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ABSTRACT

The effects of federal funds upon the viability of selected biomedical and behavioral disciplines were studied based on multivariate analyses of a longitudinal data base, supplemented by case study field trips to nine carefully selected universities. In the quantitative analyses, models were constructed to predict several indices of academic department structure and function; e.g., Ph.D. production, graduate enrollment, and department size, which were postulated to be linked in a recursive model. The degree to which the federal funding effect varied as a function of the kind of institution was also examined. The key finding was that federal funding has a clear, strong, and positive relationship to department and structure, and that this holds true even when other factors in the model are taken into account. The detailed results are presented in numerous statistical tables. (Author/LBH)

THE EFFECTS OF FEDERAL FUNDS UPON SELECTED HEALTH-RELATED DISCIPLINES

PREPARED FOR THE PRESIDENT'S BIOMEDICAL RESEARCH PANEL

DAVID E. DREW, JOHN G. WIRT

WITH THE ASSISTANCE OF
FREDERICK W. FINNEGAN
MISAKO ... FUJISAKI
[illegible]

R-1944-PBRP
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A. LEE LANIEAR

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PREFACE

The work reported in this volume was performed as part of a Rand Corporation research effort carried out in conjunction with the American Council on Education and the Association of American Medical Colleges for the President's Biomedical Research Panel (under Contract No. NO1-PP-5-2159). The purpose of the total project was to trace the effects of federal health-related research funds on the nation's medical schools and universities. The work conducted under the contract has included both descriptive research and impact studies. The results of the research are reported in four documents:

Medical Schools—Descriptive: T. E. Morgan and D. D. Jones, *Trends and Dimensions of Biomedical and Behavioral Research Funding in Academic Medical Centers: 1964-1974*, Association of American Medical Colleges, January 1976.

Medical Schools—Impact Study: A. P. Williams, G. M Carter, D. S. C. Chu, S. Coleman, A. P. Massell, C. R. Neu, R. Rasmussen, and W. Rogers, *The Effect of Federal Biomedical Research Programs on Academic Medical Centers*, The Rand Corporation, R-1943-PBRP, March 1976.

Research Universities—Descriptive: Lyle H. Lanier and Ivars Zageris, *A Study of Financial and Educational Trends in Research Universities, with Special Reference to Federal Funding of Health-Related Research*, American Council on Education, 1976.

Research Universities—Impact Study: This report.

Our specific goal was to assess the unique association between federal funding of selected university science departments and various indicators of the viability of those departments. While our analyses grew out of significant national policy concerns and are relevant to those concerns, we have avoided drawing normative implications or issuing policy recommendations. Our hope is that these findings will be useful to life scientists, researchers who study graduate education, and policymakers concerned about the strength of the nation's life and behavioral science departments.

SUMMARY

Rand's study of the effects of federal funds upon the viability of selected biomedical and behavioral disciplines was based on multivariate analyses of a longitudinal data base, supplemented by case study field trips to nine carefully selected universities (plus one pilot visit).

In the quantitative analyses, we constructed models to predict several indices of academic department structure and function—e.g., Ph.D. production. These models included factors from earlier years that might have affected the variable under study. In each case, the key independent variable was federal expenditures for the department. Through this approach we were able to isolate the unique association of federal funding with each of these indices while controlling for other factors that also affected them.

Perhaps the most important quantitative indicator of departmental structure is faculty size. In addition, several key qualitative aspects of departmental structure were relevant. The thrust of research in the biological sciences has changed dramatically over the past 15 years in the direction of molecular and cellular research. In our field trips we examined the shifting structure of life science departments as it related to federal funding. Similarly, through the field trips we explored the research productivity of the faculties.

Many would argue that the reason for graduate education is the education of graduate students; these students also provide a valuable resource for faculty engaged in scholarly research. We examined the effects of federal funding upon graduate enrollment and upon the production of the Ph.D. Much of the recent controversy about graduate education has grown out of the highly publicized unemployment and underemployment of Ph.D.s in the early 1970s.

Although our analysis examined the separate predictors of Ph.D. production, graduate enrollment, and department size, we postulated that they were linked in a recursive model.

We also wanted to assess the degree to which this federal funding effect varied as a function of the kind of institution. We compared funding effects in several categories of universities. Any examination of higher education must differentiate public universities from private institutions. The history, budgeting, and orientation of these two sets of institutions are totally different. The relationship between federal funding and development of the basic life sciences at a university clearly differs depending on whether the institution has a medical school. In fact, the entire budgetary structure of the institution is greatly affected by the presence or absence of a medical school and the presence or absence of a hospital. We also examined the distinctive phenomena associated with the establishment of a new medical school at an institution during the past decade.

A major theory about graduate education during the past few years held that *leading* departments reduced their enrollments and Ph.D. production as a result of federal funding trends while *lesser* schools continued to produce large numbers of doctorates, the net effect being a reduction in the quality of the Ph.D.s in the country. This is a testable hypothesis.

Our multivariate analyses are presented in numerous statistical tables. The key findings:

1. Federal funding has a clear, strong, and positive relationship to department structure and function. This holds true even when other factors in our model are taken into account.
2. A notable exception is graduate enrollment in psychology, which does not appear to be associated with federal funding. However, this exception probably results from two factors: the large number of masters degree candidates in psychology and the combining of masters and Ph.D. candidates in the available federal data.
3. Examination of the findings for public and private universities yielded a mixed profile.

   Graduate enrollments in biology consistently were more closely tied to federal funds in the public than in the private sector.

   Ph.D. production in both fields showed a stronger tie to federal funds in the private sector during the early years and in the public sector during the later years.

   In the more recent years, faculty size has been more associated with federal funds in private institutions than at the state schools.
4. The presence or absence of a medical school had no consistent relationship to the effects of federal funds. However, our analysis of this factor was greatly hampered by limitations in available federal data. It was impossible to isolate, for example, graduate enrollments in a basic science at the main campus from those at the medical school.
5. The effects of federal funds on faculty size and enrollment did not vary substantially between leading research universities and doctoral granting institutions; the results for Ph.D. production were mixed.
6. Although a causal chain is difficult to establish, the level of federal funding is correlated with the level of other outside research support.
7. Our analyses showed that other outside research funding had a smaller effect on these indices than federal funds.

Carrying out this study has permitted us to make some observations about the problems and potential of research commissioned by the federal government to provide information on policy related issues.

The government retrieves vast quantities of data each year from the nation's universities for research purposes. Yet, when a study like this one is to be conducted, information from separate agencies must be combined in a process that turns out to be quite difficult. It has been our observation that the data assembled by the different agencies vary considerably in their quality, that some are of poor quality and that little thought has been given to the process of merging these separate files for policy analysis. Thus, when meaningful questions are to be asked of the data, one discovers that two agencies have dealt with branch campuses differently, that disciplines and professional fields are defined inconsistently, etc., substantially impeding the research process and greatly reducing the value of these data to policymakers. In our judgment, wiser interagency planning could reduce the number of requests for data to universities while greatly increasing the potential value of the data that are collected.

ACKNOWLEDGMENTS

Fred Finnegan and Misako Fujisaki played key roles in developing our computerized data base, maintaining it and carrying out the multivariate analyses we requested. Lee Laniear assisted us in conducting the field trips and in drawing up our observations about those visits. William Rogers carried out the computerized analyses that we used to select the field trip sample.

Our colleagues from the Rand medical school impact study, particularly Albert P. Williams, Principal Investigator for the entire Rand effort, contributed numerous comments and constructive criticisms.

Our colleagues at the American Council on Education, under the direction of Lyle Lanier, assembled most of the data we used in our analyses.

A number of distinguished scientists and administrators served as advisors on our field trips; they are listed in Table 2. In addition we are indebted to the people at each university we visited who assisted our research effort.

Finally, we received useful comments and suggestions from the Study Advisory Panel, chaired by Dr. Steven Muller, and from the formal reviewers of this report, Rand colleague Walter Baer and Donald Stewart of the University of Pennsylvania.

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I. INTRODUCTION

The past two decades have been tumultuous ones for life science departments in this nation's research universities. The advances in our understanding of fundamental biological phenomena have been spectacular, paralleling in significance the earlier revolution in physics. Behavioral and biological science departments in universities have significantly increased in size during this period. Much of this growth has been supported by the federal government.

The general pattern of support for research over the last 30 years has been well documented. Spurred by the spectacular success of the Manhattan Project during World War II, federal obligations for basic research increased dramatically throughout the 1950s and 1960s. These increases reached a peak in 1967 and then, for a variety of reasons, including an economy strained by the Vietnam War, obligations actually declined by a small amount over the next three years. In 1970, these federal commitments for basic research began to rise again, but at a much slower rate of increase than in the 1960s.[1]

Early in the deliberations of the President's Biomedical Research Panel, for which this study was conducted, a major concern was expressed about the viability of the nation's university life science departments in view of the ebbing of federal support. It is clear that the federal investment in scientific research at universities is not the result of a well-coordinated long range plan with widely understood parameters, but rather a mixed bag of programs developed for a variety of reasons and subject to abrupt increases, decreases, and cancellations.

We wanted to see if the leveling of federal support had damaged university departments and their research activities. It is easy and perhaps misleading to cite examples of university activities that were briefly strengthened only to be weakened in the long run by federal support: a research lab standing empty (or not being fully utilized) because it was built under a huge grant that was not renewed; a public university totally out of balance because one area had been overextended when federal funds created faculty positions that were made permanent in the state budget to the detriment of other disciplines; and so forth. We proposed going beyond such anecdotal information. Our goal was to systematically trace the effects of federal funding upon a variety of indicators of departmental structure and function, whether those effects were positive or negative. This assessment required taking into account other sources of financial support of the departments as well as structural characteristics of the university that were likely to affect the indicators we observed. Our basic goal was translated into a series of specific questions as outlined in the contract for this research.

Below we shall discuss the indices of departmental functioning we used and the other components of the departmental budget (beyond federal funds) we considered. These elements were combined analytically in an organizational model that also took into account basic differences between types of universities.

The methodology of the study consisted of two complementary approaches. The

[1] National Science Foundation, "Federal Funds for Research, Development and Other Scientific Activities," *Surveys of Science Resources Series*. Vol. 20 (NSF 71-35) and Vol. 23 (NSF 74-320), Washington, D.C.

main focus of the research was a set of multivariate analyses of longitudinal data about 148 of the nation's leading universities. However, in our judgment such mathematical exercises conducted in a vacuum can sometimes lack a firm basis in reality. We therefore supplemented the multivariate statistical analyses with a series of field visits to a sample of nine carefully selected universities (plus one pilot visit). We do not pretend that ten short visits, no matter how well organized and intensive, can provide definitive answers to the questions we posed. However, they were extremely useful in terms of generating hypotheses for the data analysis, testing relationships uncovered in those quantitative analyses, and providing some fairly well-grounded observations about the effects of federal funding upon the life sciences.

INDICES OF DEPARTMENTAL FUNCTIONING

Perhaps the single most important quantitative indicator of departmental structure is faculty size. We were interested not only in trends in overall department size over time as it related to federal funding but also in the numbers of people at each professional level and, in particular, in the percentage of the faculty who were tenured.

In addition to these quantitative indices, several key qualitative aspects of departmental structure were relevant to these issues. The thrust of research in the life sciences has changed dramatically over the past 15 years in the direction of molecular and cellular research. In our field trips we examined the shifting structure of life science departments as it related to federal funding. Similarly, through the field trips we explored the research productivity of the faculties.

Many would argue that the *raison d'être* of graduate education is the education of graduate students. These students also provide a valuable resource for faculty engaged in scholarly research. In this study we examined the effects of federal funding upon graduate enrollment and upon the production of the Ph.D. Much of the recent controversy about graduate education has grown out of the highly publicized unemployment and underemployment of Ph.D.s in the early 1970s. There have been a number of assertions about the relationship of federal funding to enrollment and Ph.D. production at leading and lesser institutions.

FINANCIAL FACTORS AFFECTING UNIVERSITIES

This study was conducted against the background of the recent financial history of the nation's universities. Early in the 1970s, a number of observers described in rather stark terms the "new depression" in higher education.[2] The nation's higher education institutions, long accustomed to comfortable financial support from all sectors, were being forced to trim their sails for the first time in years. Although the bleakness of their financial picture may have been exaggerated at times, this clearly has been a much more difficult period financially for universities than the 1960s because of the coincidence of several factors:

[2] See, for example, Earl F. Cheit, *The New Depression in Higher Education*, McGraw-Hill, New York, 1971; and *The New Depression in Higher Education—Two Years Later*, McGraw-Hill, New York, 1973.

- Institutions that depend for a significant portion of their income upon donor gifts, notably the private universities, have suffered because of the decrease in philanthropic donations, which has been a by-product of the decline of the economy during the past few years. Even wealthy donors are less likely to give to universities because of the "relative deprivation effect" when they see the value of their portfolio reduced as the market falls.
- Parallel to the leveling of federal support has been a reduction in the enthusiasm and support state legislatures provide public universities. One reason was the reaction of a number of conservative legislators to student protests at some public institutions.
- State legislatures were also responding to the increased financial constraints faced by states as the economy became weaker. With tight budgets, higher education had a difficult time competing with such items as feeding the poor and care for the aged.
- The highly publicized unemployment and underemployment of Ph.D.s made both national and state legislators reluctant to support graduate education.

