638	-63	-44	-1.1
Research exp per tenured and tenure-track faculty	20	51,429	44	57,264	-5,834	-4,011	-11.3
Public service exp per tenured and tenure-track faculty	20	22,130	44	21,140	990	681	4.5
Academic support expenditure per FTE enrollment	20	1,424	44	1,414	10	7	0.7
Average scholarship per FTE enrollment	20	1,423	44	1,200	223	153	15.6
Library expenditure per FTE enrollment	20	541	44	465	76	52	14.0
Comprehensive (not included in the survey)							
Baccalaureate (not included in the survey)							

[1]Calculated as $(Y_1-Y_2) * (N_2/(N_1+N_2))$.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1997–2001; U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), *Institutional Characteristics Surveys*, 1997–2001.

Table D-4. Nonresponse bias for 1998 Delaware Study, by institution's Carnegie classification

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference	Magni-tude of	Percent
	N_1	Avg (Y_1)	N_2	Avg (Y_2)	(Y_1-Y_2)	bias[1]	difference
Research							
Total tenure-track faculty	49	703	77	614	89	54	12.6
Total full-time faculty	49	1,034	77	925	109	67	10.6
Tenure-track faculty as percent of total full-time faculty	49	67	77	67	1	0	0.7
Total full-time-equivalent (FTE) enrollment	49	21,154	77	17,156	3,998	2,443	18.9
Undergraduate enrollment as percent of total	49	79	77	68	11	7	13.8
FTE enrollment per full-time faculty	49	20	77	18	2	1	10.7
Bachelor's degrees awarded as percent of total	49	67	77	57	9	6	14.0
Master's degrees awarded as percent of total	49	24	77	29	-5	-3	-21.2
Doctor's degrees awarded as percent of total	49	10	77	14	-4	-3	-44.6
Instructional expenditure per FTE enrollment	44	7,052	41	8,962	-1,910	-921	-27.1
Research exp per tenured and tenure-track faculty	44	146,536	41	181,987	-35,451	-17,100	-24.2
Public service exp per tenured and tenure-track faculty	44	55,827	41	52,169	3,658	1,764	6.6
Academic support expenditure per FTE enrollment	44	1,871	41	3,470	-1,598	-771	-85.4
Average scholarship per FTE enrollment	44	1,491	41	1,798	-307	-148	-20.6
Library expenditure per FTE enrollment	44	591	41	719	-128	-62	-21.6
Doctoral							
Total tenure-track faculty	26	320	84	255	64	49	20.1
Total full-time faculty	26	522	84	413	109	83	20.9
Tenure-track faculty as percent of total full-time faculty	26	63	84	60	3	2	4.3
Total full-time-equivalent (FTE) enrollment	26	11,181	84	8,565	2,616	1,998	23.4
Undergraduate enrollment as percent of total	26	81	84	71	10	8	12.3
FTE enrollment per full-time faculty	26	21	84	21	0	0	1.3
Bachelor's degrees awarded as percent of total	26	66	84	57	9	7	13.7
Master's degrees awarded as percent of total	26	28	84	33	-4	-3	-14.7
Doctor's degrees awarded as percent of total	26	5	84	10	-5	-4	-95.2
Instructional expenditure per FTE enrollment	22	5,320	42	5,775	-455	-298	-8.5
Research exp per tenured and tenure-track faculty	22	43,563	42	61,662	-18,099	-11,878	-41.5
Public service exp per tenured and tenure-track faculty	22	20,464	42	21,965	-1,501	-985	-7.3
Academic support expenditure per FTE enrollment	22	1,425	42	1,414	12	8	0.8
Average scholarship per FTE enrollment	22	1,246	42	1,282	-36	-24	-2.9
Library expenditure per FTE enrollment	22	509	42	478	32	21	6.2

See notes at the end of the table.

Table D-4. Nonresponse bias for 1998 Delaware Study, by institution's Carnegie classification—Continued

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference (Y_1-Y_2)	Magni-tude of bias[1]	Percent difference
	N_1	Avg (Y_1)	N_2	Avg (Y_2)			
Comprehensive							
Total tenure-track faculty	63	179	466	123	56	49	31.2
Total full-time faculty	63	286	468	203	83	73	28.9
Tenure-track faculty as percent of total full-time faculty	63	61	467	54	7	6	11.3
Total full-time-equivalent (FTE) enrollment	63	5,995	468	4,524	1,471	1,296	24.5
Undergraduate enrollment as percent of total	63	87	468	84	2	2	2.9
FTE enrollment per full-time faculty	63	21	466	25	-4	-3	-18.9
Bachelor's degrees awarded as percent of total	63	75	468	72	4	3	4.7
Master's degrees awarded as percent of total	63	23	468	27	-4	-3	-17.3
Doctor's degrees awarded as percent of total	63	2	468	2	0	0	19.7
Instructional expenditure per FTE enrollment	43	4,326	232	4,377	-52	-44	-1.2
Research exp per tenured and tenure-track faculty	43	13,306	231	11,707	1,599	1,348	12.0
Public service exp per tenured and tenure-track faculty	43	15,923	231	13,114	2,810	2,369	17.6
Academic support expenditure per FTE enrollment	43	1,022	232	988	35	29	3.4
Average scholarship per FTE enrollment	43	1,090	232	1,320	-231	-195	-21.2
Library expenditure per FTE enrollment	43	372	232	360	13	11	3.4
Baccalaureate							
Total tenure-track faculty	15	62	600	42	21	20	33.3
Total full-time faculty	15	112	610	77	35	34	31.2
Tenure-track faculty as percent of total full-time faculty	15	54	607	48	6	6	11.6
Total full-time-equivalent (FTE) enrollment	15	2,066	616	1,452	615	600	29.7
Undergraduate enrollment as percent of total	15	96	616	96	0	0	0.4
FTE enrollment per full-time faculty	15	19	606	20	-1	-1	-6.1
Bachelor's degrees awarded as percent of total	15	96	611	94	2	2	2.1
Master's degrees awarded as percent of total	15	4	611	5	-1	-1	-29.9
Instructional expenditure per FTE enrollment	9	3,418	74	3,836	-418	-373	-12.2
Research exp per tenured and tenure-track faculty	9	1,900	72	7,464	-5,564	-4,945	-292.8
Public service exp per tenured and tenure-track faculty	9	23,595	72	14,840	8,755	7,783	37.1
Academic support expenditure per FTE enrollment	9	946	74	893	53	47	5.6
Average scholarship per FTE enrollment	9	1,360	74	1,549	-188	-168	-13.8
Library expenditure per FTE enrollment	9	305	74	333	-28	-25	-9.1

[1]Calculated as $(Y_1-Y_2) * (N_2/(N_1+N_2))$.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1997–2001; U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), *Institutional Characteristics Surveys*, 1997–2001.

Table D-5. Nonresponse bias for 1997 Delaware Study, by institution's Carnegie classification

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference	Magnitude of	Percent
	N_1	Avg (Y_1)	N_2	Avg (Y_2)	(Y_1-Y_2)	bias[1]	difference
Research							
Total tenure-track faculty	48	688	78	625	64	40	9.3
Total full-time faculty	48	1,003	78	946	57	35	5.7
Tenure-track faculty as percent of total full-time faculty	48	68	78	66	2	1	2.4
Total full-time-equivalent (FTE) enrollment	48	21,161	78	17,202	3,959	2,451	18.7
Undergraduate enrollment as percent of total	48	79	78	68	11	7	14.1
FTE enrollment per full-time faculty	48	21	78	18	3	2	15.1
Bachelor's degrees awarded as percent of total	48	67	78	57	10	6	14.3
Master's degrees awarded as percent of total	48	24	78	29	-5	-3	-19.8
Doctor's degrees awarded as percent of total	48	9	78	14	-5	-3	-52.4
Instructional expenditure per FTE enrollment	41	6,570	44	9,282	-2,712	-1,404	-41.3
Research exp per tenured and tenure-track faculty	41	138,841	44	186,741	-47,900	-24,796	-34.5
Public service exp per tenured and tenure-track faculty	41	58,345	44	50,073	8,272	4,282	14.2
Academic support expenditure per FTE enrollment	41	1,753	44	3,471	-1,719	-890	-98.1
Average scholarship per FTE enrollment	41	1,466	44	1,800	-334	-173	-22.8
Library expenditure per FTE enrollment	41	568	44	732	-164	-85	-29.0
Doctoral							
Total tenure-track faculty	35	298	75	258	40	27	13.4
Total full-time faculty	35	498	75	411	87	59	17.5
Tenure-track faculty as percent of total full-time faculty	35	60	75	61	-1	-1	-2.3
Total full-time-equivalent (FTE) enrollment	35	10,762	75	8,447	2,316	1,579	21.5
Undergraduate enrollment as percent of total	35	81	75	69	12	8	14.8
FTE enrollment per full-time faculty	35	21	75	21	0	0	2.3
Bachelor's degrees awarded as percent of total	35	67	75	56	10	7	15.6
Master's degrees awarded as percent of total	35	28	75	33	-6	-4	-19.8
Doctor's degrees awarded as percent of total	35	6	75	11	-5	-3	-84.5
Instructional expenditure per FTE enrollment	27	5,476	37	5,723	-247	-143	-4.5
Research exp per tenured and tenure-track faculty	27	66,853	37	47,113	19,740	11,412	29.5
Public service exp per tenured and tenure-track faculty	27	27,330	37	17,158	10,171	5,880	37.2
Academic support expenditure per FTE enrollment	27	1,525	37	1,340	185	107	12.1
Average scholarship per FTE enrollment	27	1,232	37	1,298	-66	-38	-5.3
Library expenditure per FTE enrollment	27	488	37	489	0	0	0.0

See notes at the end of the table.

