

**FEDERAL FUNDING AND UNIVERSITY BEHAVIOR :  
A SYSTEMS VIEWPOINT<sup>1</sup>**

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**Abstract**

Operations researchers have made relatively few studies of higher education. The studies that have been made for the most part have dealt with routine administrative matters such as admission and registration of students, assignment of classrooms, and allocation of expenditures into budgetary categories. The size and importance of higher education call for investigations which deal with more significant variables than these.

This study looks at a small segment of higher education (a professional school on a university campus in the United States) from a systems viewpoint. It emphasizes organizational and administrative problems in a university environment which arise from federally funded research and fellowships. Federal policies, university rules and regulations, and educational activities of a professional school interact in complex ways. The outcomes of the interaction affect the achievement of federal, university,

and professional school goals. This entire area would seem to be a fruitful one for operations researchers to study.

In 1962 Platt invited management scientists and operations analysts to add education to their list of important systems to study [1]. He pointed out that while educators, economists, psychologists, and others had been studying education,<sup>2</sup> systems analysts had not. However, education in the United States viewed as a system presented obstacles as well as opportunities for the systems analyst. For example, Platt characterized education as having rich problems (i.e., ones that are non-trivial and complex) but poor markets (i.e., highly decentralized decision making with policy makers often not interested in examining their operations).

The study reported in this paper looks at a small segment of higher education (a professional school on a university campus) from a systems viewpoint. It emphasizes the organizational and administrative considerations which arise from federally funded research in a university environment.

The paper includes a brief survey of the literature on operations research studies of higher education.<sup>3</sup> Mention is also made of the relation of the present study to the "research on research" literature. For the benefit of Japanese readers data are given on the magnitude of higher education in the United States and its degree of dependence upon the federal government for financial support.

Higher education, especially in those states which have large systems of public higher education, seems to offer opportunities for systems analysts. However, a recent survey by Rath [2] on the use of operations research in universities indicated that most efforts to date have dealt with computerized student registration and course scheduling—hardly the most significant problems facing universities today. Rath's conclusions were confirmed by Dean [3].

A sampling of current work not covered by Rath reveals that the mathematical models of university operations constructed by researchers

use categories and data contained in university accounting records [4, 5, 6, 7, 8, 9, 10, 11]. Accounting data are usually the data required to calculate the "rule-of-thumb" measures by which public universities justify their requests for state funds. These are such well-known measures as student credit hours, student/faculty ratio, square feet of office space/faculty, and library books/student. The categories of major university activities built into the models are usually teaching, research, and public service and are assumed to be mutually exclusive.<sup>4</sup> Thus, the studies uncritically accept the traditional ways in which universities have presented themselves to the world.

The authors of the studies referred to above often state that their models are merely tools for administrators to use in evaluating different alternatives. These models, when programmed for a computer, are said to help the administrator to obtain quickly and cheaply quantitative evaluations of alternative policy decisions. However, because current operations of the university are built into the model the administrator can never really consider more than marginal adjustments to his present system. These models can be very useful in generating data on future demands for such things as faculty, classrooms, and office space—data which administrators need to justify their requests for funds. But these models do not help in studying how the present structure of a university affects performance or in evaluating possible structural changes.

Many current issues are neglected. Students enter only in the calculation of student credit hours. Problems such as those brought about by the rapid increase on campuses of persons supported by research and other extramural funds—new categories of personnel neither faculty members nor students—are ignored. The interrelationships of university rules and regulations and university performance are not captured in the equations, neither are the possible dysfunctional consequences of the university's own data collection system and the measures it uses of its own performance. Rather the models programmed for computers give essentially the same kinds of output as the less mechanized systems

they replace. Their advantage lies not so much in providing new kinds of data but in generating data more rapidly and in providing the opportunity to see the results of many more perturbations of the same old parameters.

The "research on research" literature is also relevant to a study of university operations. The diversity of this literature is shown by the collection of articles assembled by Dean [12]. The studies reported in that book range from global historical trends in science and technology to case studies of the application of PERT and CPM in R & D projects. Rubenstein provides another example of the breadth and diversity of the studies in this field. In an overview of the literature he divided the work in the field into fifteen categories [13].