COMPONENTS OF THE DEPARTMENTAL BUDGET

In developing our model of departmental functioning we took into account the many sources of income beyond federal support available to the sciences in a university. These included:

- Other outside sources of support for research. For example, the American Cancer Society has supported the research efforts of young biologists in some states.
- University support for "instruction and departmental research."
- Federal support itself is not a unitary item. We were particularly interested in the relationship of National Institutes of Health (NIH) funding to that from other sources.

One of our major goals in this study was to investigate the relationships among these different sources of departmental income. Did an increase in federal support of a department tend to attract other sources of funds?

BASIC STRUCTURAL CHARACTERISTICS

Certain distinctions between types of universities were built into all our analyses. Any examination of higher education must differentiate public universities from private institutions because their history, budgeting, and orientation are different.

The relationship between federal funding and development of the health-related sciences at a university clearly differs depending on whether the institution has a medical school. In fact, the entire budgetary structure of the institution is greatly affected by the presence or absence of a medical school and the presence or absence of a hospital.

We felt it would be an oversimplification to treat these two dichotomies as representing absolute distinctions between totally different categories of schools. For example, some public institutions may be almost indistinguishable from private schools in many respects and vice versa. In short, this distinction is really not a dichotomy but a continuum. We assumed that both public and private institutions would show a full range of variation on the other characteristics we were examining —i.e., we made no assumptions about financial or departmental variables because we knew whether an institution was public or private. One practical effect was that we conducted all analyses for public institutions only, private institutions only, and for all schools combined.

CENTRAL ISSUES EXAMINED IN THIS RESEARCH

The general issues discussed above were presented as specific questions for purposes of the proposal to the President's Biomedical Research Panel and were then incorporated in the contract for this study. The specific questions we addressed in our work are listed below:

A. Effects of Funding on Educational Programs
   1. What are the relationships between graduate enrollment in life science and behavioral science departments and federal biomedical funding?
   2. What are the relationships between federal biomedical (and related) funding and the rate of Ph.D. production by graduate life sciences and behavioral sciences departments?

B. Effects of Faculty Hiring and Compensation Policy
   1. What are the relationships between characteristics of faculty in life science and behavioral science departments and federal biomedical and related funding?

C. Changes in Funding
   1. What are the relationships between NIH/ADAMHA[a] funding to university departments and that from other sources?

We attempted to go beyond merely answering these questions to some of the more general issues discussed above. For example, there has been little rigorous research with longitudinal data relating trends in federal funding to changes in faculty size, enrollment, and Ph.D. production in the life sciences. However, a major hypothesis about graduate education during the past few years held that as funding ebbed leading departments reduced their enrollments and Ph.D. production while lesser schools continued to produce large numbers of doctorates, the net effect being a reduction in the quality of the Ph.D.s in the country. This hypothesis is based on a number of testable assertions, none of which have been examined in the life sciences. Specifically, to what degree has Ph.D. production at either level been affected by federal funding? (Policymakers in Washington often act as though graduate enrollments were strictly a function of federal support of students, and that if they cut back the support to students in a given field that will wipe out Ph.D. production in that field.) Our data provided an opportunity to test this assertion with multivariate techniques.

[a] Alcohol, Drug Abuse, and Mental Health Administration.

II. METHODS

As noted above, the methods for this study consisted of quantitative analyses of longitudinal data supplemented by field trips.

During the field trips we were able to examine the effects of federal funding on the full range of departments representing the life sciences, especially biology, both at the main campuses and at related health professional schools. We also examined psychology departments and other social science departments. However, in our quantitative analyses we were forced to draw some limits. Practical realities and theoretical considerations led us to reject the notion of analyses at the department level in favor of analyses at the discipline level. The biological sciences, in particular, are organized differently at every university. It would have been meaningless to analyze the relationship between federal funds to departments with identical titles—e.g., plant physiology—and, say, Ph.D. production in those departments. Many of the people who study plant physiology might be housed in a department with a different name—e.g., Division of Biology. Thus, we decided to work at a higher level of aggregation, the discipline known as "biological sciences." A practical factor in this decision was that many federal data items are collected only at the discipline level, presumably for the same reason. Some of the crucial variables we needed would not have been available at the department level. In the discussion of our quantitative work then, references to departments are, strictly speaking, references to disciplines.

In the quantitative analyses, further decisions were made as a function of the structure of the available federal data. Our most important data source was the NSF survey on federal expenditures. In the survey the life sciences are divided into four categories: biological sciences, agriculture, clinical medicine, and miscellaneous. Psychology is a separate discipline, not included in the life sciences. We chose to conduct our analyses for the fields of psychology and the biological sciences. Data on agriculture were not available from some of the other federal sources, although, as noted below, the financial agriculture data were merged with those of the biological sciences in the data we received. Our focus upon university departments precluded an interest in clinical medicine, which is located almost entirely in the medical school. In addition, the inclusion of this category within life sciences ruled out the possibility that we could conduct useful analyses of the higher level category "life sciences."

In short, we analyzed data on "psychology" and "biological sciences" in our quantitative analyses; we visited the full range of life and behavioral science departments in our field trips.

DATA FOR QUANTITATIVE ANALYSES

Longitudinal data on a series of indices of departmental structure and performance were deemed to be necessary for the quantitative analyses. Wherever possible, we assembled data on the time period 1964-1975. To study the concepts discussed above, it was necessary to draw upon several federal data sources. The subjects and the federal data sources are indicated below:

- Departmental teaching staff: NSF[1] manpower survey
- Ph.D. production: NCES[2] survey of earned degrees conferred
- Graduate enrollment: NCES enrollment survey
- Federal expenditures: NSF expenditure survey
- Federal institutional obligations: NSF CASE[3] survey
- NIH funding: NIH IMPAC file.

Assembling, merging, and cleaning these data, largely the responsibility of the American Council on Education,[4] was a Herculean task. The effort taught us a great deal about the inadequacies of data available on national graduate education and the technical obstacles that must be overcome to be able to conduct meaningful analysis of graduate education. Among those technical problems:

- There are inconsistencies from data source to data source in the definition of fields and disciplines;
- Some of the surveys are not conducted on an annual basis;
- Frequently the data gathered in early years was of poor quality;
- Federal agencies differ considerably in their treatment of information from multi-campus systems; there are inconsistencies in terms of whether data are aggregated for the entire system or reported by campus, when new branch campuses are identified, and so forth.

Several of the technical problems we encountered with these data had serious implications for the interpretation of our results. The National Science Foundation survey, which compiled information on federal expenditures, did not disaggregate expenditures in the biological sciences from those in agriculture during the earlier years. Consequently the figures for those two categories were combined in the financial data made available to us.[5] However, information from other federal agencies—e.g., on graduate enrollments in biology from the Office of Education—did not include data on agriculture. The net effect of this was to add noise to our analyses of the biological sciences, probably deflating the correlations observed there. This factor somewhat clouds our comparisons of the public and private sectors since federal expenditures for agriculture are for public institutions.

The federal data files—e.g., on enrollments, Ph.D.s. and expenditures—fail to separate data from the medical school from those items obtained from the main campus. For example, all biochemistry Ph.D.s, whether at the medical school or the main campus, will be reported as one datum for a given university. This factor seriously confounds comparisons of life science departments at universities without

[1] National Science Foundation.

[2] National Center for Educational Statistics of the Office of Education.

[3] Committee on Academic Science and Engineering.

[4] These data sources are described in detail in: Lyle H. Lanier and Ivars Zageris, *A Study of Financial and Educational Trends in Research Universities, with Special Reference to Federal Funding of Health-Related Research*, American Council on Education, 1976.

[5] The departments included by NSF in each category are: Biological Sciences (anatomy, biochemistry, biophysics, biogeography, ecology, embryology, entomology, genetics, immunology, microbiology, nutrition, parasitology, pathology, pharmacology, physical anthropology, physiology, botany, zoology,) and Agriculture (agricultural chemistry, agronomy, animal science, conservation, dairy science, plant science, range science, wildlife).

medical schools and main campus departments of universities that happen also to have medical schools.

FIELD TRIPS

The ten universities that we visited were selected to be a representative sample of the entire range of institutions receiving federal health-related research funds. Our primary criterion in selecting the sample was the total amount of federal R&D funds received by the university in FY 1971, which was the midpoint of the decade we were studying. This criterion was chosen so that we could compare the effects of recent changes in federal research policy on universities that have varying dependence on federal funds. The data were from the NSF CASE obligations survey.

Four other criteria were chosen to distinguish among universities according to basic institutional characteristics. A key criterion was whether the university was a public or private institution, since we wanted to explore how these kinds of schools may be affected differently by changes in federal policy.

A second criterion was whether the university had a medical school. Although this study was primarily concerned with life science departments in schools of arts and sciences, we wanted to explore possible ways that these departments are affected by the existence of a medical school in the same university.

A third criterion was the quality of the university's faculty in the life sciences, as ranked by Roose and Andersen.[6] We wanted our sample of universities to include institutions ranging in quality from "medium" to the highest level,[7] so that we could explore the extent to which differences in quality are tied to federal funding.

Finally, we wanted the sample of universities to be geographically distributed across the country. We defined four separate regions of the country (West, South, Central and East) and selected universities accordingly.

The actual sample of ten universities was drawn using a finite sample selection algorithm developed by Carl Morris of The Rand Corporation. This algorithm accepts both continuous and discrete variables as input to the selection of an efficient sample, where efficiency is measured in terms of the ability of the sample to separate the effect of the input variables on the characteristics to be studied. For example, one seeks to avoid a sample of five private universities without medical schools and five public universities with medical schools. The program accepts information on the relative importance of the input variables and allows constraints on the composition of the sample. The sample drawn is superior to both random and representative samples because a random sample will occasionally confound the effects to be studied, and both a random sample and a representative sample concentrate on the less interesting subpopulation of mediocre, poorly funded institutions.

In selecting the sample for the field trips we specified the following criteria and conditions:

[6] K. D. Roose and C. J. Andersen, *A Rating of Graduate Programs*, American Council on Education, Washington, D. C., 1970.

[7] We defined a university to be top-ranked if three or more of its biology departments were placed by Roose and Andersen in their distinguished category. We defined a university to be "medium" if two or less of its departments were in Roose and Andersen's top category but its departments fell in their middle category. Departments ranked by Roose and Andersen in the lowest sector (or unranked departments) tend not to receive federal research funds.

- Exactly five private and five public universities were to be selected, and university control was given very high weight.
- Whether the university had a medical school was a variable whose effect it was important to understand, so it was given a high weight.
- The level of federal funding was given a high weight, and and a parabolic term in federal funding was included so that the influence of funding would be observed at intermediate funding levels as well as extreme ones.
- Exactly six top-ranked and four middle-ranked universities were to be selected, and a medium weight was specified for faculty quality.
- At least one university was to be selected from each region of the country, with an informally imposed constraint that no region would be overrepresented.
- At least one university that had high faculty quality and a below-median level of federal funding was to be selected.
- At least one university that had been visited previously in the Rand study of medical schools was to be included.
- The sample had to include three schools that had previously been selected for early visits in this study.

Table 1 indicates the characteristics of the institutions selected for our field trip sample. In the interests of confidentiality the names of the ten universities have been omitted.

The field trips to universities were one to two day visits. Typically, the field trip team consisted of several members of the Rand project staff, an experienced higher education administrator, and a distinguished life scientist.[8] During the day, we conferred with key administrators at the university—e.g., the Vice President for Research, the President, the Graduate Dean—and interviewed department chairmen, senior faculty, junior faculty, and graduate students in those departments that received significant federal funds for health-related research. Interviews with administrators and scientists from medical schools and related health professional schools on the campus also were scheduled.

Each site visitor was given a list comprising the key issues that were to be examined during the visit:

1. In what areas of science did the most growth occur in this university during the 1960s? Why?
2. What had been the university's policies regarding the growth of the biological sciences with respect to priority areas of growth, faculty size, research productivity, types of new faculty sought?
3. What growth actually occurred in the biological sciences?
4. What was the role of federal funds in financing whatever development occurred in the biological sciences?
5. What are the administrative mechanisms through which research dollars are incorporated in the departmental budget?

[8] The field trip consultants are listed in Table 2. Their comments aided us greatly in drawing together the general observations presented in Section IV. However, the authors assume full responsibility for the statements in that section.

On our pilot field trip we joined forces with two colleagues, Bruce Smith of the Brookings Institution and Charles Kidd of the Association of American Universities, who are conducting a study of science in America's research universities.

Table 1

FIELD TRIP SAMPLE

School	Control	Medical School	Distinguished in Biology	Total Annual R&D Funds FY71* (in thousands)
1	Public	Yes	No	$10-15,000
2	Private	Yes	No	10-15,000
3	Public	No	No	< 5,000
4	Public	Yes	Yes	> 35,000
5	Public	No	Yes	10-15,000
6	Public	Yes	No	10-15,000
7	Private	No	Yes	10-15,000
8	Private	Yes	Yes	20-25,000
9	Private	No	Yes	< 5,000
10	Private	No	Yes	15-20,000

*These data indicate total federal obligations for R&D to the institution, including professional schools.