Table D-5. Nonresponse bias for 1997 Delaware Study, by institution's Carnegie classification—Continued

Carnegie classification and institutional characteristic	Participants		Nonparticipants		Difference	Magni-tude of	Percent
	N_1	Avg (Y_1)	N_2	Avg (Y_2)	(Y_1-Y_2)	bias[1]	difference
Comprehensive							
Total tenure-track faculty	54	189	475	123	66	59	34.9
Total full-time faculty	54	305	477	202	103	93	33.8
Tenure-track faculty as percent of total full-time faculty	54	61	476	55	7	6	10.8
Total full-time-equivalent (FTE) enrollment	54	6,723	477	4,469	2,253	2,024	33.5
Undergraduate enrollment as percent of total	54	88	477	84	4	4	5.0
FTE enrollment per full-time faculty	54	22	475	25	-3	-3	-13.6
Bachelor's degrees awarded as percent of total	54	77	477	72	5	5	6.7
Master's degrees awarded as percent of total	54	22	477	27	-5	-5	-23.9
Doctor's degrees awarded as percent of total	54	2	477	2	0	0	2.4
Instructional expenditure per FTE enrollment	39	4,089	236	4,416	-326	-280	-8.0
Research exp per tenured and tenure-track faculty	39	11,360	235	12,057	-696	-597	-6.1
Public service exp per tenured and tenure-track faculty	39	13,550	235	13,555	-5	-4	0.0
Academic support expenditure per FTE enrollment	39	895	236	1,009	-114	-98	-12.7
Average scholarship per FTE enrollment	39	1,058	236	1,322	-264	-227	-25.0
Library expenditure per FTE enrollment	39	350	236	363	-13	-11	-3.7
Baccalaureate							
Total tenure-track faculty	13	88	602	41	47	46	53.2
Total full-time faculty	13	132	612	76	56	55	42.2
Tenure-track faculty as percent of total full-time faculty	13	67	609	48	19	19	28.9
Total full-time-equivalent (FTE) enrollment	13	2,179	618	1,451	728	713	33.4
Undergraduate enrollment as percent of total	13	95	618	96	-1	-1	-1.2
FTE enrollment per full-time faculty	13	17	608	20	-3	-3	-20.2
Bachelor's degrees awarded as percent of total	13	90	613	94	-4	-4	-4.4
Master's degrees awarded as percent of total	13	10	613	5	5	4	46.8
Instructional expenditure per FTE enrollment	2	4,067	81	3,784	284	277	7.0
Research exp per tenured and tenure-track faculty	2	6,839	79	6,846	-7	-6	-0.1
Public service exp per tenured and tenure-track faculty	2	18,473	79	15,745	2,728	2,661	14.8
Academic support expenditure per FTE enrollment	2	811	81	901	-89	-87	-11.0
Average scholarship per FTE enrollment	2	1,114	81	1,539	-425	-415	-38.2
Library expenditure per FTE enrollment	2	438	81	327	110	108	25.2

[1]Calculated as $(Y_1-Y_2) * (N_2/(N_1+N_2))$.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1997–2001; U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), *Institutional Characteristics Surveys*, 1997–2001.

Table D-6. Results of the ANOVA to test for differences in average cost of instruction, by discipline and Carnegie classification of the institution, highest degree offered, and undergraduate/graduate program mix in discipline: 1998, 2000, and 2001 Delaware Study

Factor and data collection cycle	Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value	Probability of F
Carnegie class (CC) by discipline (CIP)						
1998						
	CC	2	4.8861	2.4430	85.24	<.0001
	CIP	24	32.1579	1.3399	46.75	<.0001
	CC X CIP	48	3.8341	0.0799	2.79	<.0001
	Error	3,099	88.8238	0.0287		
2000						
	CC	2	5.3914	2.6957	102.42	<.0001
	CIP	24	43.6920	1.8205	69.17	<.0001
	CC X CIP	48	2.6104	0.0544	2.07	<.0001
	Error	3,140	82.6453	0.0263		
2001						
	CC	2	4.9285	2.4643	86.16	<.0001
	CIP	24	48.5772	2.0241	70.77	<.0001
	CC X CIP	48	2.7734	0.0578	2.02	<.0001
	Error	3,653	104.4761	0.0286		
Highest degree offered (HD) by discipline (CIP)						
1998						
	HD	2	6.0696	3.0348	113.4	<.0001
	CIP	24	27.7793	1.1575	43.25	<.0001
	HD X CIP	48	3.6752	0.0766	2.86	<.0001
	Error	2,972	79.5361	0.0268		
2000						
	HD	2	5.1815	2.5907	104.34	<.0001
	CIP	24	34.8753	1.4531	58.52	<.0001
	HD X CIP	48	3.8069	0.0793	3.19	<.0001
	Error	3,067	76.1559	0.0248		
2001						
	HD	2	5.2497	2.6248	98.88	<.0001
	CIP	24	38.1435	1.5893	59.87	<.0001
	HD X CIP	48	2.9195	0.0608	2.29	<.0001
	Error	3,540	93.9682	0.0265		
Undergraduate/graduate mix (UGG) by discipline(CIP)						
1998						
	UGG	1	2.4526	2.4526	77.9	<.0001
	CIP	24	37.5560	1.5648	49.7	<.0001
	UGG X CIP	24	2.5507	0.1063	3.38	<.0001
	Error	3,004	94.5782	0.0315		
2000						
	UGG	1	2.1884	2.1884	78.62	<.0001
	CIP	24	44.1356	1.8390	66.06	<.0001
	UGG X CIP	24	2.1691	0.0904	3.25	<.0001
	Error	3,033	84.4280	0.0278		
2001						
	UGG	1	2.4208	2.4208	78.72	<.0001
	CIP	24	43.8759	1.8282	59.45	<.0001
	UGG X CIP	24	2.5170	0.1049	3.41	<.0001
	Error	3,569	109.7507	0.0308		

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-7. Pairwise multiple comparison of cost of instruction by discipline within Carnegie classification based on the Bonferroni procedure at the 5 percent of level of significance: 2001 Delaware Study

Carnegie classification and discipline	Sample size	Average cost/SCH	Groupings[1]							
Research										
Sociology	33	124	a							
Philosophy	47	137	a							
English	50	140	a							
History	37	149	a	b						
Psychology	39	150	a	b						
Economics	28	153	a	b						
Anthropology	27	157	a	b						
Mathematics	53	160	a	b						
Political Science	33	164	a	b	c					
Geography	23	164	a	b	c					
Communication	45	169	a	b	c					
Foreign Languages	84	171	a	b	c					
Business	128	177	a	b	c					
Computer Science	34	204		b	c	d				
Geology	30	211		b	c	d				
Art	114	228			c	d				
Education	96	260				d				
Physics	33	263				d	e			
Chemistry	35	264				d	e			
Biology	82	276				d	e			
Electrical Engineering	24	359					e	f		
Mechanical Engineering	26	379					e	f		
Nursing	17	388					e	f		
Civil Engineering	27	411					e	f		
Chemical Engineering	25	472						f		
Doctoral										
Sociology	25	106	a							
Mathematics	34	116	a	b						
English	37	116	a	b						
History	29	124	a	b						
Philosophy	34	125	a	b						
Geography	16	125	a	b						
Anthropology	16	126	a	b	c					
Communication	34	130	a	b	c					
Foreign Languages	37	131	a	b	c					
Psychology	34	131	a	b	c					
Computer Science	28	142	a	b	c	d				
Economics	19	144	a	b	c	d				
Political Science	27	152	a	b	c	d				
Business	97	157		b	c	d				
Biology	41	191		b	c	d	e			
Geology	22	197		b	c	d	e			
Education	77	198			c	d	e			
Art	84	199				d	e			
Physics	29	203				d	e	f		
Chemistry	30	233				d	e	f	g	
Electrical Engineering	17	276					e	f	g	h
Mechanical Engineering	17	315						f	g	h
Nursing	21	332							g	h
Civil Engineering	14	379								h
Chemical Engineering	9	524								h

See notes at the end of the table.

Table D-7. Pairwise multiple comparison of cost of instruction by discipline within Carnegie classification based on the Bonferroni procedure at the 5 percent of level of significance: 2001 Delaware Study—Continued

Carnegie classification and discipline	Sample size	Average cost/SCH	Groupings[1]					
Comprehensive and Baccalaureate								
Geography	21	100	a					
Mathematics	80	106	a					
Sociology	53	106	a					
History	64	112	a					
English	94	116	a	b				
Psychology	82	118	a	b				
Philosophy	76	127	a	b	c			
Political Science	54	136	a	b	c	d		
Economics	34	138	a	b	c	d		
Communications	82	139	a	b	c	d		
Anthropology	16	145	a	b	c	d		
Geology	22	147	a	b	c	d		
Computer Science	65	152		b	c	d		
Business	229	153			c	d		
Biology	83	155			c	d		
Foreign Languages	85	161			c	d		
Education	196	179				d		
Physics	49	181				d	e	
Art	196	190				d	e	
Chemistry	63	193				d	e	
Electrical Engineering	13	293					e	f
Nursing	46	314						f
Chemical Engineering	3	321						f
Civil Engineering	10	322						f
Mechanical Engineering	14	327						f

[1]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-8. Pairwise multiple comparison of cost instruction by discipline within Carnegie classification based on the Bonferroni procedure at the 5 percent level of significance: 2000 Delaware Study

Carnegie classification and discipline	Sample size	Average cost/SCH	Groupings[1]					
Research								
Sociology	35	130	a					
Philosophy	48	134	a					
English	56	138	a					
History	37	142	a	b				
Economics	31	145	a	b				
Mathematics	54	147	a	b				
Anthropology	28	148	a	b				
Psychology	40	150	a	b				
Geography	25	155	a	b				
Communication	49	164	a	b				
Political Science	36	168	a	b				
Foreign Languages	90	169	a	b				
Business	132	172	a	b				
Computer Science	36	203		b	c			
Art	115	214			c			
Geology	35	223			c			
Chemistry	37	255			c	d		
Education	104	269			c	d		
Physics	38	284			c	d	e	
Biology	99	286			c	d	e	
Electrical Engineering	31	358				d	e	f
Nursing	19	368				d	e	f
Mechanical Engineering	30	400					e	f
Civil Engineering	30	401					e	f
Chemical Engineering	27	484						f
Doctoral								
Sociology	14	104	a					
English	29	113	a					
Anthropology	10	121	a	b				
Mathematics	26	123	a	b				
Philosophy	24	124	a	b				
Foreign Languages	25	125	a	b				
Geography	10	126	a	b				
History	20	127	a	b				
Psychology	23	136	a	b	c			
Economics	14	139	a	b	c			
Communication	26	143	a	b	c			
Political Science	18	151	a	b	c			
Business	60	163	a	b	c			
Computer Science	18	167	a	b	c			
Education	54	183		b	c			
Physics	21	191		b	c	d		
Biology	27	200		b	c	d		
Art	58	201		b	c	d		
Geology	18	201		b	c	d		
Chemistry	22	221			c	d	e	
Electrical Engineering	13	318				d	e	f
Mechanical Engineering	12	353					e	f
Nursing	15	357					e	f
Civil Engineering	9	367					e	f
Chemical Engineering	8	474						f

See notes at the end of the table.