Much of the "research on research" literature deals with new product selection by industrial corporation [14, 15, 16], the use of economic analysis in research and development activities [17, 18, 19, 20], investigations into the productivity and creativity of scientists in bureaucratic organizations [21, 22, 23] and the related work on strains which may arise between scientists and managers in bureaucracies [24, 25]. The literature on diffusion of innovation which could be considered a part of the "research on research" literature is very large and contains work from several disciplines. A survey by Rogers [26] listed over 500 studies.

These brief comments on the literature on operations research in higher education and the "research on research" literature indicate that systems studies on university campuses focusing on federal funding would illuminate an important but neglected area at the intersection of these two literatures. Much of the basic research in the United States is carried on at universities through grants and contracts from the federal government. Hence, studies dealing with the management of research in university settings are of interest.

Several books describe the great increase in federal funds going to universities in the post-World War II period and point to the problems these funds have caused university administrators [27, 28]. However,

only a few studies deal with the impact of federal funds on individual universities<sup>5</sup> [29, 30, 31]. Without knowing the impact of federal funds on individual universities it will be hard indeed to formulate rational science policy at the national level.

Investigations which attempt to relate the structure and properties of a system to its problems may be the best way for operations researchers to proceed in studying universities. At the present time the use of operations research in analyzing university operations is in the "hypothesis forming" rather than in the "hypothesis testing" stage.<sup>6</sup>

The study presented here describes some of the interrelationships among federal support of higher education, university rules and regulations, and educational activities in a professional school (hereinafter called the School) within a university. This approach seems justified because as shown in the next section the federal government has become the principal source of support for research and development projects undertaken at universities in the United States and because much of the School's growth in the post-World War II period has been financed by federal funds. Some of the major problems—space requirements, faculty recruitment, and curriculum offerings—facing the leadership of the School are intimately related to the research effort and to the support of some faculty members by federal funds.

### **The Federal Government's Involvement in Higher Education**

In the post-World War II period the federal government became a major factor in the support of research and development (R&D) in the United States. Federal expenditures for R&D increased from \$ 1.1 billion in 1950 to approximately \$ 15 billion in 1965. As might be expected development requires more money than research, and amounted to over \$ 9.7 billion in 1965. Educational institutions received almost \$ 1.2 billion from the federal government for R&D in 1965. An additional \$ 142 million was classified as R&D plant. Thus only \$ 1.3 billion of the \$ 15 billion

in federal expenditures went to universities [32]. Nevertheless, the amount is substantial for the National Science Foundation estimated that in 1965 almost 60 percent of all R&D work done in universities and colleges proper was performed under federal grant or contract [32, p. 6].

In addition to providing grants for R&D projects, the federal government has used a variety of other means to channel funds to colleges and universities. Because the federal government has so far refrained from stating that general support of higher education is proper govern-

**Table 1.**  
**Total federal obligations to universities and colleges\***

(Millions of Dollars)

Categories of Federal Support	1963	1966
Academic Science Obligations		
R&D	813.2	1257.7
R&D Plant	105.9	114.8
Other Science Activities**	393.1	798.6
(Subtotal)	(1312.2)	(2171.1)
Non-science Activities***	84.5	846.5
Grand Total	1396.7	3017.5

\* The total obligations do not include funds for federal contact research centers which a relatively few universities operate for federal agencies. Total federal obligations in this area were almost one billion dollars in 1966.

\*\* This category represents funds for the support of education in the sciences and certain types of institutional grants. For example, included in this category is the National Aeronautics and Space Administration's sustaining university program of fellowships for graduate training of scientists and engineers.

\*\*\* This category consists of programs primarily financed by the Office of Education chiefly for undergraduate facilities and equipment, and for fellowships and training in fields other than the natural sciences and engineering.

Source: National Science Foundation, *Federal Support to Universities and Colleges, Fiscal Years 1963-1966*, (NSF 67-14).

ment policy the support has come in such forms as institutional grants for development and maintenance of science programs, training grants for areas considered essential for national security and welfare, and grants for physical plants, fellowships and scholarships.<sup>7</sup>

Total federal support for universities has increased rapidly in recent years and in 1966 exceeded \$3 billion.

Among the major sources of support for higher education the federal government has shown the greatest percent increase in recent years and is now the single most important source of university funds.

**Table 2.**  
**Major sources of support of institutions of higher learning**  
(Millions of Dollars)

Sources of Support	1959-60	1963-64
State Governments	1,389	2,134
Federal Government	1,041	2,171
Student Tuition and Fees	1,162	1,899
Private Gifts and Grants	383	552

Source: U.S. Office of Education, *Digest of Educational Statistics*, 1966.  
U.S. Office of Education, *Digest of Educational Statistics*, 1967.