Table 2

FIELD TRIP CONSULTANTS

H. Vasken Aposhian
Department of Cell and Developmental Biology
University of Arizona

Glen F. Clanton
Deputy Provost and Dean for Planning
Vanderbilt University

Hans Laufer
The Biological Science Group
University of Connecticut

Louis Levin
Retired
Formerly National Science Foundation administrator

David McBride
Director, Office of Research & Project Administration
University of Rochester

John Millett
Vice President
Academy for Educational Development, Inc.

Meredith Runner
Department of Molecular, Cellular, and Developmental Biology
University of Colorado

Michael Useem
Department of Sociology
Boston University

6. What are, and have been, the trends in student enrollment in the biological sciences? How are these trends related to federal funding?
   a. Number of M.S. and Ph.D. students enrolled.
   b. Proportion supported by fellowships, research assistantships, teaching assistantships.
   c. Number of postdoctoral students.
   d. Undergraduate student enrollments—any consequences for the graduate program.
7. What proportion of the faculty is and has been tenured?
8. What are the current sources of outside support for research in the biological sciences besides the federal government—state government, private sources, etc.?
9. Are there any cost commitments to biology made by the university in earlier years that currently are creating budget problems?
10. Are there any serious imbalances in the biological science programs that have been caused by shifts in the pattern of federal funds? What mechanisms does the university have for restoring the balance in those groups—e.g., proportion of tenured faculty, ratio of faculty to graduate students?
11. Has the average time to the completion of the Ph.D. changed during the past ten years?
12. Have there been changes in the types of federal funding—grants versus contracts, ratio of research support to traineeships and fellowships?
13. What was the university policy regarding hard versus soft funding during the growth period?
14. What has been the effect upon this institution of shifts in federal policy with respect to investigator-initiated versus targeted research?
15. What observations can the faculty and administrators in this institution contribute about the current peer review controversy?
16. What is the institutional attitude toward the present federal percentage of levels of, restrictions on, and administrative procedures relative to indirect cost reimbursements?
17. How are indirect costs handled adminstratively within the institution?

We found that we were able to answer some of these questions more fully than others.

III. RESULTS: QUANTITATIVE ANALYSIS

We began our analyses by examining the basic questions from the contract one by one. Our study of the relationship of federal funds to each dependent variable—e.g. Ph.D. production—required elaborating a multivariate model of the determinants of that phenomenon alone.

In the work reported below we were conducting cross-sectional analyses aimed at uncovering the unique association between federal funding and each of the departmental indices. We did this for different sectors of higher education, such as public and private, and for different years during the past decade. However, these were not causal analyses, and causal inferences should be drawn from these results only with the utmost caution. For example, we report a significant association between federal funding of biology departments and the rate of Ph.D. production by those departments in 1974. The regression coefficient indicates that, even when other factors affecting Ph.D. production are considered, $1 million of federal funding at a university was associated with approximately one extra Ph.D. produced during 1974. This means that those schools with extra money produced extra Ph.D.s, when the effects of other factors such as enrollment were controlled for. It does not *necessarily* mean that a school would produce one extra Ph.D. if it were to be given an additional $1 million in the forthcoming year.

In short, our goal was to isolate the unique associations of federal funding with various departmental parameters in a cross-sectional analysis and to compare the strength of those associations in different types of institutions.

A MODEL OF DEPARTMENTAL FUNCTIONING

In addition to exploring predictors of Ph.D. production, graduate enrollment, and department size, we postulated that they were linked. An academic department, like any other complex system, consists of a network of interdependent structural units and functions. Through our analyses, which focused on federal funding, we hoped to elaborate and refine a model of these complex interactions. Figure 1 portrays the network of relationships implicit in those multivariate analyses. Note that in addition to the direct effect federal funding has upon Ph.D. production, it has an indirect effect through its influence upon graduate enrollment and faculty size.

Ph.D. PRODUCTION

Perhaps no other indicator has had as much effect during this period of crisis for graduate education as the rate at which Ph.D.s are produced by the nation's graduate schools. In the mid-1960s, national support for graduate education was at its height, and most experts were predicting a shortage of Ph.D.s through the next decade. Economist Allan Cartter, however, took a different view. His analyses and projections indicated that the future demand for Ph.D.s would not be likely to exceed the supply. As a partial explanation of the differences between his conclusions and

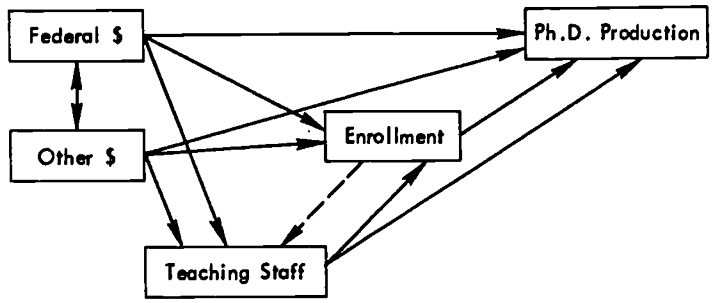

Fig. 1—Proposed model of departmental functioning

those of other specialists, Cartter noted that "educational researchers in government agencies had collected the wrong information for many years and had drawn hasty conclusions from imperfect data."[1] He was one of the first, if not the first, to predict an oversupply of Ph.D.s beginning in the 1970s. For example, in 1972 he stated: "We are on a course which would result in one-third too many Ph.D.s produced in the latter part of this decade and perhaps one-half too many in the 1980s for the types of employment we have known in the past."[2]

In light of the accuracy of his early projections, Cartter's work has received a good deal of attention. But he is not without critics. For example, Vaughn and Sjoberg have considered some of Cartter's assumptions and have given a number of reasons for viewing his projections with some skepticism. They charge that Cartter "ignores fundamental social changes already underway within American society, changes that are likely to erode the very basis of his projections."[3] They argue that basic shifts in the nature of the American economy will lead a larger number of people to seek higher education than Cartter had assumed. The emerging primacy of the service sector in the economy implies a greater reliance on advanced education, as does the increase in leisure time and the growing demands of women, minorities, and others for advanced education on a part-time or full-time basis.

While national policymakers have been responding slowly to this problem, a number of states have taken direct action. Foremost among these is New York, where the State Board of Regents is invested with considerable authority over both public and private education. Three years ago, a report recommended that the number of doctoral-producing programs be reduced, citing, among other factors, the overproduction of Ph.D.s by the state's higher education institutions.[4] A special study was commissioned to review and evaluate the adequacy of doctoral programs on a field-by-field basis, and to make recommendations about which ones should be abolished and which strengthened.[5]

[1] Allan M. Cartter, "A New Look at the Supply of College Teachers," *Educational Record*, Vol. 46, Summer 1965, pp. 267-277.

[2] Allan M. Cartter, "Scientific Manpower of 1970-85," *Science*, April 9, 1972, p. 243.

[3] Ted R. Vaughan and Gideon Sjoberg, "The Politics of Projection: A Critique of Cartter's Analysis," *Science*, July 14, 1972, p. 142.

[4] "Meeting the Needs of Doctoral Education in New York State," New York Board of Regents, Commission on Doctoral Education, Albany, New York, January 1973.

[5] Decisions by the state to eliminate two doctoral programs at the State University of New York, Albany campus as a result of that study recently have been contested by SUNY trustees in a New York Supreme Court action. See "SUNY Challenges Right of State to Curb Courses," *The Chronicle of Higher Education*, March 8, 1976, p. 3.

The growth of graduate education during the 1960s occurred at different rates in different sectors of the academic world. For example, as Kidd has noted, over the decade doctoral production in the top 30 private universities dropped from 39 percent to 27 percent of the total of all doctorates produced, whereas in the public universities below the top 30, it increased from 9 percent to 24 percent. Overall Ph.D. production tripled between 1960 (10,000) and 1969 (30,000). Among the reasons Kidd notes for the differential growth rates of different types of institutions are the steep increases in state budgets for support of state institutions in the 1960s, the greater expansion of public universities in every aspect, and the pressure to provide teaching assistants for the rapidly growing undergraduate population at public universities.[6]

Such observations as these about the differential growth rates of public and private institutions have led some observers to argue that Ph.D. output should be limited to elite institutions.[7] Ph.D. production is often seen to be an indication of graduate quality. For example, Cartter used a measure of doctorate production as the key criterion for inclusion of schools and programs to be assessed in his ratings; Roose and Andersen, in their replication of his study, followed this lead.

To trace the effects of federal funds (F) upon Ph.D. production, we built a model specifying other departmental factors that might have a bearing on this index:

- Departmental graduate enrollment (E);
- Faculty size, in this case our measure of teaching staff (T);
- Control—i.e., whether the institution was public or private (C);
- Whether the institution contained a medical school (M);
- Other outside sources of support of the department, including private and state sources (O).

The equation relating these variables to Ph.D. production (P) is shown below.

$$P_t = B_1E_{t-j} + B_2T_{t-k} + B_3C + B_4M + B_5O_{t-1} + B_6F_{t-m} .$$

Prediction of Ph.D. production in year t is a function of each variable measured in that or a previous year. The lags for each variable were determined as follows. The zero-order Pearson product-moment correlation between a dependent variable at year t and the independent variable at year t, t−1, t−2, and t−3 were examined and the year associated with the highest correlation selected. (This determination was based on the total sample; separate lags were not created for each subgroup—e.g., private institutions only.)

In our analyses we constructed the above equation for each year from 1969 to 1974. We examined the results to answer four questions:

1. How successful was the model in accounting for Ph.D. production? In other words, what percent of the variance in this index was explained by the model?
2. In a given year, what was the relative contribution of each of the independent variables in the model?

[6] Charles V. Kidd, "Shifts in Doctoral Output: History and Outlook," *Science*. February 9, 1973, pp. 538-543.

[7] John R. Niland, "Allocation of Ph.D. Manpower in the Academic Labor Market," *Industrial Relations*. Vol. II, No. 2, May 1972, pp. 141-156.

3. How significant was the association of federal funding, our key variable, with Ph.D. production?
4. Did the importance of federal support vary across the different sectors of higher education?

Table 3 indicates the success of the model in predicting Ph.D. production in the biological sciences; Table 4 presents similar information for psychology. The results are presented for all institutions, public only, private only, universities with medical schools, those without medical schools, and for each of the leading three categories of universities as defined by the Carnegie Commission on Higher Education.[8]

Table 3

PREDICTION OF PH.D. PRODUCTION IN THE BIOLOGICAL SCIENCES
(R^2 = Percentage of Variance Explained)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	.88	.82	.85	.88	.90	.85
Public	9[illegible]	.95	.85	.91	.91	.90	.89
Private	55	.80	.78	.85	.89	.90	.74
With Medical School	68	.84	.74	.84	.86	.90	.79
Without Medical School	80	.92	.89	.88	.92	.89	.97
Research Universities 1	49	.87	.77	.81	.85	.88	.77
Research Universities 2	40	.88	.67	.72	.87	.77	.75
Doctoral Granting Universities	47	.78	.59	.60	.63	.61	.72

Table 4

PREDICTION OF PH.D. PRODUCTION IN PSYCHOLOGY
(R^2 = Percentage of Variance Explained)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	.84	.80	.66	.62	.66	.65
Public	93	.94	.86	.69	.73	.80	.72
Private	55	.78	.61	.61	.39	.50	.58
With Medical School	68	.83	.76	.64	.58	.58	.59
Without Medical School	80	.91	.83	.73	.74	.75	.71
Research Universities 1	49	.94	.81	.81	.65	.76	.61
Research Universities 2	40	.86	.77	.56	.57	.65	.75
Doctoral Granting Universities	47	.83	.71	.49	.45	.64	.57

[8] Statistical considerations—some missing observations combined with small sample sizes—led us to reject groupings based on combinations of the structural variables (e.g., private institutions with medical schools, private institutions without medical schools).

In biology the model accounted for 82 percent to 90 percent of the variance, depending on the year. The model was more successful in predicting Ph.D. production for public institutions than private, and for those without medical schools than those with medical schools. The R^2 tended to be somewhat higher for Research Universities 1 than for the lower two Carnegie categories.

In psychology the model accounted for between 62 percent and 84 percent of the variance, depending on the year. Again it was more successful in universities that were public, had no medical school, and fell in the leading Carnegie category.

We next examined the relative contribution of each of the variables in the model. The 1974 equation for each discipline based on all institutions is given below. The coefficients are standardized; those that are significant at the .05 level are indicated with an a and at the .01 level with a b.

Biological Sciences:

$$P = .81^{b}E - .05T + .08^{a}C + .00M + .09O + .17^{b}F.$$

Psychology:

$$P = .64^{b}E - .06T + .04C + .11M - .04O + .32^{b}F.$$

In both fields enrollment was the largest determinant of the rate of Ph.D. production. However, in both fields, federal funding was the next most important factor; in each case the coefficient for federal funding is significant at the .01 level.[9]

A comparison of the importance of federal funding across different types of universities with respect to Ph.D. production, enrollment, and faculty size is reported below.