Table D-8. Pairwise multiple comparison of cost instruction by discipline within Carnegie classification based on the Bonferroni procedure at the 5 percent level of significance: 2000 Delaware Study—Continued

Carnegie classification and discipline	Sample size	Average Cost/SCH	Groupings[1]					
Comprehensive and Baccalaureate								
Sociology	46	100	a					
History	52	100	a					
Anthropology	13	103	a	b				
Mathematics	65	106	a	b				
English	77	111	a	b				
Philosophy	50	111	a	b				
Psychology	64	113	a	b				
Economics	21	117	a	b	c			
Geography	19	121	a	b	c			
Political Science	40	129	a	b	c			
Communication	63	133	a	b	c			
Foreign Languages	54	137	a	b	c			
Computer Science	51	138	a	b	c	d		
Biology	66	141		b	c	d		
Business	193	150		b	c	d		
Geology	20	158		b	c	d	e	
Physics	39	168			c	d	e	
Chemistry	49	172			c	d	e	
Art	155	174			c	d	e	
Education	168	183				d	e	
Electrical Engineering	10	278					e	f
Nursing	42	323						f
Mechanical Engineering	10	333						f
Civil Engineering	8	362						f
Chemical Engineering	4	460						f

[1]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-9. Pairwise multiple comparison of cost of instruction by discipline within Carnegie classification based on the Bonferroni procedure at the 5 percent level of significance: 1998 Delaware Study

Carnegie classification and discipline	Sample size	Average cost/SCH	Groupings[1]						
Research									
Sociology	34	108	a						
English	52	122	a	b					
Philosophy	49	124	a	b					
History	37	129	a	b					
Psychology	34	131	a	b					
Economics	28	134	a	b					
Anthropology	24	139	a	b					
Geography	22	140	a	b	c				
Mathematics	54	144	a	b	c				
Communication	50	157	a	b	c				
Political Science	36	160	a	b	c				
Business	149	160		b	c				
Foreign Languages	81	165		b	c				
Computer Science	29	171			c	d			
Chemistry	36	205			c	d	e		
Art	112	205			c	d	e		
Geology	33	208			c	d	e		
Education	115	235				d	e		
Physics	35	249				d	e		
Biology	97	261				d	e	f	
Nursing	19	300					e	f	g
Electrical Engineering	31	360						f	g
Civil Engineering	29	379							g
Mechanical Engineering	31	415							g
Chemical Engineering	28	432							g
Doctoral									
English	28	111	a						
Mathematics	25	113	a						
Anthropology	12	118	a	b					
Geography	9	119	a	b					
Sociology	18	122	a	b					
Psychology	24	124	a	b					
Foreign Languages	26	124	a	b					
Communication	22	132	a	b					
Philosophy	27	138	a	b					
History	21	139	a	b					
Computer Science	19	141	a	b					
Economics	14	142	a	b	c				
Business	77	150	a	b	c				
Geology	15	159	a	b	c				
Education	60	167	a	b	c				
Biology	23	167	a	b	c				
Political Science	20	172	a	b	c				
Physics	21	178	a	b	c				
Art	57	193		b	c	d			
Chemistry	22	197		b	c	d			
Nursing	16	270			c	d			
Electrical Engineering	12	273			c	d			
Mechanical Engineering	11	321				d			
Civil Engineering	8	329				d			
Chemical Engineering	5	355				d			

See notes at the end of the table.

Table D-9. Pairwise multiple comparison of cost of instruction by discipline within Carnegie classification based on the Bonferroni procedure at the 5 percent level of significance: 1998 Delaware Study—Continued

Carnegie classification and discipline	Sample size	Average cost/SCH	Groupings[1]			
Comprehensive and Baccalaureate						
Geography	19	95	a			
Sociology	46	101	a			
Mathematics	55	103	a			
Psychology	63	105	a			
History	52	105	a			
English	74	107	a			
Philosophy	62	111	a			
Anthropology	14	112	a	b		
Economics	26	113	a	b		
Communication	58	124	a	b		
Political Science	42	126	a	b		
Biology	67	126	a	b		
Computer Science	40	133	a	b		
Education	149	145	a	b		
Foreign Languages	61	147	a	b		
Business	178	148	a	b		
Geology	24	156	a	b	c	
Chemistry	48	162		b	c	
Physics	42	168		b	c	d
Art	155	180		b	c	d
Chemical Engineering	6	251			c	d
Electrical Engineering	10	255			c	d
Nursing	31	257				d
Civil Engineering	8	262				d
Mechanical Engineering	7	264				d

[1]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-10. Pairwise multiple comparison of cost of instruction by discipline within highest degree offered based on the Bonferroni procedure at the 5 percent level of significance: 2001 Delaware Study

Highest degree offered and discipline	Sample size	Average cost/SCH	Groupings[1]						
Doctor's									
Sociology	33	132	a						
Communication	17	135	a						
English	47	140	a						
History	41	146	a						
Psychology	63	150	a						
Mathematics	66	151	a						
Economics	28	153	a						
Anthropology	19	154	a						
Geography	18	166	a	b					
Philosophy	31	167	a	b					
Political Science	27	172	a	b					
Computer Science	44	182	a	b					
Foreign Languages	45	184	a	b					
Business	59	188	a	b					
Education	151	250		b	c				
Geology	33	253		b	c	d			
Art	44	253		b	c	d			
Chemistry	55	256		b	c	d			
Biology	104	266			c	d			
Physics	42	266			c	d			
Electrical Engineering	39	327				d	e		
Mechanical Engineering	38	358				d	e		
Nursing	10	399					e		
Civil Engineering	33	423					e		
Chemical Engineering	30	487					e		
Master's									
Sociology	29	101	a						
English	70	111	a	b					
Mathematics	47	112	a	b	c				
Psychology	40	113	a	b	c				
History	47	115	a	b	c				
Philosophy	23	120	a	b	c	d			
Anthropology	14	133	a	b	c	d			
Geography	18	140	a	b	c	d			
Biology	45	145	a	b	c	d			
Economics	23	146	a	b	c	d			
Political Science	32	148	a	b	c	d			
Foreign Languages	51	149	a	b	c	d			
Geology	21	150	a	b	c	d			
Computer Science	31	154		b	c	d			
Communication	59	158			c	d			
Business	201	159				d			
Education	172	166				d			
Physics	24	174				d	e		
Chemistry	29	182				d	e	f	
Art	145	213					e	f	
Mechanical Engineering	11	296					e	f	g
Electrical Engineering	10	313					e	f	g
Civil Engineering	12	314						f	g
Nursing	49	321							g
Chemical Engineering	6	472							g

See notes at the end of the table.

Table D-10. Pairwise multiple comparison of cost of instruction by discipline within highest degree offered based on the Bonferroni procedure at the 5 percent level of significance: 2001 Delaware Study—Continued

Highest degree offered and discipline	Sample size	Average cost/SCH	Groupings[1]				
Bachelor's[2]							
Sociology	47	100	a				
History	39	103	a				
Mathematics	53	106	a				
Geography	20	107	a	b			
Psychology	51	114	a	b			
Philosophy	92	121	a	b			
English	57	122	a	b			
Communication	80	134	a	b	c		
Economics	28	135	a	b	c	d	
Political Science	51	135	a	b	c	d	
Computer Science	46	136	a	b	c	d	
Anthropology	20	140	a	b	c	d	
Foreign Languages	99	148	a	b	c	d	
Geology	21	150	a	b	c	d	
Business	178	153		b	c	d	
Biology	57	163		b	c	d	
Education	31	170		b	c	d	
Physics	43	174			c	d	
Art	188	187				d	
Chemistry	41	190				d	
Electrical Engineering	7	269					e
Civil Engineering	7	301					e
Mechanical Engineering	8	312					e
Nursing	24	343					e

[1]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

[2]Chemical Engineering is not included in the analysis since it has only 1 data point.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-11. Pairwise multiple comparison of cost of instruction by discipline within highest degree offered based on the Bonferroni procedure at the 5 percent level of significance: 2000 Delaware Study

Highest degree offered and discipline	Sample size	Average cost/SCH	Groupings[1]						
Doctor's									
Sociology	35	127	a						
English	49	132	a						
Mathematics	68	140	a						
History	38	142	a	b					
Economics	32	144	a	b					
Psychology	55	149	a	b					
Communication	17	153	a	b					
Anthropology	21	158	a	b					
Geography	18	160	a	b					
Philosophy	27	163	a	b					
Business	76	173	a	b					
Political Science	27	174	a	b	c				
Foreign Languages	49	174	a	b	c				
Computer Science	42	201		b	c	d			
Art	50	249			c	d	e		
Geology	34	253			c	d	e		
Education	135	259				d	e		
Chemistry	50	261				d	e		
Biology	113	279				d	e		
Physics	44	287					e	f	
Electrical Engineering	42	334					e	f	g
Nursing	13	371					e	f	g
Mechanical Engineering	38	376						f	g
Civil Engineering	34	405							g
Chemical Engineering	31	481							g
Master's									
Sociology	25	102	a						
Psychology	40	106	a						
Mathematics	41	106	a						
Philosophy	17	110	a						
History	42	111	a						
English	66	113	a						
Anthropology	14	121	a	b					
Biology	40	131	a	b					
Economics	16	133	a	b					
Geography	22	134	a	b					
Political Science	35	144	a	b					
Geology	19	145	a	b					
Computer Science	26	149	a	b					
Foreign Languages	52	149	a	b					
Communication	58	153		b					
Chemistry	32	163		b	c				
Physics	23	166		b	c	d			
Business	149	167		b	c	d			
Education	156	174		b	c	d			
Art	126	201			c	d			
Electrical Engineering	7	327				d	f		
Nursing	40	335					f		
Mechanical Engineering	11	373					f		
Civil Engineering	10	383					f		
Chemical Engineering	6	462					f		

See notes at the end of the table.