As late as 1951 enrollment in private institutions of higher education exceeded that in public institutions. However, by the fall of 1966 enrollment in public universities and colleges was twice that in private institutions (approximately 4.3 million against 2 million). This trend to public higher education seems certain to continue. As public funds (both state and federal) for higher education continue to increase both in absolute terms and in percent of total support, public officials will undoubtedly want to know more about the use of these funds.

One consequence of the large sums of money pouring into American universities has been a dramatic increase in the number of degrees granted. The greatest percent increases in the 1960's have been in advanced degrees.

**Table 3.**  
**Number of earned degrees conferred by institutions  
of higher education**

Type of Degree	1954-55	1959-60	1964-65
Bachelor's & First Professional	287, 401	394, 889	535, 031
Master's	58, 204	74, 497	112, 124
Doctorate	8, 840	9, 829	16, 467

Source: U.S. Office of Education, *Digest of Educational Statistics*, 1967.  
U.S. Bureau of the Census, *Statistical Abstract of the United States*, 1966.

### A Case Study

Certain professional schools and academic departments in which the research and teaching programs are largely supported by federal funds may be thought of as microcosms of what the university of the future may be since federal funds will probably come to support more and more university programs. Thus a study of one such professional school may indicate some administrative problems which will be faced by other departments and schools, particularly those in state universities, as federal funds play an ever increasing role in higher education. This professional school was chosen because its field is one in which new concepts of federal and university relationships *vis-a-vis* research, graduate education, and student support have been pioneered.

Data on which this study is based were obtained through interview, questionnaire, and review of records. Selected members of the faculty and staff of the School and persons outside the School who were familiar with its operations were interviewed by the author. A questionnaire was distributed to all faculty members and approximately 80 percent of the questionnaires were completed and returned. Files in the University's offices and the School's office yielded additional information.

The graduate program of the School has grown rapidly in the post-World War II period. In 1955 when the School was supported primarily



by state funds there were 180 students—76 undergraduates and 104 master's degree candidates. Later a doctoral program was initiated and the undergraduate program was dropped. In 1966 the School had 279 graduate students. Of these 64 were doctoral candidates and with the exception of 12 non-degree students the rest were candidates for the master's degree. Thus in terms of numbers of students, the emphasis was on preparing persons at the master's level for professional work in the field. State funds provided support for approximately 35 faculty positions and federal funds provided support for approximately 22 more.

Table 4 shows the impact of federal grants on the School. As shown in the table federal funds have financed an ever increasing percent of the School's growth. In 1955 the School was supported primarily by state funds. However, ten years later almost two-thirds of the School's support came from other than state funds. In addition, fellowships provided primarily by the federal government were available to almost all students. The rapid rise of research activity in the School in the past decade is reflected in the rise of funds for organized research from \$ 20,000 in 1955 to \$ 450,000 in 1965. The actual amount of research carried on by members of the School is greater than this total. Several members hold joint appointments and their research projects are often listed under other schools or departments. In addition some members do research in conjunction with organizations outside the university. In total there were at least 90 research projects financed primarily by federal funds involving School members in progress during the twelve month period covered by the questionnaire.

Analysis of the questionnaires completed by the School of Public Health faculty indicated that most persons believed that research activity carried on in the School has an overall beneficial effect and has resulted in a good distribution of research effort. This is not at all surprising, since most persons in the School have research grants.

Faculty members reported certain benefits from the research grants. In addition to the obvious benefits of contributing to the advancement

**Table 4.**  
**Professional school**  
**major categories of expenditure and sources of funds**  
 (Thousands of Dollars)

Year	Instruction & Departmental Research (IDR)		Organized Research (OR)	
	State Funds	Non-State Funds (Primarily Federal Funds)	State Funds	Non-State Funds (Primarily Federal Funds)
1955	388	45	0	20
1960	525	273	0	131
1965	645	632	0	450

Note: Fellowships for students (primarily federal funds) are not included in the above figures. In 1965 these fellowships amounted to approximately \$ 580,000.

Explanation: In 1965 the \$ 645,000 in IDR State funds represents the salaries of the tenured faculty and some 23 clerical positions.