ENROLLMENTS

A model of factors that were hypothesized to affect enrollment for advanced degrees—i.e., graduate enrollment (E)—was developed and used in multivariate analyses aimed at uncovering the unique effect of federal funds upon graduate enrollment. The following variables were included:

- Faculty size—i.e., full-time teaching staff (T);
- Whether the institution was public or private (C);
- Whether the institution has a medical school (M);
- Federal expenditures in the discipline (F);
- Other outside sources of support of the discipline (O).

These variables were combined in a multiple regression model as follows:

$$E_t = B_1T_{t-j} + B_2C + B_3M + B_4O_{t-k} + B_5F_{t-i}$$

As before, the lag for each independent variable was determined through inspection of the Pearson product-moment correlations between the dependent and the

[9] The reader should note that the coefficient for federal funding indicates the *direct* effects of funding upon Ph.D. production, given a certain enrollment, faculty size, etc. The indirect effects of federal funding through the effect of funding upon enrollment or upon faculty size are not reflected in the coefficient for federal funding. Thus, the total funding effect upon Ph.D. production, both indirect and direct, is substantially larger than indicated by this coefficient.

independent variable measured in the same year and each of the three previous years; the year associated with the largest of the four zero-order correlations was selected. In order to explore the nature of the different relationships for public institutions versus private institutions, and those with medical schools versus those without, we ran separate regressions for each of those four subgroups.

Tables 5 and 6 indicate the success of this model in explaining the variation in graduate enrollment in the biological sciences and psychology. In both fields, the explanatory power of the model is substantial but not as great as it had been for Ph.D. production. In both fields, enrollment can be predicted better at public institutions than at private. In biology the model does better at universities without a medical school and at those in the second Carnegie category. In psychology the model predicts enrollment better for universities with a medical school and those in the leading Carnegie category. For psychology the explanatory power of the model improves in the more recent years.

Table 5

PREDICTION OF GRADUATE ENROLLMENT IN THE BIOLOGICAL SCIENCES
(R^2 = Percentage of Variance Explained)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	.57	.59	.57	.53	.56	-
Public	93	.63	.67	.64	.66	.74	-
Private	55	.57	.57	.62	.54	.48	-
With Medical School	68	.56	.55	.49	.41	.47	-
Without Medical School	80	.59	.62	.67	.78	.77	-
Research Universities 1	49	.35	.42	.45	.43	.42	-
Research Universities 2	40	.64	.67	.72	.67	.72	-
Doctoral Granting Universities	47	.62	.30	.33	.36	.26	-

Table 6

PREDICTION OF GRADUATE ENROLLMENT IN PSYCHOLOGY
(R^2 = Percentage of Variance Explained)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	.39	.39	.58	.65	.63	-
Public	93	.37	.37	.62	.73	.72	-
Private	55	.36	.50	.39	.35	.31	-
With Medical School	68	.37	.42	.73	.74	.60	-
Without Medical School	80	.41	.30	.49	.52	.65	-
Research Universities 1	49	.51	.53	.86	.79	.76	-
Research Universities 2	40	.16	.13	.60	.49	.41	-
Doctoral Granting Universities	47	.54	.41	.34	.54	.45	-

The equations for the most recent year, 1973, generated by these multivariate analyses to predict graduate enrollment are presented below. As before, the coefficients are standardized; the sample consists of all institutions.

Biological Sciences:

$$E = .29^{b}T - .23^{b}C + .14^{a}M + .24^{b}O + .30^{b}F.$$

Psychology:

$$E = .76^{b}T - .02C + .04M - .01O + .05F.$$

In biology federal funds have a statistically significant effect on enrollment; this factor is more important than any other (although faculty size has almost as strong a coefficient).[10]

Federal funds do not appear to be significantly associated with enrollments in psychology. However, this finding may be the result of two factors in combination: the large number of masters candidates in psychology and that masters and Ph.D. candidates are lumped together in the available federal data.

DEPARTMENT SIZE

As noted earlier, department size was measured by the National Science Foundation manpower survey; we took the index of full-time scientists and engineers engaged in teaching. We then built a model in which the following factors were hypothesized to determine department size:

- Type of control—i.e., public or private (C);
- The presence of a medical school (M);
- Federal funds to the discipline (F);
- Other outside sources of support of the discipline (O);

The multivariate equation relating these structural and financial variables to the dependent variable, size of department teaching staff (T), is given below:

$$T_t = B_1C + B_2M + B_3O_{t-j} + B_4F_{t-k}.$$

Tables 7 and 8 present information indicating the degree to which this model explained the variation in teaching faculty for the biological sciences and psychology. The R^2 statistics are lower than those for the previous two departmental indices. Note that our model as summarized in Fig. 1 postulated fewer determinants for faculty size than for the student variables.

In biology the model fits better for universities without medical schools than for those with medical schools. In psychology the model does somewhat better in institutions that are private and those that have medical schools.

The analysis of data for all institutions in 1975 yielded the following regression equations for the two fields:

[10] The funding coefficient reported here indicates only the direct effect of funding upon enrollments, given a certain faculty size. The indirect effect of funding on enrollment through its effect on faculty size is not reflected in this funding coefficient. Consequently, the net effect, both direct and indirect, is larger than that indicated by the coefficient.

Table 7

PREDICTION OF TEACHING MANPOWER IN THE BIOLOGICAL SCIENCES
(R^2 = Percentage of Variance Explained)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	.30	-	.41	-	.31	.37
Public	93	.32	-	.54	-	.22	.35
Private	55	.32	-	.40	-	.46	.41
With Medical School	68	.16	-	.29	-	.21	.28
Without Medical School	80	.46	-	.51	-	.33	.43
Research Universities 1	49	.08	-	.19	-	.17	.19
Research Universities 2	40	.47	-	.39	-	.47	.42
Doctoral Granting Universities	47	.42	-	.61	-	.43	.36

Table 8

PREDICTION OF TEACHING MANPOWER IN PSYCHOLOGY
(R^2 = Percentage of Variance Explained)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	.23	-	.27	-	.32	.27
Public	93	.16	-	.26	-	.31	.21
Private	55	.38	-	.33	-	.30	.61
With Medical School	68	.22	-	.41	-	.46	.37
Without Medical School	80	.23	-	.20	-	.19	.20
Research Universities 1	49	.21	-	.29	-	.38	.30
Research Universities 2	40	.28	-	.38	-	.30	.38
Doctoral Granting Universities	47	.14	-	.06	-	.08	.10

Biological Sciences:

$$T = -.14C + .26^{b}M + .02O + .48^{b}F.$$

Psychology:

$$T = -.31^{b}C + .10M - .04O + .41^{b}F.$$

In each field the coefficient for federal funds is statistically significant at the .01 level. Furthermore, in each case it is the most powerful determinant of faculty size.[11]

[11] In the construction of our model, a particular problem was posed by the relationship between faculty size and enrollment. Those familiar with graduate education know that, to a certain degree, these two indices are interdependent; further, the relationship between the two is different in the public institutions than in the private. However, to postulate each as a determinant of the other would have created a model that was statistically and logically unresolvable. On the basis of previous research, the literature about graduate education, our field trips, and substantial accumulated knowledge about the functioning

While the NSF manpower data were the best available sources of longitudinal information about faculty size, some technical problems should be noted. Both postdoctorals and residents are included as well as faculty. We used that subset of full-time manpower in the department "primarily employed" in teaching. Certain obvious ambiguities exist in differentiating those faculty primarily engaged in teaching from those primarily engaged in research. In fact, some universities, especially public institutions that are struggling with their legislatures, insist on reporting all faculty in the teaching staff column.

As a check on these problems we coded faculty size data from the American Council on Education quadrennial, *American Universities and Colleges*. Here, too, there were some technical problems: faculty size data were available for only two academic years—1966-67 and 1970-71—and the categorization of departments from school to school was ambiguous and inconsistent. We then repeated those biological science analyses in which faculty size was predicted or was used as a predictor, substituting the ACE measure. We found we were able to predict this new faculty size measure at about the same level as before and that group comparisons of the relationship between manpower and federal funding remained the same. Similarly, our ability to predict Ph.D. production remained the same when we used the new faculty size variable; our ability to predict graduate enrollment improved very slightly.

COMPARISON OF DIFFERENT TYPES OF INSTITUTIONS

In the sections above we assessed the adequacy of our model in explaining the variation in each of three indices of departmental structure and function. In addition we determined whether federal funding was a significant factor in estimating each criterion and compared its predictive power with that of the other variables in the model. A related question is how the effects of federal funding vary across different sectors of higher education. In Tables 9-14 unstandardized regression coefficients representing the relationship between (a million dollars of) federal funding and each of the three indices in each field are presented for the following subgroups within higher education:

- Public or private;
- Universities with medical schools and those without medical schools;
- Each of the three leading Carnegie Commission categories.

By using these subsamples we hoped to examine interaction effects and thus to trace the unique configurations associated with type of control and presence of a

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of academic life sciences departments, we postulated faculty size as a determinant of enrollment, not vice versa.

In this chicken-egg problem, it is clear that federal funding nourishes both. To the degree that prior enrollment (for example, in public institutions) is a determinant of faculty size, the equations reported in this section may somewhat overestimate the federal funding coefficient. Conversely, had faculty size not been postulated as a determinant of enrollment it is likely that the coefficients for predicting enrollment on the basis of funding would have been larger. However, examination of our results indicated that this factor would not have changed the direction of the comparisons we report between public and private institutions.

Table 9

RELATIONSHIP OF FEDERAL FUNDING TO PH.D. PRODUCTION IN THE BIOLOGICAL SCIENCES

(Unstandardized Regression Coefficients)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	2.07[b]	.81	2.04[b]	1.20[b]	1.18[b]	.98[b]
Public	93	.79	.42	1.55	.85	1.65[b]	1.26[b]
Private	55	2.64[b]	1.87[b]	3.22[b]	2.51[b]	.77[b]	.98[a]
With Medical School	68	2.36[b]	.81	2.37[b]	.74	.91[b]	.91[a]
Without Medical School	80	2.88[b]	1.12	1.15	2.50[b]	1.94[b]	-.42
Research Universities 1	49	2.31[b]	.33	1.87[a]	1.13	1.43[b]	.92
Research Universities 2	40	3.46[b]	3.18	2.55	-1.52	.00	2.29
Doctoral Granting Universities	47	1.37	3.35	.76	3.10	1.44	.00

[a]Coefficient significant at .05 level.

[b]Coefficient significant at .01 level.

Table 10

RELATIONSHIP OF FEDERAL FUNDING TO ENROLLMENT IN THE BIOLOGICAL SCIENCES

(Unstandardized Regression Coefficients)

	N	1969	1970	1971	1972	1973
All Institutions	148	26.72[b]	30.10[b]	25.67[b]	17.53[b]	13.08[b]
Public	93	34.65[b]	42.30[b]	31.93[b]	18.42[b]	14.13[b]
Private	55	14.04[a]	15.23[a]	16.34[b]	15.98[b]	8.90[a]
With Medical School	68	24.11[b]	29.09[b]	24.57[b]	13.60[a]	9.28
Without Medical School	80	27.83[a]	29.87[b]	25.27[b]	25.76[b]	26.94[b]
Research Universities 1	49	19.30	21.93[a]	18.41	9.85	9.20
Research Universities 2	40	35.66[b]	30.97[a]	18.34	18.26	6.69
Doctoral Granting Universities	47	-15.27	13.61	-16.73	-17.92	-19.92

[a]Coefficient significant at .05 level.

[b]Coefficient significant at .01 level.

Table 11

RELATIONSHIP OF FEDERAL FUNDING TO TEACHING MANPOWER IN THE BIOLOGICAL SCIENCES

(Unstandardized Regression Coefficients)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	12.10[b]	-	13.03[b]	-	6.83[b]	8.20[b]
Public	93	9.52[b]	-	15.76[b]	-	3.24	6.46[b]
Private	55	13.37[b]	-	9.49[b]	-	12.11[b]	9.33[b]
With Medical School	68	11.57[b]	-	12.61[b]	-	6.98[a]	9.70[b]
Without Medical School	80	15.06[b]	-	14.61[b]	-	6.38[b]	6.40[b]
Research Universities 1	49	7.37	-	11.40[b]	-	6.24	7.57[a]
Research Universities 2	40	7.63	-	12.30[a]	-	18.10[b]	12.79[b]
Doctoral Granting Universities	47	1.53	-	29.23[b]	-	-4.48	1.50

[a]Coefficient significant at .05 level.

[b]Coefficient significant at .01 level.

Table 12

RELATIONSHIP OF FEDERAL FUNDING TO PH.D. PRODUCTION IN PSYCHOLOGY

(Unstandardized Regression Coefficients)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	1.72	- .42	5.53[b]	1.45	4.14[a]	6.72[b]
Public	93	.41	.00	7.18[a]	2.05	5.27[b]	7.43[b]
Private	55	7.07[a]	- .71	3.59	.73	2.10	-5.91
With Medical School	68	4.12	- .75	4.21	2.13	3.49	7.49[b]
Without Medical School	80	2.95[a]	1.89	11.89[b]	3.33	4.74	5.23[a]
Research Universities 1	49	4.24[b]	-2.89	.50	-1.39	.00	3.67
Research Universities 2	40	1.24	- .86	5.99	.00	5.72	6.47
Doctoral Granting Universities	47	.00	-4.96	.00	4.14	6.98	2.77

[a]Coefficient significant at .05 level.