Table D-11. Pairwise multiple comparison of cost of instruction by discipline within highest degree offered based on the Bonferroni procedure at the 5 percent level of significance: 2000 Delaware Study—Continued

Highest degree offered and discipline	Sample size	Average cost/SCH	Groupings[1]			
Bachelor's						
Sociology	34	102	a			
Mathematics	32	108	a	b		
Geography	13	108	a	b		
History	30	109	a	b		
Psychology	30	113	a	b		
Philosophy	70	113	a	b		
Anthropology	17	115	a	b		
Economics	16	115	a	b		
English	43	117	a	b		
Political Science	32	130	a	b		
Computer Science	35	133	a	b		
Communication	61	138	a	b		
Foreign Languages	61	141	a	b		
Business	155	145	a	b		
Education	20	153	a	b		
Biology	37	153	a	b	c	
Art	139	168		b	c	
Geology	18	172		b	c	
Chemistry	27	174		b	c	
Physics	28	176		b	c	d
Electrical Engineering	4	286			c	d
Mechanical Engineering	2	287			c	d
Civil Engineering	4	329			c	d
Nursing	21	361				d
Chemical Engineering	2	496				d

[1]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-12. Pairwise multiple comparison of cost of instruction by discipline within highest degree offered based on the Bonferroni procedure at the 5 percent level of significance: 1998 Delaware Study

Highest degree offered and discipline	Sample size	Average cost/SCH	Groupings[1]						
Doctor's									
Sociology	31	115	a						
English	44	128	a						
Economics	29	134	a						
History	34	136	a						
Communication	16	138	a	b					
Mathematics	61	145	a	b					
Psychology	52	149	a	b					
Business	78	152	a	b					
Computer Science	29	170	a	b	c				
Philosophy	30	172	a	b	c				
Geography	15	174	a	b	c	d			
Computer Science	28	176	a	b	c	d			
Foreign Languages	38	177	a	b	c	d			
Anthropology	19	192	a	b	c	d			
Education	137	204		b	c	d			
Chemistry	47	208		b	c	d			
Geology	25	231		b	c	d	e		
Biology	100	242			c	d	e		
Physics	40	249			c	d	e		
Art	40	262				d	e	f	
Nursing	12	292				d	e	f	g
Electrical Engineering	43	342					e	f	g
Civil Engineering	33	361						f	g
Mechanical Engineering	39	413							g
Chemical Engineering	31	423							g
Master's									
Psychology	34	88	a						
Mathematics	36	95	a	b					
Sociology	25	95	a	b	c				
English	57	101	a	b	c				
Geography	19	110	a	b	c	d			
Philosophy	21	114	a	b	c	d			
History	37	115	a	b	c	d			
Anthropology	16	119	a	b	c	d			
Biology	40	125	a	b	c	d			
Computer Science	29	131	a	b	c	d			
Economics	17	133	a	b	c	d	e		
Political Science	34	133		b	c	d	e		
Communication	55	137			c	d	e		
Chemistry	30	141			c	d	e		
Foreign Languages	44	143			c	d	e		
Education	141	145				d	e		
Geology	24	153				d	e		
Business	137	157				d	e		
Physics	20	160				d	e	f	
Art	130	192					e	f	
Electrical Engineering	6	255					e	f	g
Nursing	33	261						f	g
Mechanical Engineering	10	285						f	g
Chemical Engineering	7	291						f	g
Civil Engineering	9	347							g

See notes at the end of the table.

Table D-12. Pairwise multiple comparison of cost of instruction by discipline within highest degree offered based on the Bonferroni procedure at the 5 percent level of significance: 1998 Delaware Study—Continued

Highest degree offered and discipline	Sample size	Average cost/SCH	Groupings[1]		
Bachelor's					
Geography	14	90	a		
Mathematics	35	104	a		
History	37	106	a		
Sociology	39	107	a		
Psychology	36	109	a		
Philosophy	70	113	a		
Economics	20	116	a	b	
Anthropology	14	118	a	b	
English	47	120	a	b	
Computer Science	29	129	a	b	
Communication	56	139	a	b	
Political Science	32	140	a	b	
Biology	42	141	a	b	
Geology	20	143	a	b	
Foreign Languages	76	147	a	b	
Business	168	150	a	b	
Education	24	157	a	b	
Physics	31	172		b	
Art	136	177		b	
Chemistry	28	178		b	c
Civil Engineering	4	214		b	c
Mechanical Engineering	2	258		b	c
Electrical Engineering	5	274		b	c
Nursing	17	275			c
Chemical Engineering	3	410			c

[1]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-13. Pairwise multiple comparison of cost of instruction by discipline within undergraduate/graduate program mix based on the Bonferroni procedure at the 5 percent level of significance: 2001 Delaware Study

Program mix[1] and discipline	Sample size	Average cost/SCH	Groupings[2]							
Undergraduate degree: 75-100%										
Sociology	100	108	a							
Mathematics	78	113	a	b						
Psychology	128	121	a	b	c					
Philosophy	107	123	a	b	c					
History	107	124	a	b	c					
English	123	126	a	b	c					
Geography	36	130	a	b	c	d				
Economics	52	137	a	b	c	d	e			
Anthropology	43	140	a	b	c	d	e			
Communication	148	142		b	c	d	e			
Foreign Languages	137	146			c	d	e			
Political Science	90	147			c	d	e			
Geology	27	147			c	d	e	f		
Computer Science	61	151			c	d	e	f		
Education	79	152			c	d	e	f		
Business	311	157				d	e	f		
Physics	48	174				d	e	f		
Biology	160	186					e	f		
Art	285	190						f		
Chemistry	66	196						f		
Electrical Engineering	16	282							g	
Mechanical Engineering	37	337							g	
Nursing	59	338							g	
Civil Engineering	24	339							g	
Chemical Engineering	22	449							g	
Undergraduate degree: 0-75%										
History	22	117	a							
Sociology	8	130	a							
English	49	132	a							
Political Science	20	149	a	b						
Philosophy	38	153	a	b						
Geography	21	154	a	b	c					
Economics	25	155	a	b	c					
Mathematics	88	168	a	b	c					
Computer Science	60	169	a	b	c					
Anthropology	11	169	a	b	c	d				
Communication	8	175	a	b	c	d				
Foreign Languages	58	183	a	b	c	d				
Business	128	186	a	b	c	d				
Psychology	26	187	a	b	c	d				
Geology	47	215		b	c	d	e			
Education	283	236			c	d	e	f		
Physics	60	236			c	d	e	f		
Chemistry	60	246				d	e	f	g	
Art	93	260					e	f	g	
Biology	45	320					e	f	g	h
Nursing	23	322						f	g	h
Electrical Engineering	40	332							g	h
Mechanical Engineering	21	358							g	h
Civil Engineering	27	411								h
Chemical Engineering	14	473								h

[1]Based on the number of bachelor's degrees as percent of total degrees granted in discipline.

[2]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-14. Pairwise multiple comparison of cost of instruction by discipline within undergraduate/graduate program mix based on the Bonferroni procedure at the 5 percent level of significance: 2000 Delaware Study

Program mix[1] and discipline	Sample size	Average cost/SCH	Groupings[2]			
Undergraduate degree: 75-100%						
Mathematics	61	111	a			
Sociology	87	112	a			
Philosophy	84	114	a			
English	104	117	a	b		
History	90	121	a	b		
Anthropology	41	123	a	b		
Geography	34	123	a	b		
Psychology	105	123	a	b		
Economics	43	130	a	b		
Computer Science	46	142	a	b	c	
Foreign Languages	99	145	a	b	c	
Political Science	74	148	a	b	c	
Communication	132	148	a	b	c	
Business	283	151		b	c	
Education	66	157		b	c	
Geology	25	165		b	c	
Art	225	174			c	
Physics	31	175			c	
Chemistry	57	178			c	
Biology	141	193			c	
Electrical Engineering	16	308				d
Mechanical Engineering	30	345				d
Nursing	49	353				d
Civil Engineering	21	366				d
Chemical Engineering	26	472				d
Undergraduate degree: 0-75%						
History	20	122	a			
Sociology	9	122	a			
English	50	124	a			
Mathematics	83	137	a			
Political Science	20	144	a			
Economics	22	144	a			
Psychology	20	148	a	b		
Communication	6	148	a	b		
Geography	19	158	a	b		
Philosophy	33	165	a	b		
Foreign Languages	66	174	a	b		
Anthropology	11	175	a	b		
Business	93	183	a	b		
Computer Science	57	192	a	b		
Education	245	225	a	b		
Geology	49	233	a	b	c	
Chemistry	53	244		b	c	
Physics	65	249		b	c	
Art	87	250		b	c	
Nursing	24	320			c	
Biology	49	337			c	d
Electrical Engineering	38	345				d
Mechanical Engineering	20	399				d
Civil Engineering	27	416				d
Chemical Engineering	12	454				d

[1]Based on the number of bachelor's degrees as percent of total degrees granted in discipline.

[2]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-15. Pairwise multiple comparison of cost of instruction by discipline within undergraduate/graduate program mix based on the Bonferroni procedure at the 5 percent level of significance: 1998 Delaware Study

Program mix[1] and discipline	Sample size	Average cost/SCH	Groupings[2]				
Undergraduate degree: 75-100%							
Sociology	85	105	a				
Mathematics	54	105	a	b			
Geography	31	109	a	b			
Psychology	98	112	a	b			
Philosophy	81	114	a	b			
English	103	115	a	b			
History	87	118	a	b			
Economics	43	124	a	b	c		
Computer Science	40	127	a	b	c		
Anthropology	32	129	a	b	c	d	
Political Science	74	139	a	b	c	d	
Foreign Languages	100	140	a	b	c	d	
Geology	27	143	a	b	c	d	
Communication	123	144		b	c	d	
Education	64	146		b	c	d	
Business	276	151			c	d	
Biology	117	153			c	d	
Physics	33	171			c	d	e
Chemistry	51	173			c	d	e
Art	223	178				d	e
Nursing	39	256					e
Electrical Engineering	16	261					e
Civil Engineering	15	289					
Mechanical Engineering	24	350					
Chemical Engineering	27	360					
Undergraduate degree: 0-75%							
Communication	8	100	a				
English	43	110	a				
Sociology	10	119	a	b			
History	22	123	a	b			
Geography	15	128	a	b			
Economics	23	136	a	b	c		
Mathematics	82	141	a	b	c		
Psychology	23	156	a	b	c		
Computer Science	48	168	a	b	c		
Business	105	173	a	b	c		
Political Science	18	174	a	b	c	d	
Foreign Languages	58	178	a	b	c	d	
Philosophy	39	178	a	b	c	d	
Anthropology	18	182	a	b	c	d	
Chemistry	54	191	a	b	c	d	
Education	248	195		b	c	d	
Geology	43	215		b	c	d	e
Physics	59	224			c	d	e
Art	84	240				d	e
Nursing	22	287					e
Biology	63	336					e
Electrical Engineering	37	348					
Civil Engineering	30	368					
Mechanical Engineering	26	391					
Chemical Engineering	13	448					

[1]Based on the number of bachelor's degrees as percent of total degrees granted in discipline.