[b]Coefficient significant at .01 level.

Table 13

RELATIONSHIP OF FEDERAL FUNDING TO ENROLLMENT IN PSYCHOLOGY

(Unstandardized Regression Coefficients)

	N	1969	1970	1971	1972	1973
All Institutions	148	- 24.07	-11.79	- 41.30[a]	- 5.97	8.54
Public	93	- 35.81	- 7.60	- 56.16[a]	-15.45	3.78
Private	55	8.38	-86.93[b]	- 34.82	- 7.51	.00
With Medical School	68	- 36.27	- 7.49	-103.46[b]	-11.89	8.72
Without Medical School	80	- 9.30	- 9.49	- 10.86	.00	16.06
Research Universities 1	49	- 14.52	3.28	.00	- 2.14	.00
Research Universities 2	40	- 30.19	-11.82	-180.72[a]	-25.13	30.92
Doctoral Granting Universities	47	-148.89	-57.27	6.30	- 7.84	43.44

[a]Coefficient significant at .05 level.

[b]Coefficient significant at .01 level.

Table 14

RELATIONSHIP OF FEDERAL FUNDING TO TEACHING MANPOWER IN PSYCHOLOGY

(Unstandardized Regression Coefficients)

	N	1969	1970	1971	1972	1973	1974
All Institutions	148	16.44[b]	-	22.15[b]	-	18.57[b]	15.31[b]
Public	93	17.02[b]	-	29.35[b]	-	15.62[b]	10.89[a]
Private	55	16.65[b]	-	9.10	-	22.47[b]	25.09[b]
With Medical School	68	18.41[b]	-	16.11[b]	-	14.79[b]	9.49[a]
Without Medical School	80	16.80[b]	-	32.40[b]	-	22.76[b]	14.30
Research Universities 1	49	18.62[a]	-	14.50	-	14.47[b]	9.44
Research Universities 2	40	9.15	-	25.97[a]	-	29.53[a]	28.55
Doctoral Granting Universities	47	2.40	-	-9.62	-	17.80	10.11

[a]Coefficient significant at .05 level.

[b]Coefficient significant at .01 level.

medical school (beyond the effects reflected in their coefficients when they were represented above as dummy dichotomous variables above).[12]

We included the Carnegie groupings to test some hypotheses that have been proposed about the distribution of scientific resources among the universities in this country. The concentration of federal support in a limited set of institutions that tend to be clustered geographically has been a persistent political issue for at least 15 years. A major 1960 report of the President's Science Advisory Committee, known as the Seaborg Committee (after Glenn T. Seaborg, Chancellor of the University of California, Berkeley, and chairman of the committee) recommended, "over the next 15 years the United States should seek to double the number of universities doing generally excellent work in basic research and graduate education.[13] Among other things, concern about this issue led to the creation of the NSF Science Development Program of the 1960s, sometimes referred to as the "Centers of Excellence" grants. This program flourished during President Johnson's administration and was consistent with his philosophy of geographic diffusion of funds. In fact a 1965 executive order on that subject was closely tied to the dispersal of NSF funds for Science Development. During the more recent period of retrenchment in graduate education, one of the national debates has been whether limited resources should be distributed widely or reserved for only elite institutions.

In the wake of the crisis that hit graduate education, it frequently was asserted that the elite leading universities were "responsibly" reducing their graduate enrollments and Ph.D. production while "lesser" institutions continued to confer doctorates at a lively rate. This particular theory stated that the result would be a reduction in the quality of the Ph.D.s produced nationally, the implicit assumption being that better quality Ph.D.s are generated by the leading institutions.[14] Perhaps the most eloquent expression of this fear was contained in the highly publicized Newman report on graduate education.[15] All of these assertions are subject to empirical test and have not been examined previously for the life sciences. It seemed to us that the key test of these hypotheses required use of the multivariate conceptual model we have elaborated here. That is, the central question is not the number

[12] In the equations for public institutions and for private institutions the dichotomy about medical schools was retained; similarly, in the equation for the two medical school groups the dichotomy about type of control was included. Both dichotomies were included in the equations for the Carnegie groupings.

[13] President's Science Advisory Committee, *Scientific Progress, the Universities, and the Federal Government*, The White House, Washington, D.C., November 1960, p. 28.

[14] The most widely used assessments of graduate departments were two studies conducted by the American Council on Education. (A. M. Cartter, *An Assessment of Quality in Graduate Education*, American Council on Education, Washington, D.C., 1966; and K. D. Roose and C. J. Andersen, *A Rating of Graduate Programs*, American Council on Education, Washington, D.C., 1970.) These evaluations, based on peer ratings of the quality of graduate faculty, not only have been widely used to establish an academic pecking order but also have become points of reference among federal officials, university administrators, and scientists to infer growth and change in the capabilities of specific science departments.

Several investigators have addressed themselves to discovering the objective correlates of the (subjective) ACE ratings. David Drew and Ronald Karpf ("Evaluating Science Departments: A New Index," The Rand Corporation, P-5521, Santa Monica, California, October 1975) tested a number of objective indices and found that rate of publication in key journals predicted the ACE quality rating almost perfectly—i.e., with a correlation of .91. Their findings confirm the results of some prior investigations that indicated the ACE rankings favored larger departments, a failing that would be corrected by the use of per-person indicators. In addition, they note the great need for an effective means of assessing the quality of teaching in a department.

[15] U.S. Department of Health, Education, and Welfare, *Report on Higher Education: The Federal Role—Graduate Education*. Frank Newman, Chairman, Washington, D.C., 1973.

of Ph.D.s or the enrollments of leading and less outstanding institutions, but rather how sensitive these indices are to federal funds in both categories of schools. Consequently, we conducted these analyses to test the effects of federal funds upon doctorate production, graduate enrollment, and manpower—i.e., teaching staff—in the three categories of institutions that constituted the bulk—i.e., all but thirteen universities—of our sample:

- Those institutions listed as "Research Universities 1" by the Carnegie Commission on Higher Education
- Those universities listed as "Research Universities 2"
- Those universities listed as "Doctoral Granting Universities 1"

Of the remaining 13 institutions, nine had been selected for the full sample because they had medical schools; four others were parts of multi-campus universities.

Numbers within a column in Tables 9-14 are comparable such that the criterion can be compared directly across sectors of institutions. The superscript provides a preliminary indication as to whether the coefficient represents a statistically significant relationship. The significant coefficients then can be read as reflecting the increment in, for example, Ph.D. production uniquely associated with a million dollars additional federal funding, independent of all other variables in the model.

Examination of these tables reveals a mixed profile with respect to type of institutional control. Graduate enrollments in biology consistently were more closely tied to federal funds in the public than in the private sector (Table 10). In addition, the association of funding with enrollments declined over time in both sectors, but the drop occurred sooner in the state institutions. Thus, the time of responsiveness to funding changes may vary between the public and the private domains.

Ph.D. production in both fields exhibited a stronger tie to federal funds in the private sector during the early years and in the public sector during the later years. (Tables 9 and 12).[16]

In the more recent years, faculty size has been more associated with federal funds in private institutions that at the state schools (Tables 11 and 14).

The presence or absence of a medical school had no consistent relationship to the effect of federal funds. However, as noted earlier, our analysis of this factor was greatly hampered by limitations in the available federal data. It was impossible to isolate, for example, graduate enrollments in a basic science at the main campus from those at the medical school.

The direct effects of federal funds did not vary substantially between leading research universities and doctoral granting institutions. Furthermore, funding, enrollment and Ph.D. trend data on biology and psychology revealed very similar patterns for the leading and lower-ranked institutions. This analysis, of course, is *not* a test of whether leading and lesser universities respond differently to *job market* trends but is limited to the direct effects of *federal funding*.

While formal control was included as a control variable, sample size limitations precluded analysis of funding effects differentially by type of control *and* level of institution. The few leading-lesser differences evident in these tables may reflect public-private variation at the two levels of quality.

[16] One reviewer of this report, Donald Stewart, commented that this finding jibes with an observation made in a research project being conducted by Martin Myerson and colleagues that the past decade has witnessed the overtaking of the private universities by the public institutions. These structural changes in higher education may be reflected in the statistics reported here. Martin Meyerson et al., *The Future of Research Universities*, forthcoming.

CUMULATIVE EFFECTS OF FEDERAL FUNDING

The analyses reported above focused on the direct effects of federal funding upon Ph.D. production and enrollment. In addition, as indicated in Fig. 1 above, funding has an indirect effect on each through its effect on faculty size and has additional indirect effects on Ph.D. production through enrollment. In our next analysis, the combined direct plus indirect effects of federal funding on Ph.D. production and enrollment were calculated for the most recent year. These results provide the best estimate from these data of the current cumulative federal effect on each of these variables. (Note that the model postulates no indirect effects of federal funding on faculty size through mediating variables.) Table 15 presents those results for the biological sciences. Of course, the cumulative effect of federal funding exceeds the direct effect. Note that the direction of the differences between types of institutions —e.g., public or private—remains unchanged.

Perhaps the most interesting finding in the table are for the three Carnegie categories. Enrollment levels in leading institutions are not tied to federal funds. No difference among the Carnegie levels is found in the link between enrollment and funding. However, the group of institutions at which federal funding is most closely tied to Ph.D. production may not be the institutions represented by the Carnegie categories "Research Universities 1" and "Doctoral Granting Institutions 1." They may be those universities in the intermediate "Research Universities 2" category.

Table 15

CUMULATIVE FEDERAL FUNDING EFFECTS IN THE BIOLOGICAL SCIENCES

(Unstandardized Regression Coefficients)

	N	Graduate Enrollment 1973	Ph.D. Production 1974
All Institutions	148	18.07[b]	2.78[b]
Public	93	23.63[b]	3.63[b]
Private	55	11.74[b]	2.12[b]
With Medical School	68	12.94[b]	2.20[b]
Without Medical School	80	36.29[b]	4.71[b]
Research Universities 1	49	10.75	1.94[a]
Research Universities 2	40	16.58	4.58[b]
Doctoral Granting Universities	47	-6.39	-.17

[a]Coefficient significant at .05 level.

[b]Coefficient significant at .01 level.

RELATIONSHIPS BETWEEN FEDERAL SUPPORT AND OTHER SOURCES OF DEPARTMENTAL INCOME

In the above discussion, we included both federal support of each discipline and nonfederal outside support. The latter category comprises both private and state funds for research. Additionally, we retrieved data from the NSF expenditure survey on "departmental research and instruction," the internal university funds for the discipline. The NSF data were available only for the aggregate category "life sciences"—which contains biology, agriculture, clinical medical fields, and a miscellaneous category—and psychology; consequently, the statistics reported in this section are for those two discipline categories.

A final financial datum was the total flow of NIH research money to the discipline as retrieved from NIH's "IMPAC" file on awards.

We wanted to study the relationships among these various sources of departmental income over time.[17] Do other nonfederal outside funds for research follow federal funds? Is the pattern of NIH support over time parallel to that for all federal support?[18]

The trends in each of these financial indices over the past decade are presented for each category of institution in Tables 16 and 17 (life sciences) and Tables 18 and 19 (psychology).[19] Examination of these tables reveals considerable information about the flow of dollars to the academic research and instruction efforts during the past decade.

Federal and nonfederal funds appear to vary in parallel patterns, a phenomenon that could result from a number of causes. However, these simple trend data do not support the notion that one federal dollar is seed money for the attraction of several nonfederal dollars.

A special analysis was conducted to test the degree to which an *increase* in federal funds in a given year is tied to an *increase* in nonfederal funds in a subsequent year. Specifically, the change in federal funds to the biological sciences between 1972 and 1973 was correlated with the change in nonfederal funds from 1973 to 1974. The partial correlation (i.e., federal 1973 with nonfederal 1974 controlling for federal 1972 and nonfederal 1973) was not significant. This finding also does not support the idea that federal funds seed nonfederal. The partial correlation for public universities only also was not significant. Surprisingly, the partial correlation for private institutions was significant but *negative*. Although this is difficult to interpret, it may indicate a zero-sum situation in which a dollar of federal money

[17] Balderston has commented on some inherent problems in this type of investigation: "These funding agencies often wish to ensure that funds awarded are used for the purpose agreed, which is something that adequate financial stewardship and grant administration by the university can cope with up to a point. But, as several components of funding are used to support intertwined activities, funding agencies can never be quite certain that they are getting what they think they are for their money." F. E. Balderston, "Difficulties in Cost Analysis of Graduate Education," in National Board on Graduate Education, *Federal Policy Alternatives Toward Graduate Education*, Washington, D.C., January 1974, p. 96.

[18] Unfortunately, we did not receive these NIH data in time to incorporate them in our multivariate analyses; similarly, ADAMHA funding data arrived too late to be included in these trend analyses.