[2]Disciplines that are assigned the same letter are not different from each other with respect to instructional cost. It is possible for a discipline to be in more than one group.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-16. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2001 Delaware Study

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Communication (CIP: 09.XX)		Computer Science (CIP: 11.XX)		Education (CIP: 13.XX)		Engineering[1]	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.017064*	0.63	0.015616*	0.69			0.020877*	1.12
FTE instructional tenured/tenure-track faculty					0.008097*	0.43		
Tenured/tenure-track instructional faculty as percent of total instr. faculty					0.000980*	0.09		
Tenured/tenure-track faculty as percent of total faculty			0.005581*	0.63			-0.001115*	-0.12
Academic year total student credit hours (undergrad+ graduate)	-3.164E-05*	-1.14	-1.031E-05*	-0.55	-2.378E-05*	-0.82	-7.696E-05*	-2.04
Quadratic term of academic year total student credit hours	5.116E-10*	0.43			3.734E-10*	0.35	1.577E-09*	0.85
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total	0.005778*	0.15					0.001164	0.09
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)	-0.005023*	-0.64	-0.003010*	-0.40				
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)	5.566E-05*	0.81						
Average student credit hours per faculty (fall data)	-0.000725*	-0.32	-0.002261*	-1.27	-0.002895*	-0.97	-0.000615*	-0.21
Quadratic term of average student credit hours per faculty (fall data)			1.927E-06*	0.67	3.621E-06*	0.51		
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)					0.000450*	0.11		
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.004894*	-0.22	-0.002839*	-0.14	-0.002665*	-0.08	-0.004149*	-0.16
Highest degree offered: Doctor's (1:yes; 0:no)					0.059237*	0.15	0.048115*	0.14
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)	0.067736*	0.18	0.083602*	0.22	0.040180*	0.09		
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.850956		2.628626		2.827763		3.078780	
Adjusted R^2	0.67		0.68		0.69		0.64	
Standard error of estimate	0.093950		0.092600		0.108900		0.093280	
Number of cases used in estimation	148		115		345		190	
Number of outliers and influential cases omitted in the analysis	6		8		19		5	

See notes at the end of the table.

Table D-16. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2001 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Foreign Languages (CIP:16.XX)		English (CIP: 23.XX)		Biology (CIP: 26.XX)		Mathematics (CIP: 27.XX)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty					0.002876*	0.25		
Total FTE tenured/tenure-track faculty	0.014835*	0.76	0.007957*	0.72			0.013421*	0.89
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty	0.001022*	0.14	0.001107*	0.14	0.002231*	0.19	0.001289*	0.12
Academic year total student credit hours (undergrad+ graduate)	-2.944E-05*	-1.48	-1.334E-05*	-1.26	-7.501E-06*	-0.28	-1.813E-05*	-1.27
Quadratic term of academic year total student credit hours	3.659E-10*	0.56	0.000000*	0.50			1.063E-10*	0.35
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total								
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)								
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.002682*	-1.15	-0.002813*	-1.06	-0.001056*	-0.48	-0.000769*	-0.34
Quadratic term of average student credit hours per faculty (fall data)	0.000004*	0.86	3.503E-06*	0.65				
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)	-0.000281*	-0.17						
Personnel expenditure as percent of total instr. expenditure			-0.004793*	-0.10	-0.003555*	-0.13	-0.007559*	-0.16
Highest degree offered: Doctor's (1:yes; 0:no)	0.065342*	0.17	0.052144*	0.16	0.103243*	0.25		
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)							0.120510*	0.31
Carnegie Classification: Doctoral (1:yes; 0:no)							0.080747*	0.18
Carnegie Classification: Comprehensive (1:yes; 0:no)					-0.055899	-0.13		
Constant	2.553016		2.946443		2.641794		2.914871	
Adjusted R^2	0.66		0.66		0.65		0.76	
Standard error of estimate	0.088600		0.081580		0.120020		0.087940	
Number of cases used in estimation	193		174		193		164	
Number of outliers and influential cases omitted in the analysis	9		7		9		6	

See notes at the end of the table.

Table D-16. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2001 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Philosophy (CIP: 38.XX)		Chemistry (CIP: 40.05)		Geology (CIP: 40.06)		Physics (CIP: 40.08)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.025115*	0.75	0.013965*	0.72	0.025069*	0.55	0.012821*	0.69
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty	0.001704*	0.20					0.003395*	0.32
Academic year total student credit hours (undergrad+ graduate)	-2.643E-05*	-0.74	-3.682E-05*	-1.52	-3.218E-05*	-0.49	-1.646E-05*	-0.53
Quadratic term of academic year total student credit hours			0.000000*	0.79				
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total			0.004944*	0.18				
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)							-0.001631*	-0.19
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.000621*	-0.33	-0.000683*	-0.32	-0.000836*	-0.49	-0.000999*	-0.45
Quadratic term of average student credit hours per faculty (fall data)								
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure			-0.006938*	-0.31	-0.004384*	-0.13	-0.003954*	-0.12
Highest degree offered: Doctor's (1:yes; 0:no)	0.108603*	0.28	0.103160*	0.30	0.084066*	0.19	0.088786*	0.24
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)								
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.083707		3.060764		2.755820		2.673635	
Adjusted R^2	0.61		0.70		0.80		0.66	
Standard error of estimate	0.093460		0.092410		0.096530		0.105230	
Number of cases used in estimation	142		121		71		102	
Number of outliers and influential cases omitted in the analysis	10		3		2		8	

See notes at the end of the table.

Table D-16. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2001 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Psychology (CIP: 42.XX)		Economics (CIP: 45.06)		History (CIP: 45.08)		Sociology (CIP: 45.11)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.016073*	0.90	0.014877*	0.83	0.015384*	0.85	0.018182*	0.69
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty			0.001594*	0.20				
Academic year total student credit hours (undergrad+ graduate)	-2.208E-05*	-1.08	-2.077E-05*	-1.22	-3.171E-05*	-1.33	-2.070E-05*	-0.81
Quadratic term of academic year total student credit hours	2.419E-10*	0.37	0.000000*	0.49	3.519E-10*	0.41		
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total								
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)								
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.000659*	-0.43	-0.000794*	-0.48	-0.000453*	-0.30	-0.000584*	-0.39
Quadratic term of average student credit hours per faculty (fall data)								
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)					0.002559*	0.16		
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.007347*	-0.17					-0.005066*	-0.12
Highest degree offered: Doctor's (1:yes; 0:no)			0.074566*	0.27	0.113616*	0.32	0.113024*	0.34
Highest degree offered: Master's (1:yes; 0:no)			0.062445*	0.22	0.066900*	0.20		
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)								
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.955874		2.228765		2.179921		2.673010	
Adjusted R^2	0.63		0.70		0.70		0.66	
Standard error of estimate	0.105130		0.072800		0.090730		0.087650	
Number of cases used in estimation	148		77		126		104	
Number of outliers and influential cases omitted in the analysis	4		1		3		3	

See notes at end of table.

Table D-16. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2001 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Other social sciences[2]		Art (CIP: 50.XX)		Nursing (CIP: 51.16)		Business[3]	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.020065*	0.74	0.008687*	0.58	-0.003729*	-0.23	0.010317*	0.59
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty			0.000621	0.07	0.001347	0.21	0.002416*	0.28
Academic year total student credit hours (undergrad+ graduate)	-2.729E-05*	-0.72	-1.558E-05*	-0.53			-1.590E-05*	-0.86
Quadratic term of academic year total student credit hours							8.526E-11*	0.17
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total	0.004912*	0.15			0.006699*	0.68		
Quadratic term of academic year graduate student credit hours as percent of total					-0.000104*	-0.74		
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)							-0.001223*	-0.17
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.000847*	-0.46	-0.003032*	-1.12	-0.005351*	-1.49	-0.001035*	-0.57
Quadratic term of average student credit hours per faculty (fall data)			4.433E-06*	0.66	1.066E-05*	0.84		
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)			0.001857*	0.13			0.000337*	0.09
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.005590*	-0.17	-0.005562*	-0.23	-0.008636*	-0.38	-0.006722*	-0.17
Highest degree offered: Doctor's (1:yes; 0:no)								
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)	0.034275*	0.10					0.018645*	0.06
Carnegie Classification: Research (1:yes; 0:no)			0.030539*	0.08	0.112895*	0.32	0.207096*	0.61
Carnegie Classification: Doctoral (1:yes; 0:no)							0.177990*	0.51
Carnegie Classification: Comprehensive (1:yes; 0:no)	-0.038218*	-0.11					0.124025*	0.43
Constant	2.862103		3.099232		3.668123		2.883694	
Adjusted R^2	0.66		0.60		0.69		0.60	
Standard error of estimate	0.097100		0.102760		0.077750		0.091250	
Number of cases used in estimation	222		337		81		392	
Number of outliers and influential cases omitted in the analysis	10		12		5		23	

*p = 0.05

[1] Includes Chemical Engineering (14.07), Civil Engineering (14.08), Electrical Engineering (14.10), and Mechanical Engineering (14.19).

[2] Includes Political Science (45.10), Anthropology (45.02), and Geography (45.07).

[3] Includes Business General (52.01), Business Administration and Management (52.02), Accounting (52.03), Business Economics (52.06), Financial Management (52.08), International Business (52.11), Business Information (52.12), Business Quantitative Methods (52.13) & Marketing (52.14).

NOTE: Cost determinant is included in equation if coefficient is significant at the 10 percent level.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-17. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2000 Delaware Study

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Communication (CIP: 09.XX)		Computer Science (CIP: 11.XX)		Education (CIP: 13.XX)		Engineering[1]	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty	0.013160*	0.84			0.006121*	0.61		
Total FTE tenured/tenure-track faculty							0.009967*	0.82
FTE instructional tenured/tenure-track faculty			0.009921*	0.39				
Tenured/tenure-track instructional faculty as percent of total instr. faculty	0.002869*	0.31	0.002036*	0.24	0.002998*	0.26		
Tenured/tenure-track faculty as percent of total faculty							0.002177*	0.25
Academic year total student credit hours (undergrad+ graduate)	-4.731E-05*	-1.51	-7.788E-06*	-0.38	-2.385E-05*	-0.88	-3.204E-05*	-1.35
Quadratic term of academic year total student credit hours	7.988E-10*	0.64			2.900E-10*	0.32	4.015E-10*	0.43
Academic year graduate student credit hours					-8.987E-06*	-0.14		
Academic year graduate student credit hours as percent of total					0.001822*	0.27	0.001625*	0.13
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)	0.001286*	0.16						
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-3.303E-04*	-0.15			-0.001776*	-0.57	-0.002835*	-0.96
Quadratic term of average student credit hours per faculty (fall data)					1.799E-06*	0.24	4.156E-06*	0.48
Average undergraduate student credit hours per faculty (fall data)			-0.002169*	-1.15				
Quadratic term of average undergraduate student credit hours per faculty (fall data).			2.273E-06*	0.70				
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.007065*	-0.25	-0.004156*	-0.21	-0.005644*	-0.18	-0.004294*	-0.24
Highest degree offered: Doctor's (1:yes; 0:no)								
Highest degree offered: Master's (1:yes; 0:no)	0.048331*	0.13						
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)	0.080381*	0.21	0.094296*	0.27	0.050930*	0.12	0.054706*	0.20
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.656497		2.754042		2.824106		3.043519	
Adjusted R^2	0.70		0.65		0.73		0.69	
Standard error of estimate	0.097260		0.098060		0.103960		0.073790	
Number of cases used in estimation	131		102		313		176	
Number of outliers and influential cases omitted in the analysis	2		0		6		5	

See notes at end of table.