[19] Specific NIH figures should be compared with comparable statistics on federal and nonfederal funding in a given category and year only with extreme caution because the NIH statistics represent obligations, not expenditures, and reflect only the main campus, not associated health professional or medical schools. Finally, it was not possible to classify a number of NIH grants by department from the available descriptive information, and it was therefore necessary to omit significant amounts of NIH funding. In short, were it not for these factors, the actual NIH amounts would represent a much larger proportion of "all federal sources" for these disciplines.

In computing the statistics in those tables, schools for which information from a given source was missing in a given year were omitted from that calculation only. An alternative approach, which we rejected in light of the very small number of missing observations, would have been to drop any school that had any item missing. This would have reduced the sample from 148 to 99 and severely biased our statistics. In fact, missing observations in these financial data were negligible except for internal funds in 1968 and 1970. A check of those means against the means that would have resulted from the alternative approach showed little discrepancy.

Table 16

TRENDS IN NIH SUPPORT TO UNIVERSITY LIFE SCIENCE DEPARTMENTS
BY TYPE OF INSTITUTION *

(Thousands of Dollars)

	N	1969	1970	1971	1972	1973	1974	1975
All Institutions	148	380	374	425	470	456	579	643
Public	93	323	331	363	400	388	479	538
Private	55	476	447	532	589	572	748	819
With Medical School	68	361	355	390	421	429	544	620
Without Medical School	80	396	390	456	513	480	609	662
Research Universities 1	49	864	856	994	1078	1064	1344	1531
Research Universities 2	40	258	256	266	303	276	344	349
Doctoral Granting Universities	47	73	64	72	94	84	113	113

*See text for discussion of these data.

Table 17

TRENDS IN FEDERAL AND OTHER SUPPORT TO UNIVERSITY
LIFE SCIENCE DEPARTMENTS BY TYPE OF INSTITUTION

(Thousands of Dollars)

	N	1964	1968	1970	1972	1973	1974
All Institutions	148						
All Federal Sources		2521	3941	4483	4626	5445	5553
Nonfederal Outside Sources		1289	1637	2026	2448	2748	3055
Internal Funds		-	4042	4359	5318	6100	6883
Public	93						
All Federal Sources		2089	3135	3814	3732	4427	4463
Nonfederal Outside Sources		1603	1948	2367	2660	3093	3488
Internal Funds		-	4036	4342	5318	6470	7216
Private	55						
All Federal Sources		3244	5300	5579	6138	7167	7397
Nonfederal Outside Sources		763	1115	1467	2089	2164	2322
Internal Funds		-	4052	4389	5319	5496	6338
With Medical School	68						
All Federal Sources		4032	6380	7746	8164	9599	9729
Nonfederal Outside Sources		1512	1833	2488	3211	3486	3789
Internal Funds		-	6166	7015	9303	10772	12053
Without Medical School	80						
All Federal Sources		1255	1788	1681	1619	1915	2004
Nonfederal Outside Sources		1101	1465	1628	1799	2121	2431
Internal Funds		-	2245	2266	1947	2198	2564
Research Universities 1	49						
All Federal Sources		5395	8407	10202	10682	12594	12615
Nonfederal Outside Sources		2491	3032	4004	4958	5353	5968
Internal Funds		-	7329	8883	10309	11757	13138
Research Universities 2	40						
All Federal Sources		1761	2769	2653	2576	2962	3197
Nonfederal Outside Sources		1197	1637	1858	2118	2500	2797
Internal Funds		-	3126	3752	3866	4661	4972
Doctoral Granting Universities	47						
All Federal Sources		564	782	821	846	1041	1102
Nonfederal Outside Sources		352	483	538	628	816	873
Internal Funds		-	1548	1455	1818	2090	2581

Table 18

TRENDS IN NIH SUPPORT TO UNIVERSITY PSYCHOLOGY DEPARTMENTS BY TYPE OF INSTITUTION*

(Thousands of Dollars)

	N	1969	1970	1971	1972	1973	1974	1975
All Institutions	148	59	59	57	63	54	82	77
Public	93	59	54	42	48	43	70	64
Private	55	60	68	82	88	72	101	99
With Medical School	68	91	93	82	89	69	97	103
Without Medical School	80	33	30	35	40	40	68	55
Research Universities 1	49	130	133	123	134	107	160	163
Research Universities 2	40	39	38	39	39	43	68	66
Doctoral Granting Universities	47	18	13	16	24	20	33	15

*See text for discussion of these data.

Table 19

TRENDS IN FEDERAL AND OTHER SUPPORT TO UNIVERSITY PSYCHOLOGY DEPARTMENTS BY TYPE OF INSTITUTION

(Thousands of Dollars)

	N	1964	1968	1970	1972	1973	1974
All Institutions	148						
All Federal Sources		141	269	282	305	326	322
Nonfederal Outside Sources		23	61	70	87	89	93
Internal Funds		-	423	520	653	674	756
Public	93						
All Federal Sources		129	286	310	323	345	346
Nonfederal Outside Sources		23	72	86	101	103	142
Internal Funds		-	466	577	772	791	884
Private	55						
All Federal Sources		162	239	236	274	293	281
Nonfederal Outside Sources		24	42	44	63	65	62
Internal Funds		-	335	416	461	481	541
With Medical School	68						
All Federal Sources		213	377	405	425	455	454
Nonfederal Outside Sources		30	71	99	113	103	111
Internal Funds		-	481	611	827	830	971
Without Medical School	80						
All Federal Sources		82	174	176	203	216	209
Nonfederal Outside Sources		17	52	45	65	76	78
Internal Funds		-	371	446	507	540	573
Research Universities 1	49						
All Federal Sources		297	539	590	636	682	669
Nonfederal Outside Sources		33	108	157	195	205	214
Internal Funds		-	651	830	1071	1024	1152
Research Universities 2	40						
All Federal Sources		115	229	206	225	242	240
Nonfederal Outside Sources		38	51	42	57	43	53
Internal Funds		-	382	519	543	598	724
Doctoral Granting Universities	47						
All Federal Sources		31	77	88	97	104	103
Nonfederal Outside Sources		6	33	19	19	25	18
Internal Funds		-	257	312	412	447	457

substitutes for nonfederal funds. (Bear in mind that nonfederal outside research support includes only private sources for the private institutions, but includes private and state research support in the public institutions.) While a definitive interpretation of this finding was not possible in the limited time available, the possible explanations provide fascinating hypotheses for future research.

A full examination requires exploring the *effects* of the nonfederal money that presumably is drawn by the magnet of federal dollars. The analyses reported earlier in this study consistently indicated that nonfederal outside research funds have a weaker tie to the basic indices of departmental structure and function than do federal funds.[20]

[20] One exception in biology: In 1969, 1972, and 1973 the effects of nonfederal funding exceeded those of federal funding in the "Doctoral Granting Universities," perhaps reflecting the influence of state funds at public institutions.

IV. FIELD TRIP RESULTS

The field trips were conducted for three main reasons. First, the visits aided in interpreting the results of our data analysis. Second, we wanted to explore some of the *causal* relationships between shifts in federal research funding policy and changes in universities that we could not examine in our data analysis. Third, and most important, we wanted to determine the variety of institutional factors in universities that mediate the effects of federal research funds, and to find out how strong these factors are in relation to federal policy.

Because we visited only ten universities and could spend only a limited time at each one, the results from our field work are less well-grounded than those from our data analysis. Therefore, they are not clearly generalizable to the entire university community affected by federal research funds. Our findings should be regarded as providing a background against which to assess the results of the data analysis and some suggestive insights into the workings of federal research funds on universities, but not as substantial conclusions. However, since our sample of universities was selected to be representative of the research university community, we are confident that our results have some validity and, at a minimum, suggest topics that merit additional research.

UNIVERSITY ADMINISTRATION

As noted above, the universities we visited represented a range of administrative structures. Five were public universities receiving substantial funds for instruction from state government, and five were private universities with most of their funds for instruction coming from private sources. Five of the ten universities had a medical school and five did not. We chose not to include university size as an explicit criterion in selecting our sample. However, by including the total amount of federal research funds received in a given year as a selection criterion, we had universities that spanned the full range of sizes. One university had a total student enrollment under 2000 while at the largest institution over 40,000 students were enrolled.

As expected, the formal organizational structures of the larger universities were more complex, primarily in that they had an additional layer of vice-presidents (for academic affairs, health affairs, sponsored research, and so forth) over the usual corps of deans (for faculty, arts and sciences, the graduate school, and so forth). In addition, the larger universities tended to have more, and larger, specialized support offices of various kinds.

A notable (though difficult to describe) difference among the universities we visited was the strength of the central administration. This bore little relationship to a university's size or complexity, or simple measures of authority. In our view, strong central administrations were both forward-looking and balanced with regard to the development of departments and had specific knowledge at their fingertips concerning their institution's budget, faculty size, and so forth. In strong administrations power was shared among several top-level administrators in close communication with each other; they were more skilled at dealing with department chairmen and faculty members and at changing policy without generating excessive conflict. A strong central administration was a recent development in several of the universities that we visited, having been caused by the onset of financial problems that led to the appointment of new leadership.

There did not appear to be any correlation between either the organizational structure or the strength of a university's central administration and the quality of its departments of life and behavioral sciences. High quality life science departments were seen in large, complex universities and in smaller universities with leaner and less formal administrations.

Larger universities tended to have larger sponsored research or grants and contracts offices to perform more support functions. Traditionally, the primary responsibility of this office was keeping the financial records needed by the university or required by the federal government; another related and important function has been tracking the university's indirect cost expenses and negotiating a recovery rate with the federal government.

In several of the universities we visited, the quality of the financial records kept by sponsored research offices has been spotty in the past, but partly as a result of increasing university and federal demands for improved financial information, these offices are developing more sophisticated accounting systems.

A new role being assumed by sponsored research offices is assisting faculty in the preparation of research proposals through providing editorial, graphic, and clerical services, and in the location of potential funding sources. Some offices have developed to the point where selected staff members are assigned responsibility for keeping track of the research needs of certain federal agencies and notifying faculty of opportunities. Some have gone a step further and become involved in initiating and coordinating the development of large-scale projects, including recruiting faculty, providing start-up resources, and managing the submission of proposals for federal funding. These new roles of sponsored research offices can be seen as responses on the part of universities to the shift in federal funding toward contract research, and the increasing complexity and intensity of competition for federal research funds. In general, our visits suggest that sponsored research offices tend to be more active in the area of contract research than in investigator-initiated research and to have developed the furthest in large, public universities receiving substantial federal funds, not necessarily those that are the most prestigious.

A clear picture of the extent to which these offices increase a university's success in obtaining federal research funds did not emerge from our field trips. Administrators tend to see sponsored research offices as indispensable to obtaining research support in an increasingly complex environment, while faculty tend to see them as being of little value other than in providing assistance in the preparation of proposals. There was no clear relationship between the size and strength of the sponsored research office and the quality of a university's life science departments.

The directors of four of these offices were university vice-presidents (typically vice-president for research); three of them appeared to be highly influential in developing research programs in their universities. Again, these were not necessarily the largest research offices. The influence of these individuals was not so much their ability to find federal funds as their ability to work with faculty and organize interdepartmental research activities. Often this involved securing federal research support after a team of professors had been organized to conduct research on a topic.

Frequently university funds were used to get these teams started. By contrast, the other directors of sponsored research were oriented largely to tracking federal funding policy and standard administrative functions; they appeared to have much less effect on research in their university. In short, the research office directors who had high status in their universities and were internally oriented to developing the substance of their university's research programs appeared to be having more effect than directors oriented largely to dealing with the government.

Our observations have been that the administrative structure of a university is unrelated to the quality of its life science departments, except that strong support from the central administration appears necessary for departmental development and that a vice-president for research can perform a useful research program development function. In other words, departmental quality probably depends far more strongly on factors other than the structure of the central administration.

INDIRECT COSTS

There was great institutional variation in the stress or lack of it felt by the central administration with respect to recovery of indirect costs from the federal government. Two public institutions illustrate the extremes. At one, very little federal support is received and indirect cost is not an issue. In addition, at that institution, the state routinely makes up the difference between what the government pays in indirect costs and what a full recovery from the point of view of the school would be. As a result, this university is less motivated to try to extract every last dollar from the federal government. At the other extreme is a university that does a huge volume of federal research where the administrators feel that they are losing millions of dollars anr by not recovering their full indirect costs. Legislators at the state capitol are acutely aware that the state is picking up the difference and want to know whether the university can justify doing this much research, making it even more difficult for scientists at this leading institution to propose doing new research with federal support.

Indirect cost is the cause of lively controversy between the academic community and the federal government and within universities. The latter controversy centers about the distribution within the institution of those costs recovered from the federal government. Scientists believe that they earn all indirect costs associated with their grants and contracts; administrators tend to feel the funds belong in a general pool and cover a multitude of institutional costs not directly associated with a given researcher. There is extreme variation in policy from institution to institution. At some the funds are turned back directly to the investigator. At some they are kept by the central administrator and spent in whatever manner the leaders of the institution feel is necessary. At some a percentage is kept and the remainder returned. To a degree, the manner in which indirect costs are handled is a function of the network of power relationships within the institution. For example, at one leading research university all indirect costs are kept by the central administration as discretionary funds—except for one powerful, fairly independent unit, which keeps *all* of its own indirect costs.

Another problem mentioned in several universities is the difficulty caused by the different approaches to indirect costs taken by the National Science Foundation and the National Institutes of Health.[1] NIH awards grants in terms of direct costs. NSF often awards an amount for the total budget. If this is less than that originally proposed by the investigator, the breakdown of this new, smaller total budget figure into direct and indirect costs is a matter left to be negotiated between the institution and the faculty member. This, obviously, often causes stress between them.

Weaker research offices tend to get caught between their faculty and agencies that negotiate proposed budgets with principal investigators on the basis of total rather than direct costs, so that cutbacks required by the agency often come disproportionately from indirect costs. Strong sponsored research offices have standard policies and are able to enforce them, so that there is little difference in the actual rate of indirect cost recovery across agencies.

FINANCIAL CONDITION OF UNIVERSITIES

All of the universities we visited are having financial problems to differing degrees. Two of the private institutions had deficits of several million dollars in their current operating budgets and were in serious trouble but hoped to regain financial health through proposed adjustments. The budgets of the three other private universities were either in the black or sufficiently close to being balanced that small adjustments would eliminate any deficits. The five public universities had all been through a decade of rapid growth in revenues and student enrollment but were in various stages of having to cope with smaller increases in their total revenues. The prospect was that for the foreseeable future economic pressures on state revenue would preclude any substantial increases in funds for higher education.

Our impression based on these field trips is that the "new depression," which hit graduate education at the beginning of this decade, was experienced first by the private institutions. The public universities were cushioned from the shock somewhat by continuing increases in enrollments that states were willing to fund; only recently, with the growing disenchantment of some state legislators, are they anticipating the same kind of financial strains. Perhaps the most dramatic example we saw was a state institution that grew at an astonishing pace in the sciences during the early 1970s, when many private institutions were beginning to experience financial difficulties. Throughout this period, both this state's population and enrollments in the university grew rapidly, and there was strong support in the state capital for increasing the university's budget to pay for these increases. But opposition to further large increases in the university's budget emerged recently in the legislature, and relations are likely to be even more difficult in the future. An indication of this change is that the state legislators refused to appropriate money for shelves and other basic equipment to furnish a library that they had generously appropriated $10,000,000 to construct several years earlier. As a result, the library stands completed, but empty and unused.

Since all universities receive funds from a variety of public and private sources and spend in a broad range of categories, it is hard to generalize about the causes of current financial problems. With some exceptions, all universities that we visited

[1] For a detailed examination of differences among federal agencies in the administration of research and development, see John Wirt et al., *R&D Management: Methods Used by Federal Agencies*, D. C. Heath, Lexington, Mass., 1975.

have been experiencing increases in most sources of revenue. However, there are strains because these sources of revenue are not increasining at the same rates as in the past. The most pervasive cause of financial problems was *inflation*, which was obviously occurring in all expenditure categories. Salaries and wages, which are the bulk of university expenditures, are up substantially; utility bills have doubled and tripled; construction costs are up; and the same piece of research equipment costs far more today than it did in the past. For example, the chairman of the biology department at a private institution noted that the cost of an electron microscope had more than doubled in the past five years; he added that only 15 to 20 percent of the increase resulted from increased sophistication in the instrument.

Universities with strong central administrations appeared to be coping more effectively with their financial problems; that is, their budgets were closer to being balanced and instead of being buffeted by successive financial crises, they have moved aggressively but carefully in recent years to make the necessary cutbacks.

Financial problems in the universities that we visited did *not* appear to be generally attributable to federal research funding. This would have been the case if institutions were experiencing substantial declines in their overall levels of federally sponsored research, which then created problems in covering the salaries of personnel to whom the institution was committed. With one exception, total federal research funds received by the universities we visited had steadily increased over the last few years. Or, difficult readjustment problems could also occur if an institution experienced severe cutbacks in funding for key large research facilities, even though overall levels of federal research funding have continued to increase. One of the universities in our sample had experienced such a decline in funding but was coping with the problem.

Two indirect effects of federal research funding may be more serious. To the extent rates of reimbursement for the indirect costs of federally sponsored research are not sufficiently high to cover expenses, universities are making up the difference from their other sources of funds. Several of the universities we visited claimed that their indirect cost reimbursement rates were too low by a few percent, a substantial amount when total federal research support is several tens of millions of dollars. To the extent that science departments do not fully cover new research faculty with federal funds, inflation in their salaries represents a cost burden being borne by universities rather than by the government.

At several institutions a special cash flow problem caused by federal government policies was cited as troublesome. There often is a great delay in the federal bureaucracy between the time a grant is awarded and the time the paperwork has been cleared up and the money comes in. During this period the institution feels an obligation to allow the investigator to begin (or continue) his research. The institution must temporarily advance the funds for this and loses interest on that money during the interim period. Enough funds fall into this category that the interest lost is a nontrivial amount at some universities.

The financial situation at the departmental level of universities is clearly different and is directly related to federal research funding. In general, university departments in the health-related sciences were continuing to obtain research funds and, as mentioned above, usually in increasing amounts. However, particularly in physics and most fields of chemistry the situation was bleak.[2] For example, in one university, which was otherwise highly research-oriented and experiencing a steady growth in federal funds, the chairman of the department of chemistry said that 70 percent of his faculty who previously had federal grants were now unable to obtain support except in the area of analytic chemistry. The faculty members unable to obtain research funding were in what the department chairman called a "downward spiral": Without federal grants, they could not support graduate students and purchase equipment to conduct research; without conducting research, they cannot continue publishing in the journals; and, without publishing, it becomes even more difficult to obtain grants.

An analogous though less protracted situation exists among the different fields of the life sciences in the universities that we visited. Funding for research is plentiful in the health-related areas of the biological sciences and psychology compared with other areas in these fields related, say, to the environment and agriculture. Many faculty that were interested in conducting research in these other areas were having great difficulty obtaining grants to support their work. Examples were limnology (fresh water biology) and photosynthesis. The National Science Foundation is the principal source of funds for those investigators. These faculty members have not found such agencies as the Environmental Protection Agency, the Department of Interior, and the Department of Agriculture to be as supportive.

ORGANIZATION OF THE LIFE SCIENCES IN UNIVERSITIES

Reflecting the breadth of the field of biological science and its direct relevance to such diverse fields as health, agriculture, and the environment, the patterns of organization of the biological sciences in university schools of arts and sciences were highly varied. One formal difference was whether the university had one department or division spanning all the traditional disciplines of the biological sciences (e.g., biochemistry, botany, and zoology) or separate departments. Biological science departments also existed in medical schools and in agricultural schools. These departments often duplicated the name if not the substance of academic activities in the university departments.

Since the companion study by our colleagues at Rand focused on the effects of federal funding at medical schools, we did not visit medical school departments. Our work was concentrated on the life sciences at the main campus of the institutions we visited as well as at auxiliary, related health professional schools—e.g., the dental school, school of public health, agriculture school, veterinary school. However, we did schedule some interviews at medical schools to explore how much activities there might have affected the relationship between federal funding and scientific research at the main campus.

Four of the ten universities we visited were in various stages of consolidating

[2] The relative success of the life sciences perhaps should not be surprising. As far back as November 1965, Alvin Weinberg, a noted expert on relationships between the government and the scientific community, hypothesized that the future volume of government expenditures for universities and research would probably hinge on three factors, one of which was expenditures on biological research. (The other two were the discovery of ways to attack certain social problems and the role of the National Science Foundation.) Alvin Weinberg, "Government Allocations to Basic Research," in Harold Orlans (ed.), *Science Policy and the University*, The Brookings Institution, Washington, D.C., 1968, p. 159.

their separate biological science departments into a single department or division. Typically, before reorganization, one of the departments had had several faculty oriented to the traditional areas of biology—systematic biology, botany, zoology, and so forth. (Departments of psychology were not included in these reorganizations.) The primary theoretical reason for these efforts is that recent fundamental advances in understanding of basic biological processes (for example, the mechanisms of cell replication) have unified the traditional disciplines of biological science, requiring new forms of departmental structure. Typically, a university's objectives for reorganization were to shift faculty orientation from traditional to modern forms of biology, unify and modernize curriculum offerings, and increase funds for externally sponsored research. The bulk of these funds are available only in the new areas of inquiry. The rationale for reorganization as a way of achieving these objectives was to increase interaction among faculty in the new areas through breaking down traditional departmental barriers to communication, and to free resources for hiring new faculty trained in modern areas of biology by eliminating duplication in faculty positions, course offerings, degree programs, and research equipment and facilities.

All four examples of reorganization in the universities we visited had been initiated by the central administration rather than the department chairmen or faculty. In fact, the resistance of the latter groups to this innovation has been great in all four cases. Although there are often some faculty who support reorganization, in general most department chairmen and faculty do not believe that the presumed benefits will accrue and fear that their specialties will not receive proper resource support in a single, large department.

To date, these restructurings largely have failed in the universities we visited. In all four cases, it has either been a continuing process, involving a succession of reorganizations and department chairmen, faculty conflict, few new faculty hired, and no substantial increase in externally funded research; or the single department is a paper organization with little real influence on the university's biological science activities.

The only universities we visited where many new life science faculty have been added and strong, high quality departments have been built over the last decade were universities with new departments. Previously, these universities had had few life science faculty. Two universities fell in this category and both had received institutional development awards from either the NSF or NIH. One school had received two such awards. The department chairmen in these universities believed that the institutional development awards had been instrumental in moving their departments forward.

One of the universities where strength was developed in the life sciences has a single, large biology department (and a psychology department), and the other university has separate biological science departments (and no psychology department). In the former case, the single, large department functions well and is stable. The current department chairman believes that the unified structure facilitated the development of joint faculty research projects, led to an integrated educational program, and provided flexibility in utilizing space. Federally sponsored research has increased dramatically. This example indicates that the single department concept is workable. However, this department was built almost singlehanded by an extremely dynamic and able department chairman with strong support from the university administration.

Two other universities have strong, high quality, and modern life science departments in their school of arts and sciences and always had them. Quality was maintained over the years by strong departmental leadership, aggressive pursuit of federal research funds, and retention of rigorous criteria for appointments and promotions. Also, these universities have adhered to deliberate policies of concentrating faculty expertise in selected areas and maintaining a steady flow of young assistant professors trained in emerging areas of the life sciences.

The personality, drive, and leadership ability of a chairman can mean the difference between a department that grows toward excellence and one that languishes. Our observation was that the importance of a dynamic chairman in developing a given department greatly exceeds the effect of dynamic leadership in the central administration.

It was striking that none of the four universities with strong life science departments in their schools of arts and sciences had medical schools. Some of the universities with medical schools had developed strong life science departments in the medical school, but not in the school of arts and sciences. Apparently, the presence of a medical school in these universities has inhibited the development of strong life science departments at the university's main campus.[3] In fact, two of the attempts by central administrations to reorganize and improve their life science departments were in institutions with medical schools. The main disadvantages of having strong life science departments only in the medical school are that such departments are strictly health related and are unlikely to provide service courses for students from other parts of the university.

In summary, federal funds for life science research apparently have the greatest effect on departmental quality through providing the means for building new departments rather than through reorienting established ones. Furthermore, the development of strong departments is highly related to organizational factors within the university not directly susceptible to federal influence, such as the presence of a medical school, strong departmental leadership, and support from the central administration.

FEDERAL FUNDING AND FACULTY

In our field work we were interested in exploring how departments use federal funds to increase faculty size and quality, and the effects on faculty of the loss of funds. Many of the departments we visited had experienced substantial increases in federal research funds over the last decade, which made it possible to explore how departments use federal funds to grow. Only one university had experienced a substantial decline in total federal research funds in recent years. However, this was from a low funding level and its faculty are not in the top rank of life science departments. A few departments had experienced a slight decline and some a shift in the forms of funding, but these changes were not large enough to jeopardize numbers of faculty positions. In these departments a few tenured positions have

[3] One of our observations is that, regardless of departmental and institutional structure, first rate researchers will seek out other first rate researchers. For example, even at one public institution where a number of faculty and administrators commented on the lack of interaction between the medical school and the main campus, we heard of isolated examples of collaborative research between first rate scientists at the two places.

remained unfilled for longer periods of time than were normal in the 1960s, and promises by central administration for growth in tenured faculty positions made in the late 1960s have not materialized. (The shifts in forms of funding were primarily from training grants to research grants.) Thus, we could not directly observe the consequences for faculty of substantial declines in federal research funding.

Departments under financial pressure, either from loss of federal funds or reductions in university funding necessitated by general financial problems, tend to cut back first on nontenured faculty, as might be expected. But the cutbacks appeared to be more in the rate of promotion to tenure than in the total numbers of nontenured faculty. For example, in one department that we visited, the number of assistant professors had not fallen substantially in recent years, but contracts for junior faculty have been changed from three years once renewable before a tenure decision, to one year renewable six times. This allows the department to be more selective in choosing tenured faculty and provides financial flexibility. We did not find any department that had not promoted any faculty to tenure in the last two years.[4]

Some of the life science departments that grew the most over the last decade built faculty size and quality directly with federal funds through agressively seeking larger amounts of federal grants and contracts, carrying a substantial proportion of faculty salaries on the funds received, and using the monies released to hire additional and better faculty. Usually, these departments also had been successful at bargaining with their central administrations for increased internal university funds and for additional space, using as a rationale their demonstrated ability to win federal awards and improve themselves. But throughout the developmental period, these departments have continued to carry a much larger than normal proportion of their faculty salaries on federal funds. Whether the faculty carried on these government funds were tenured or nontenured varied by department.