Table D-17. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2000 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Foreign Languages (CIP:16.XX)		English (CIP: 23.XX)		Biology (CIP: 26.XX)		Mathematics (CIP: 27.XX)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty	0.005452*	0.65	0.004457*	1.03	0.002877*	0.29	0.004685*	0.89
Total FTE tenured/tenure-track faculty								
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty	0.002863*	0.32	0.002441*	0.30	0.005028*	0.44	0.003827*	0.38
Tenured/tenure-track faculty as percent of total faculty								
Academic year total student credit hours (undergrad+ graduate)	-1.954E-05*	-0.99	-1.192E-05*	-1.12	-7.813E-06*	-0.35	-9.225E-06*	-0.92
Quadratic term of academic year total student credit hours	1.798E-10*	0.29						
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total	0.008210*	0.33						
Quadratic term of academic year graduate student credit hours as percent of total	-0.000158*	-0.22						
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)					0.004568*	0.41		
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)					-0.000043*	-0.52		
Average student credit hours per faculty (fall data)	-2.597E-03*	-1.03	-0.000945*	-0.40	-0.002521*	-1.02	-0.002169*	-0.96
Quadratic term of average student credit hours per faculty (fall data)	0.000003*	0.52			2.565E-06*	0.54	1.945E-06*	0.52
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)			0.000907*	0.10	-0.000689*	-0.11		
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.002291	-0.09	-0.004081*	-0.12	-0.008318*	-0.28	-0.004609*	-0.12
Highest degree offered: Doctor's (1:yes; 0:no)			0.049759*	0.16	0.070691*	0.15		
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)					0.137083*	0.30	0.133872*	0.40
Carnegie Classification: Doctoral (1:yes; 0:no)					0.060711	0.09	0.060669*	0.14
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.616554		2.542872		2.899395		2.675949	
Adjusted R^2	0.69		0.63		0.73		0.73	
Standard error of estimate	0.086520		0.086420		0.119310		0.084600	
Number of cases used in estimation	159		158		182		139	
Number of outliers and influential cases omitted in the analysis	7		2		4		2	

See notes at end of table.

Table D-17. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2000 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Philosophy (CIP: 38.XX)		Chemistry (CIP: 40.05)		Geology (CIP: 40.06)		Physics (CIP: 40.08)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty			0.002203*	0.35	0.011214*	0.53		
Total FTE tenured/tenure-track faculty	0.015942*	0.50					0.008633*	0.61
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty			0.003330*	0.37	0.004537*	0.33	0.002231*	0.19
Tenured/tenure-track faculty as percent of total faculty	0.002334*	0.26						
Academic year total student credit hours (undergrad+ graduate)	-1.496E-05*	-0.41	-6.118E-06*	-0.34	-3.258E-05*	-0.59	-1.058E-05*	-0.44
Quadratic term of academic year total student credit hours								
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total								
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)								
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-1.042E-03*	-0.48	-0.001146*	-0.52				
Quadratic term of average student credit hours per faculty (fall data)								
Average undergraduate student credit hours per faculty (fall data)					-0.001237*	-0.57	-0.001011*	-0.50
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)			0.002326*	0.34				
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)			-0.000291*	-0.15				
Personnel expenditure as percent of total instr. expenditure			-0.005637*	-0.26	-0.005903*	-0.17	-0.004407*	-0.18
Highest degree offered: Doctor's (1:yes; 0:no)	0.086975*	0.23	0.150167*	0.44	0.148984*	0.35	0.096032*	0.27
Highest degree offered: Master's (1:yes; 0:no)					0.070181*	0.15		
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)								
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)			0.041038	0.12				
Constant	2.151888		2.775292		2.677000		2.675848	
Adjusted R^2	0.60		0.79		0.82		0.72	
Standard error of estimate	0.098600		0.077970		0.090290		0.095080	
Number of cases used in estimation	118		108		71		95	
Number of outliers and influential cases omitted in the analysis	5		0		1		1	

See notes at end of table.

Table D-17. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2000 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Psychology (CIP: 42.XX)		Economics (CIP: 45.06)		History (CIP: 45.08)		Sociology (CIP: 45.11)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty			0.010358*	0.94	0.007239*	0.75	0.007299*	0.50
Total FTE tenured/tenure-track faculty	0.008768*	0.57						
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty	0.002742*	0.27	0.003163*	0.37	0.003105*	0.28	0.003664*	0.35
Tenured/tenure-track faculty as percent of total faculty								
Academic year total student credit hours (undergrad+ graduate)	-8.009E-06*	-0.51	-1.302E-05*	-0.71	-1.048E-05*	-0.67	-1.582E-05*	-0.60
Quadratic term of academic year total student credit hours								
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total					0.005844*	0.11		
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)								
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-9.810E-04*	-0.64	-0.002872*	-1.69	-0.000794*	-0.48	-0.000831*	-0.56
Quadratic term of average student credit hours per faculty (fall data)			0.000003*	1.27				
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.006432*	-0.27	-0.005718*	-0.15	-0.005534	-0.12	-0.004354	-0.10
Highest degree offered: Doctor’s (1:yes; 0:no)							0.132799*	0.39
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)	0.065330*	0.18						
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.729795		2.943047		2.536328		2.433095	
Adjusted R^2	0.69		0.71		0.70		0.72	
Standard error of estimate	0.091180		0.072780		0.086900		0.086160	
Number of cases used in estimation	122		61		107		0	
Number of outliers and influential cases omitted in the analysis	1		2		2		1	

See notes at end of table.

Table D-17. Summary of determinants of direct instructional cost per student credit hour, by discipline: 2000 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Other social sciences[2]		Art (CIP: 50.XX)		Nursing (CIP: 51.16)		Business[3]	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty			0.006300*	0.67	0.007983*	0.80	0.005955*	0.75
Total FTE tenured/tenure-track faculty	0.021835*	0.88						
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty			0.001393*	0.16			0.002784*	0.32
Tenured/tenure-track faculty as percent of total faculty					0.001036	0.14		
Academic year total student credit hours (undergrad+ graduate)	-5.436E-05*	-1.77	-2.079E-05*	-0.74	-7.642E-05*	-1.92	-8.603E-06*	-0.72
Quadratic term of academic year total student credit hours	9.974E-10*	0.79			2.587E-09*	1.04		
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total			0.003747*	0.14			0.003744*	0.23
Quadratic term of academic year graduate student credit hours as percent of total							-0.000088	-0.19
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)								
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-5.237E-04*	-0.30	-0.000935*	-0.37	-0.004940*	-1.31	-0.001947*	-1.06
Quadratic term of average student credit hours per faculty (fall data)					1.335E-05*	1.03	1.720E-06*	0.61
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)					0.001772*	0.23		
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.006040*	-0.20	-0.006096*	-0.24	-0.008306*	-0.35	-0.009544*	-0.25
Highest degree offered: Doctor's (1:yes; 0:no)	0.084254*	0.24	0.040798*	0.09				
Highest degree offered: Master's (1:yes; 0:no)	0.033355*	0.10						
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)					0.089910*	0.25	0.171006*	0.57
Carnegie Classification: Doctoral (1:yes; 0:no)							0.142389	0.38
Carnegie Classification: Comprehensive (1:yes; 0:no)							0.118585	0.43
Constant	2.911062		2.886270		3.648880		3.126610	
Adjusted R^2	0.73		0.57		0.68		0.53	
Standard error of estimate	0.083540		0.103900		0.090560		0.095000	
Number of cases used in estimation	191		318		76		334	
Number of outliers and influential cases omitted in the analysis	8		4		1		14	

p = 0.05.
[1] Includes Chemical Engineering (14.07), Civil Engineering (14.08), Electrical Engineering (14.10), and Mechanical Engineering (14.19).
[2] Includes Political Science (45.10), Anthropology (45.02), and Geography (45.07).
[3] Includes Business General (52.01), Business Administration and Management (52.02), Accounting (52.03), Business Economics (52.06), Financial Management (52.08), International Business (52.11), Business Information (52.12), Business Quantitative Methods (52.13) & Marketing (52.14).
NOTE: Cost determinant is included in equation if coefficient is significant at the 10 percent level.
SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Table D-18. Summary of determinants of direct instructional cost per student credit hour, by discipline: 1998 Delaware Study

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Communication (CIP: 09.XX)		Computer Science (CIP: 11.XX)		Education (CIP: 13.XX)		Engineering[1]	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.018103*	0.59	0.015989*	0.66			0.013782*	0.73
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty			0.002538*	0.30	0.003493*	0.34	0.002107*	0.20
Academic year total student credit hours (undergrad+ graduate)	-2.974E-05*	-1.02	-2.273E-05*	-1.17			-6.605E-05*	-1.56
Quadratic term of academic year total student credit hours	3.84344E-10	0.35	3.216E-10*	0.58			1.620E-09*	0.69
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total							0.001459*	0.10
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)							-0.001281*	-0.11
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.003031*	-1.18	-0.000830*	-0.45	-0.003130*	-0.93	-0.001352*	-0.38
Quadratic term of average student credit hours per faculty (fall data)	3.82917E-06*	0.78			3.811E-06*	0.44		
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)					-0.000564*	-0.23		
Personnel expenditure as percent of total instr. expenditure					-0.003600*	-0.13	-0.003869*	-0.15
Highest degree offered: Doctor's (1:yes; 0:no)			0.069401*	0.21			0.081717*	0.22
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)					0.082953*	0.20	0.060795*	0.19
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)	-0.049760	-0.13	-0.056526	-0.18				
Constant	2.629499		2.216186		2.785612		2.953509	
Adjusted R^2	0.64		0.63		0.66		0.78	
Standard error of estimate	0.115460		0.095990		0.116500		0.074620	
Number of cases used in estimation	125		86		311		177	
Number of outliers and influential cases omitted in the analysis	4		1		7		6	

See notes at end of table.

Table D-18. Summary of determinants of direct instructional cost per student credit hour, by discipline: 1998 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Foreign Languages (CIP:16.XX)		English (CIP: 23.XX)		Biology (CIP: 26.XX)		Mathematics (CIP: 27.XX)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.005714*	0.33	0.008952*	0.86	0.002298*	0.12	0.011278*	0.94
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty	0.001976*	0.24	0.001016	0.12	0.005045*	0.43		
Academic year total student credit hours (undergrad+ graduate)	-1.126E-05*	-0.59	-1.732E-05*	-1.67			-1.928E-05*	-1.76
Quadratic term of academic year total student credit hours			1.368E-10*	0.66			1.438E-10*	0.72
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total								
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)							0.004206*	0.53
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)							-0.000042*	-0.60
Average student credit hours per faculty (fall data)	-0.001108*	-0.42	-0.000625*	-0.26	-0.002915*	-1.12	-0.000437*	-0.22
Quadratic term of average student credit hours per faculty (fall data)					2.375E-06*	0.48		
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)	-0.000313	-0.13	-0.000406*	-0.22				
Personnel expenditure as percent of total instr. expenditure					-0.005052*	-0.17		
Highest degree offered: Doctor's (1:yes; 0:no)	0.078670*	0.18	0.053231*	0.17	0.128692*	0.27	0.095089*	0.30
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)								
Carnegie Classification: Doctoral (1:yes; 0:no)								
Carnegie Classification: Comprehensive (1:yes; 0:no)	-0.036076	-0.10						
Constant	2.315728		2.242552		2.723573		2.099311	
Adjusted R^2	0.66		0.64		0.73		0.62	
Standard error of estimate	0.099790		0.085900		0.122070		0.098210	
Number of cases used in estimation	158		149		177		134	
Number of outliers and influential cases omitted in the analysis	2		3		7		2	

See notes at end of table.

Table D-18. Summary of determinants of direct instructional cost per student credit hour, by discipline: 1998 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Philosophy (CIP: 38.XX)		Chemistry (CIP: 40.05)		Geology (CIP: 40.06)		Physics (CIP: 40.08)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.020031*	0.62	0.017372*	0.92	0.029737*	0.67	0.013149*	0.88
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty	0.001288*	0.15	0.002659*	0.31			0.003543*	0.35
Academic year total student credit hours (undergrad+ graduate)	-2.957E-05*	-0.74	-3.278E-05*	-1.55	-0.000042*	-0.69	-2.632E-05*	-0.91
Quadratic term of academic year total student credit hours			5.219E-10*	0.69				
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total					0.023113*	0.44		
Quadratic term of academic year graduate student credit hours as percent of total					-0.001486*	-0.35		
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)			-0.001373*	-0.16			-0.001381*	-0.18
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.000583*	-0.29	-0.002654*	-1.22	-0.001332*	-0.52	-0.002633*	-1.18
Quadratic term of average student credit hours per faculty (fall data)			0.000004*	0.84			0.000003*	0.77
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure								
Highest degree offered: Doctor's (1:yes; 0:no)	0.128665*	0.33	0.137640*	0.44			0.075447*	0.21
Highest degree offered: Master's (1:yes; 0:no)	0.057013*	0.13					0.053627*	0.13
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)							0.097769*	0.27
Carnegie Classification: Doctoral (1:yes; 0:no)	0.057464*	0.14						
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.097833		2.498669		2.410171		2.433530	
Adjusted R^2	0.54		0.61		0.75		0.77	
Standard error of estimate	0.107570		0.098170		0.107550		0.082670	
Number of cases used in estimation	138		101		68		91	
Number of outliers and influential cases omitted in the analysis	1		2		3		9	

See notes at end of table.

Table D-18. Summary of determinants of direct instructional cost per student credit hour, by discipline: 1998 Delaware Study,—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Psychology (CIP: 42.XX)		Economics (CIP: 45.06)		History (CIP: 45.08)		Sociology (CIP: 45.11)	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.013415*	0.78	0.026493*	1.22	0.016643*	1.01	0.019270*	0.87
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty								
Tenured/tenure-track faculty as percent of total faculty	0.002333*	0.24	-0.001537	-0.17				
Academic year total student credit hours (undergrad+ graduate)	-1.220E-05*	-0.63	-2.715E-05*	-1.28	-0.000022*	-1.00	-1.999E-05*	-0.86
Quadratic term of academic year total student credit hours								
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total							0.005987*	0.14
Quadratic term of academic year graduate student credit hours as percent of total								
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)								
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.000844*	-0.51	-0.000471*	-0.28	-0.000508*	-0.29	-0.000698*	-0.40
Quadratic term of average student credit hours per faculty (fall data)								
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)								
Personnel expenditure as percent of total instr. expenditure	-0.005459*	-0.12						
Highest degree offered: Doctor's (1:yes; 0:no)	0.063119*	0.18			0.072955*	0.23		
Highest degree offered: Master's (1:yes; 0:no)								
Highest degree offered: Bachelor's (1:yes; 0:no)								
Carnegie Classification: Research (1:yes; 0:no)								
Carnegie Classification: Doctoral (1:yes; 0:no)					0.061792*	0.16		
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.553967		2.308420		2.156370		2.174525	
Adjusted R^2	0.74		0.71		0.67		0.70	
Standard error of estimate	0.088120		0.076790		0.085710		0.085580	
Number of cases used in estimation	116		61		103		91	
Number of outliers and influential cases omitted in the analysis	5		4		3		5	

See notes at end of table.

Table D-18. Summary of determinants of direct instructional cost per student credit hour, by discipline: 1998 Delaware Study—Continued

[Dependent variable=Log_{10}(Direct instructional cost per student credit hour)]

Cost determinant	Other social sciences[2]		Art (CIP: 50.XX)		Nursing (CIP: 51.16)		Business[3]	
	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta	b-coeff.	Beta
Total FTE faculty								
Total FTE tenured/tenure-track faculty	0.020257*	0.78			0.011807*	0.67	0.010937*	0.70
FTE instructional tenured/tenure-track faculty								
Tenured/tenure-track instructional faculty as percent of total instr. faculty					-0.002937*	-0.39		
Tenured/tenure-track faculty as percent of total faculty			0.002116*	0.24			0.001298*	0.18
Academic year total student credit hours (undergrad+ graduate)	-3.891E-05*	-1.11			-0.000057*	-1.76	-2.363E-05*	-1.37
Quadratic term of academic year total student credit hours	3.83631E-10	0.25			0.000000*	0.76	2.582E-10*	0.52
Academic year graduate student credit hours								
Academic year graduate student credit hours as percent of total	0.013120*	0.40	0.002057	0.08			0.005712*	0.54
Quadratic term of academic year graduate student credit hours as percent of total	-0.000684*	-0.39					-0.000085*	-0.40
Percent student credit hours taught by tenured/ tenure-track faculty (fall data)								
Quadratic term of percent student credit hours taught by tenured/tenure-track faculty (fall data)								
Average student credit hours per faculty (fall data)	-0.001635*	-0.86	-0.004566*	-1.57			-0.000490*	-0.28
Quadratic term of average student credit hours per faculty (fall data)	1.58506E-06*	0.50	0.000009*	1.12				
Average undergraduate student credit hours per faculty (fall data)								
Quadratic term of average undergraduate student credit hours per faculty (fall data)								
Average graduate student credit hours per tenured/ tenure-track faculty (fall data)								
Average undergrad student credit hours per tenured/ tenure-track faculty (fall data)			-0.000570*	-0.22	-0.001214*	-0.34		
Personnel expenditure as percent of total instr. expenditure	-0.003035*	-0.08	-0.005282*	-0.19	-0.007596*	-0.29	-0.003029*	-0.10
Highest degree offered: Doctor's (1:yes; 0:no)	0.052548*	0.14	0.241347*	0.44				
Highest degree offered: Master's (1:yes; 0:no)			0.154270*	0.45				
Highest degree offered: Bachelor's (1:yes; 0:no)	0.037228*	0.10	0.125685*	0.37				
Carnegie Classification: Research (1:yes; 0:no)					0.082685*	0.23	0.087599*	0.32
Carnegie Classification: Doctoral (1:yes; 0:no)							0.069840*	0.21
Carnegie Classification: Comprehensive (1:yes; 0:no)								
Constant	2.689135		3.012843		3.546854		2.461617	
Adjusted R^2	0.76		0.58		0.72		0.52	
Standard error of estimate	0.084720		0.109170		0.081090		0.090350	
Number of cases used in estimation	186		306		62		341	
Number of outliers and influential cases omitted in the analysis	5		8		4		14	

p = 0.05

[1] Includes Chemical Engineering (14.07), Civil Engineering (14.08), Electrical Engineering (14.10), and Mechanical Engineering (14.19).

[2] Includes Political Science (45.10), Anthropology (45.02), and Geography (45.07).

[3] Includes Business General (52.01), Business Administration and Management (52.02), Accounting (52.03), Business Economics (52.06), Financial Management (52.08), International Business (52.11), Business Information (52.12), Business Quantitative Methods (52.13) & Marketing (52.14).

NOTE: Cost determinant is included in equation if coefficient is significant at the 10 percent level.

SOURCE: University of Delaware, The Delaware Study of Instructional Costs and Productivity, 1998–2001.

Appendix E

Technical Notes

Technical Notes

General Approach to Data Analysis

Data analysis in this study focuses on 25 disciplines that are typically found at 4-year institutions, regardless of complexity or institutional mission. The examination focused on four-digit CIP wherever possible, or two-digit CIP as appropriate. Those disciplines and their associated CIP codes follow.

Table E-1. Classification by instructional program (CIP) codes

CIP	Discipline
09.xx	Communication
11.xx	Computer/Info Science
13.xx	Education
14.07	Chemical Engineering
14.08	Civil Engineering
14.10	Electrical Engineering
14.19	Mechanical Engineering
16.xx	Foreign Languages
23.xx	English
26.xx	Biological Sciences
27.xx	Mathematics
38.xx	Philosophy
40.05	Chemistry
40.06	Geology
40.08	Physics
42.xx	Psychology
45.02	Anthropology
45.06	Economics
45.07	Geography
45.08	History
45.10	Political Science
45.11	Sociology
50.xx	Visual/Performing Arts
51.16	Nursing
52.xx	Business

The total number of analytical units for these 25 disciplines ranges from 2,700 in the 1999 data collection cycle to 4,240 in the 2001 cycle.