The number of departments that use such a "soft money" policy is small. Most faculty are firmly against having more than their summer salaries paid from grants and contracts, which they fear might disappear overnight, leaving them extremely vulnerable. There is also strong concern that long term overdependence on federal dollars is likely to erode the institutional independence fundamental to the concept of the university.

Contrary to what might be expected, some of these departments in which faculty are strongly opposed to charging their salaries to federal grants grew as much over the last decade as departments that followed a soft money policy. They used their success in obtaining increased federal research funds to negotiate increases in faculty positions and other resources with their central administrations.

Whether salaries are charged to federal grants and contracts depends more on faculty attitudes than on attitudes of the central administration. Often within the same university some departments are highly dependent on soft money and others are not. Departments in universities experiencing strong enrollment growth over the last decade had the best of both worlds, since increasing enrollments provided uncommitted funds that central administrators could use for rapidly converting soft money into hard money positions. In every case we saw, these were public universities.

[4] One effect of the reduced rates of promotion to tenure is to make higher quality candidates available to the less prestigious departments.

We found no examples of life science departments following a risky, soft money policy and experiencing a substantial decline in federal funding and difficulty in covering faculty salaries. But the fact that federal support in the biological sciences has continued to grow is part of the explanation; we heard of physics and engineering departments that have been highly dependent and have run into serious trouble. Still, most of those departments have continued to find sources of funding and maintain faculty size, though often with great difficulty.

Another major use of federal research funds in life science departments is for purchasing research equipment. Neither private nor state universities have anywhere near sufficient funds to permit the faculty to buy enough equipment to continue conducting research at the forefront of their disciplines. Faculty needs for equipment vary by research area, of course: a theoretical biologist may need little more than a pencil and paper; a biochemist may need a vast array of sophisticated equipment. However, most life science research is highly empirical, and faculty dependence on equipment is high. They would not stop doing research if no federal funds were available, but it might be far different in quality.

Increasing technical sophistication and inflation have been driving the costs of research equipment up rapidly. There are few pieces of equipment (other than general supplies) that faculty can afford to purchase on a single project grant. Instead, money to buy equipment must be pieced together from several project grants and other sources. The faculty we interviewed report that the costs are increasing so rapidly as to create serious problems of acquiring and maintaining the stock of equipment they need for their research. This suggests that unless federal policy is changed to provide more funds for purchase and maintenance of equipment, the overall life science research effort may be increasingly hampered in the future.

A departmental expense for which federal support cannot easily be used is providing startup resources for new assistant professors. The money available for this purpose varies greatly by departments and by universities. In some departments, we interviewed assistant professors who received less than $500; in others, assistant professors received over $20,000 for this purpose. We were told about one young professor who had trouble getting hot and cold running water in her laboratory. Some sponsored research offices provide funds, some graduate schools have general fund accounts and some universities have endowment income for this purpose. Occasionally, a department has been able to obtain a small foundation grant for a new professor. One had benefitted greatly from a small grant from the National Institute of Mental Health, the only example of direct federal support for startup we found. The more prestigious universities usually had substantially more funds for starting up young professors than the less prestigious and provided these funds more uniformly across departments.

The ability of departments to attract young professors is probably highly dependent on their ability to offer startup funds, and, since the weaker departments have fewer of these funds, new federal programs to channel funds to lesser departments for startup expenses could be effective means of redistributing faculty quality among universities. NIMH's Small Grant program is a good example of such a program. Departments also could use funds they receive from NIH's General Research Support program, which provides institutional support to departments based on the amount of NIH research funds received for this purpose, but our field trips suggested that universities tend to use these funds mostly for other purposes.

An important factor in explaining faculty size, unrelated to federal research support, is the department's undergraduate teaching load. In particular, biology departments have recently been experiencing significant increases in undergraduate enrollments and have used these increases as justification for obtaining additional faculty (and teaching assistantship) positions from their central administrations.[5] By contrast, faculty size in biochemistry departments tends to be unrelated to undergraduate enrollments, since few offer any undergraduate courses. In short, department orientation can affect faculty size in a way that is independent of federal research funds.

In summary, federal funds appear to affect faculty size through increasing departmental bargaining power with central administrations and making it possible to carry extra positions on outside funds. Federal funds affect quality through providing departments with the resources needed to purchase equipment. Less tangible, though probably more important, effects on departmental quality stem from the research activity itself. Faculty who conduct research stay in touch with progress in their disciplines and attract better graduate students and other faculty interested in research. How and how much departments use federal research funds to increase their size and improve quality are highly dependent on local departmental norms and structural factors.

FEDERAL FUNDING AND STUDENTS

Another major use of federal funds in life science departments, as in most science departments, is financial support for graduate and postdoctoral students. Although we did not collect specific data, our overall impression was that almost all of these students receive financial support, the majority of them from federal funds. Departments generally prefer to support graduate students on training grants because of the flexibility provided for students to choose their area of study. However, departments also support faculty and purchase equipment with training grant funds.

As in most science areas, the commitment of faculty in biological science departments to provide [illegible] financial support to all graduate students is extremely strong. This tradition is so pervasive that we were told by one administrator (a social scientist) that [illegible]ence students cannot pay their own way as do other graduate students. There is little difference in this commitment between the strong and the weak departments. One department with very little federal research money or university money for student support had reallocated a part of the equipment budget for student support. We found no strong trend toward students paying their own way.

In the life science departments we visited, funds for training grants have been slightly declining in total dollar amount, even in strong departments. Federal fellowship support has almost disappeared from those departments.

Student enrollments in the departments that have experienced declines in training and fellowship funds have tended to decline, but not by as much as would be indicated by the extent of those drops alone. One reason is that most faculty we

[5] Unfortunately, data on undergraduate enrollments by field were not available for use in our quantitative analyses of the determinants of faculty size.

interviewed on this subject strongly believed that significant reductions in graduate enrollment would not be good for their department, even if the only alternative is for faculty to put extraordinary effort into obtaining replacement funds. The factors explaining the strength of these beliefs were not entirely clear. They included faculty members' needs for assistance in research and a desire to have sufficient students around to make a broad teaching program worthwhile. Most department chairmen believed in the importance of teaching as a measure of faculty quality. Another factor is that undergraduate enrollment in some fields of biology is up substantially, creating a great need for graduate teaching assistants to avoid greatly increasing class sizes or faculty teaching loads.

Few faculty thought that lack of job opportunities for graduate students was serious enough currently to be a reason for reducing enrollments in their departments. On the contrary, most claimed that their students were finding jobs. In fact, chairmen of strong departments felt that their departments have a responsibility to continue training the faculty needed in other universities even if there is a nationwide surplus of graduate students.

Faculty responses to cutbacks in training funds are highly varied. Some departments, especially those receiving substantial federal research funds, shift students from training grant support to research assistantships. Several we saw had made concerted efforts to increase research grant support explicitly for the purpose of supporting students no longer covered by training grants and had been successful. Another response of some departments had been to cut back drastically on the number of postdoctoral students, which freed up funds from research grants to support graduate students.

Some departments have approached their university administrations for additional teaching assistantship positions. These are usually given to first and second year graduate students so that the reduced number of positions on training and research grants can be saved for advanced graduate students to finish their doctoral dissertations. The extent to which departments can obtain teaching assistantships varies greatly among universities and among departments within a university. As noted above, biochemistry is not taken by as many undergraduate students as general biology; consequently, biochemistry departments typically have far fewer teaching assistantships available for graduate student support than biology departments. Thus, they are more highly dependent on federal support for graduate students. Also, teaching assistantships are more plentiful in state universities than in private universities.

A small number of departments contemplated initiating or greatly increasing their masters degree program as a means of generating additional income. Our observation was that lower quality departments were likely to explore this alternative.

One university we visited has responded to the decline in federal student support by greatly increasing internal funds available for stipends and fellowships. Most universities cannot afford to take this approach.

Three observations regarding graduate student enrollment emerge from this field work. First, the extent to which students in life science departments are provided with financial support is dramatic. Second, departments are reluctant to reduce enrollments. They make a variety of adjustments to find funding for students who can no longer be supported with federal training and fellowship funds. As a result, enrollments do not decline in proportion to declines in federal support directed to students. Third, departmental responses to cutbacks in funding are uneven. Departments have the greatest commitment to advanced graduate students; therefore, cutbacks appear to fall most heavily on entering graduate students and postdoctoral students.

FEDERAL FUNDING AND OTHER OUTSIDE FUNDING

During our field trips, we explored relationships between federal research funding and departmental ability to secure additional support from foundations, industry, and the state. In the universities we visited, neither industry nor foundations were a major source of direct support for research.[6]

Several of the department chairmen whom we interviewed had tried to approach industry for support but without much success. It is hard for chairmen to identify which of the almost countless companies are likely to be receptive to providing support, and who in those companies is likely to have sufficient authority to make decisions. By contrast, federal research agencies are organized specifically for the purpose of making grant awards to universities. Faculty generally know which of these agencies are likely sources of funding, how to apply, and what the decision-making process is.

Ties with foundations are stronger, but since many will not pay the indirect costs of research, university administrators do not generally see them as an attractive source of funding.

SCIENCE POLICY ISSUES

During the field trips we were able to probe the opinions held by faculty and administrators at a diverse set of universities about several national science policy issues. Peer review received mixed reviews. Those who had done well in national competition tended to think it was an excellent system; those who had been rejected were conscious of its limitations. More to the point, the consensus among scientists is that although the system has its problems, it is a sound mechanism for assuring that quality ideas and research are rewarded with a minimum of political or other nonscientific interference. The major criticism we heard is that peer review in certain specialized areas requires critics who are bound to be competitors, in one way or another, of the proposed project director.

The relative merits of project and institutional or center support were discussed. A number of scientists and administrators referred to the im[illegible] of Science Development and other institutional grants in the development of their more suc-

[6] Recently the American Council on Education, through its Higher Education Panel survey mechanism, studied nonfederal funding of biomedical research and development at doctoral institutions. One survey question asked the institutional representatives to render a judgment about their expectations with respect to nonfederal funding of biomedical research at their university during the next [illegible] years. "Only one-third of the respondents were anticipating significant increases. Public institutions tended to be slightly more optimistic than private institutions regarding an expansion in the nonfederal contributions." F. J. Atelsek and I. L. Gomberg, *Nonfederal Funding of Biomedical Research and Development: A Survey of Doctoral Institutions*, Higher Education Panel Report #25, July 1975.

cessful departments.[7] Perhaps predictably, scientists tended to favor project support while administrators were quick to see the virtues of institutional support.

In a number of institutions, great concern was expressed about the long run implications of the trend toward increased federal regulation of university policies that must be accepted with federal research funds. Regulation is rapidly spreading into new areas, including research on human subjects, student loan programs, freedom of information, and requirements to publish data on the starting jobs and salaries of graduates. Universities are bearing the costs of compiling and submitting the data required to demonstrate compliance with these regulations, and the amounts are beginning to reach significant levels. Moreover, there is concern that as regulation increases, universities will become more subservient to the federal government and lose the institutional independence central to their function in society.

UNCERTAINTY IN FEDERAL POLICY

When asked to comment generally on the effects of federal funding policy, administrators, department chairmen, and faculty consistently responded that the ramifications of uncertainty and sudden shifts in federal policy (e.g., abrupt cessation of programs and shifting of resources into new problem areas) were extremely difficult to cope with. One scientist described the problem as the reluctance of the federal government to provide enough continuity and assurance of support to last out the "intellectual lifetime of an idea." Another used the metaphor of the "unstable patron" who distributes gifts that may be taken back unpredictably with serious consequences for the quality of work completed and the lives of individuals. Some scientists even went so far as to say that uncertainty in federal policy was more difficult to handle than predictably steady declines in funding levels.[8]

The problem is exacerbated by the peculiar complexity and structure of universities as institutions. Three critical characteristics of universities are: (1) faculty have highly specialized skills, (2) a large proportion of them are tenured, and (3) departments make at least four-year commitments to graduate students. Because of these structural factors, adaptations to sudden changes in federal policy are painful and occur disproportionately in areas where there is greater flexibility. Two of these areas are the levels of untenured professors and entering graduate students. The effect is to upset the equilibrium among the many interrelated factors critical to the important functions of universities. Less sudden shifts in federal policy would allow universities to adapt more smoothly and maintain their equilibrium.

[7] For a description of the NSF Science Development program and an evaluation of its effects, see David E. Drew, *Science Development: An Evaluation Study*, National Academy of Sciences, Washington, D.C., 1975.

[8] One pervasive influence of the uncertainty about federal policy is the reduced likelihood that a department will initiate some risky new venture with, for example, junior faculty. At several affluent and fairly undisturbed institutions, uncertainty in federal policy was cited, together with the leveling of funds, as causing the institution to reduce new ventures, experimental programs, etc.