Developing National Benchmarks

In analyzing the Delaware Study data within each data set, national benchmarks are computed. The initial step in the computation is the inclusion of all institutional responses with each Carnegie class for a given variable. From those total responses, an initial mean value is calculated. The responses are then further analyzed to identify those cases that are beyond two standard deviations above or below the initial mean. These cases are then defined as outliers and are excluded from the subsequent calculation of the refined mean. This conservative approach to benchmark construction was taken to ensure that no single or set of idiosyncratic responses exert undue influence on the calculation of a mean value or benchmark. This process is known as Windsorization, and theoretically excludes 2.5 percent of the data points at the low and high end of the range. In effect, refined means are calculated from the middle 95 percent of the data points.

Each of the calculated variables described in the Glossary is analyzed to determine whether specific institutional characteristics at the academic discipline level impact upon teaching loads and expenditures. Those characteristics include:

- Carnegie institutional classification,
- highest degree offered within the discipline, and
- relative emphasis on undergraduate versus graduate instruction within discipline.

The Carnegie institutional classification, as an instructional workload/cost factor, is predicated on a series of assumptions. The expectation is that research universities teach less and cost more than doctoral universities, which in turn teach less and cost more than comprehensive and baccalaureate institutions. This will be examined for each discipline, and if and where the assumption is negated, the issue of sample dependency is examined.

Two other institutional characteristics lend themselves to analysis. The assumed impact of highest degree offered is straightforward, i.e., doctorate-granting disciplines will teach less and cost more than master's-granting disciplines, which in turn will teach less and cost more than baccalaureate-only disciplines. This is an important consideration in looking at the overall disciplinary mix at an institution. The higher the concentration of doctorate and master's degree programs, the higher would be the expected instructional costs.

It is also important to examine the relative emphasis on undergraduate versus graduate instruction. One might look at two chemical engineering departments, both offering the doctorate. One teaches only 20 percent of its total student credit hours at the graduate level, while the other teaches over half of its student credit hours at the graduate level. Consideration of this factor enables distinguishing of cost differentials that are not so directly captured by either Carnegie institutional classification or highest degree awarded in the discipline. The Delaware Study benchmarks assess undergraduate versus graduate program mix within a discipline by examining the distribution of degrees awarded at the undergraduate versus graduate levels.

Variation in Cost

National benchmark cost data derived from annual Delaware Study data collection cycles repeatedly and consistently show variations in cost by discipline. Direct instructional expense per student credit hour taught ranges from the low $100s for some disciplines in the social sciences to well over $400 in disciplines in engineering and the physical sciences. It is important to understand the nature of these cost differentials.

At the very basic level, historical data from the Delaware Study indicate that costs vary among disciplines regardless of institutional mission. The data further show that within a given discipline, there is variation in cost among the pool of institutions participating in the Delaware Study in any year. This leads to the question as to where important cost differentials occur. Are variations in cost predominantly occurring among disciplines within institutions, or are they mostly due to categorical differences among the institutions themselves? These sources of variance are examined and described using hierarchical linear modeling.

The data gathered in the Delaware Study follow a classical hierarchical data structure. Variables such as cost of instruction and faculty workload are collected at the discipline level and may be grouped by institution. Part of the variance in cost can be attributed to disciplines within institution. However, cost may in turn be affected by the type of institution such as that based on Carnegie classification. Hierarchical linear modeling allows variance decomposition into within-institution and between-institution components.

In the two-level hierarchical data structure, disciplines are considered the level 1 units and institutions the level 2 units. The one-way analysis of variance, which is the simplest possible hierarchical model, is applied to cost where no explanatory variables are used in either discipline or institution. This provides the "baseline" measure of the variation in cost. In subsequent models, the effect of Carnegie classification and broad discipline grouping according to cost levels are disaggregated from the variance.

While no inferences on population cost estimates are possible, similarities or nonsimilarities of cost among the 25 disciplines under examination are analyzed and described. An in-depth test of difference in cost by discipline is applied to the data using analysis of variance (ANOVA). How costs vary by discipline in conjunction with institutional mission, highest degree awarded in the discipline, and the relative emphasis on undergraduate versus graduate instruction in the discipline is examined. It is important to replicate the analysis over multiple data cycles for validation of the findings; hence data from the 1998, 2000, and 2001 Delaware Study data collections are analyzed and described.

Cost Factors

Prior analysis of Delaware Study data (Middaugh and Graham 1998) suggests that there is substantial variation in the unit cost of instruction between and among individual disciplines and groupings of disciplines. Based upon that analysis, it can also be postulated that determinants of instructional cost may also vary by discipline. Consequently, data from the 1998, 2000, and 2001 Delaware Study data collection cycles are systematically examined to determine factors that directly impact instructional expenditures within each discrete data collection cycle. The data are further examined to determine if there is a pattern in cost determinants over time, i.e., across multiple data collection cycles. Specifically, the following variables, each of which is a Delaware Study benchmark, are examined through multiple regression analysis with respect to their significance in predicting the direct cost of instruction.

- Department size, as measured by total FTE faculty and by FTE instructional faculty. (The latter is the former, net of any contractual buyouts for activity other than instruction.)

- Proportion of faculty who are tenured or who are on tenure track. Tenured and tenure-track faculty are, on average, better compensated than other categories of faculty. Moreover, tenure makes this group largely a fixed cost. Consequently, the larger this proportion, the higher the unit cost of instruction.

- Total student credit hours taught in an academic year. Typically, the unit cost of an item—in this instance, a student credit hour—would be expected to decrease as the number of units being produced increases.

- Graduate student credit hours as a proportion of total student credit hours taught. Graduate level instruction is more expensive than undergraduate instruction. Classes are typically smaller; interactions with faculty, particularly tenured and tenure-track faculty, are more frequent and individualized, etc. It would therefore be reasonable to expect that the more graduate oriented a department, the more expensive the instruction.

- Faculty teaching load during an academic year as measured by the number of student credit hours taught per FTE faculty, and/or the number of FTE students taught (a derivative of student credit hours that is sensitive to level of instruction) per FTE faculty. It is assumed that the heavier the teaching load per FTE faculty, the lower the cost of instruction.

- Personnel expenditures as a percentage of total instructional expenditures. For some disciplines, most notably equipment-intensive disciplines such as the natural and physical sciences and engineering, a large added cost of instruction is due to nonpersonnel expenses, i.e., expenditures not associated with employee salaries and benefits. It is assumed that the unit cost of instruction will be lower in disciplines where most of the instructional expense is personnel related.

- Highest degree offered. It is hypothesized that the expected cost of instruction in a department or discipline that offers only the bachelor's degree will be lower than those offering graduate degrees as well.

- Institutional control, i.e., publicly versus privately supported institutions. There are those who argue that private institutions typically feature smaller class sizes, more individual attention to students, etc. If this is in fact the case, it should impact direct instructional expenditures at those institutions. *The feasibility of using this variable was examined in 1998, and again in the present study, and in both instances was eliminated due to the comparatively low participation rate among private institutions, which resulted in too few data points at the academic discipline level to yield meaningful and valid analysis*.

- Institutional mission, as inferred from the 1995 Carnegie institutional taxonomy. It is hypothesized that baccalaureate and comprehensive institutions intrinsically teach more in terms of student credit hour volume and faculty teaching loads than doctoral universities, which in turn teach more than research universities. If true, this impacts direct instructional expense.

Highest degree offered and institutional mission, as previously defined, have been translated into indicator variables for multiple regression analysis. These variables take on a value of either zero or one, where a value of one signifies a class membership.

Comprehensive cost models were sought for each discipline, using multiple regression analysis. In addition to analyzing and describing the linear relationship of cost and the continuous variables—such as academic year student credit hours taught, academic year graduate student credit hours as a proportion of total student credit hours taught by tenured and tenure-track faculty, etc.—the quadratic term for each of these variables was also tested in the model to account for possible nonlinear relationships with cost. Likewise, the interaction terms between the dummy variables for Carnegie classification and highest degree offered and the same continuous variables were analyzed and described.

In order to conform to the assumptions underlying regression analysis, data points wherein the unit cost is beyond two standard deviations from the mean were eliminated at the onset of analysis. These cases were omitted from analysis, as they are idiosyncratic and potentially exert undue impact on developing equations. Outliers and influential cases were identified by examining the residuals obtained from initial regression analyses and were subsequently omitted. The majority of the outliers have unit cost per student credit hours that are grossly high, i.e., standardized residual of three or higher. Influential cases were identified as those with relatively large values for Cook's Distance. The study of the residuals from the initial analysis repeatedly showed that the assumption of constant variance or homoscedasticity is violated. To correct for this, the dependent variable, cost per student credit hour, was transformed to logarithm.

Inclusion of the independent variables in the equation is a function of how strongly the variables independently or jointly affect instructional cost. The predictor variables that are included in these equations have regression coefficients that are significant at the 10 percent level. In a few instances, however, some variables were retained in order to have more meaningful and complete cost models. In part, inclusion of the variables depends upon the magnitude of the colinearity among these variables. Care was taken to ensure that multicolinearity was minimized.

The analytical strategy employed is to identify major cost drivers within each of the 25 academic disciplines under examination, to then determine whether these cost drivers vary among disciplines, and ultimately to examine if the identified cost drivers are consistent over multiple data collection cycles. In examining the 25 disciplines within any given data collection cycle, it is imperative to ensure that sufficient data points are present to allow for reliable use of multiple regression methodology. The question of insufficient data points occurred in disciplines at the four-digit CIP grouping. In certain instances, it was necessary to collapse some disciplines at the four-digit CIP into larger naturally affiliated groupings in order to achieve sufficient data points as well as to increase the predictive power of the model. Such is the case for the four engineering disciplines where combining them yielded a more highly predictive cost model. Similarly, combining political science with anthropology and geography produced more reliable cost models than when each is taken individually.

The analytical process for each of the disciplines under examination was kept as consistent as possible. Specifically, the following protocols were adopted for all equations:

- Cost per student credit hour taught is the dependent variable. Cost is transformed to logarithm in the analysis.

- Data points wherein unit cost is beyond two standard deviations from the mean are omitted at the onset of the analysis.

- Outliers are defined as those cases in which the absolute value of the standardized residual is three or higher, and are subsequently omitted.

- Influential cases are identified as those with relatively high values of Cook's Distance and/or Mahalanobis Distance statistics. These cases are omitted in the final analysis.

- The quadratic term of all continuous variables are tested for inclusion in the model to account for possible nonlinear relationships with cost.

- Interaction terms between selected continuous variables and categorical variables (highest degree offered and Carnegie institutional classification) were tested for inclusion in the model.

- Variables are retained in the equation only if their regression coefficients are statistically significant at the 10 percent level.

For disciplines that are a two-digit CIP aggregation, data points belonging to a four-digit subdiscipline with two or fewer institutions reporting were eliminated from the aggregation.

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