The \$ 632,000 in IDR Non-State funds represents the salaries of some non-tenured faculty (e.g., lecturers, clinical professors, assistant professors), salaries of non-professional personnel (e.g., clerks and secretaries), and expenditures for supplies and equipment.

The \$ 450,000 in OR Non-State funds consisted primarily of federal research grants administered through the School which supported research projects of faculty members.

Source: Annual University Financial Statements.

of knowledge and the solution of important problems, the grants gave employment to graduate students and resulted in increased contacts between faculty members and doctoral students. The grants also increased the availability of data for teaching and for students' papers and dissertations and provided certain instruments and tools such as computers and duplicating facilities for use in faculty and student research. Of course, research is expected of faculty members and is the major factor in their professional advancement.

Several problems associated with research activity were reported. Two-thirds of the faculty members said that their research activity de-

creased the time they spent in preparing for classes. (One-third responded that they couldn't meaningfully separate research and teaching.) Because of the diversity of disciplines within the School there are many introductory courses to acquaint students with various facets of the field. This is one reason some faculty members perceive teaching and research as separable activities. Because few graduate students work as research assistants for faculty members increased research activity by these faculty members could well affect time spent in "teaching" where teaching is narrowly defined as preparation for and participation in classroom activity.

Most faculty members reported that involvement in research reduced contacts, especially informal contacts, with master's students. The terms set for federal fellowships are partially responsible for this. Students receiving fellowships (and practically all do) may not engage in remunerative employment without the prior approval of the federal agency. Increased research activity could mean increased "teaching" if master's students were working with faculty on research projects. However, the results of the questionnaire showed only eleven master's students so employed. Federal fellowships also influence the length and hence the content of the master's degree programs. The agency's regulations state that fellowships are primarily to support individuals for one year of graduate education. Because of the previous training of persons entering the School and the rapid advances which are taking place in the disciplines which make up the School, one year may not be enough time to educate those who will become the leaders in the field.

Increased research activity aggravated the space problem in the School. Part of the squeeze came about because persons hired on non-state funds (primarily federal funds) did not carry as much weight in the calculations of space requirements as those persons hired on state funds.

Research activity also involved the faculty in the time-consuming tasks of making reports and keeping records required by the various

university administrative offices and granting agencies.

In addition, increased research activity has increased the work load on the non-academic personnel in the School who type the research proposals, handle the paper work in submitting the proposals, and do the accounting work on those that are approved. Increased research activity also causes additional demands on the School' library. It is true that the federal government gives the University a sum of money (called overhead funds) in addition to the amount of the research grant to pay for indirect costs which are caused by the increased research activity but which are difficult to trace to individual research projects. However, at the University the overhead from all federal research projects is taken at the statewide level and none of the money goes directly back to the school or department where the grant originated. Naturally the University has proved to the federal government that indirect expenses caused by the federal research grants are at least as much as the amount received by the University in overhead funds. But the school or department where the grant originated does not automatically get a portion of the overhead funds to cover what it perceives as increased school or departmental costs due to increased research activity.

When faculty members considered the overall effects of their involvement in research effort, most of them said they would undertake additional research if they had the money. Because their time was already fully occupied now, most of them said they would hire persons to do research under their supervision rather than do it themselves.

One finding concerned the views faculty members had of research in their own departments in contrast to that in the School as a whole. A section of the questionnaire had a series of specific questions about the effects of research grants followed by two general questions. The first general question asked each faculty member to evaluate the proportion of effort devoted to research and teaching in his department and the second one asked him to do the same thing for the School as a whole. The tendency was for the member to answer that the balance

between teaching and research was just about right in his department, but that in other departments the emphasis should shift to more teaching and less research.

Three major points which emerged from the study are interrelated. First, the "bureaucratization" or "industrialization" of research—the necessity to form relatively complex organizations such as research centers or laboratories in order to carry out certain projects—has made it necessary for some professors to become administrators of research groups in order to carry out their investigations.<sup>9</sup> Because these research projects require full-time staff in addition to the part-time efforts of professors and graduate students, a new group has appeared on university campuses—the professional researcher. Second, the administrative rules, regulations, and procedures of the University and the Academic Senate have a profound effect on the type of staff which can be recruited and retained where the organizational form for the conduct of research is relatively complex. Finally, the difference in the relative value placed on the School's field by the federal government and by the power structure of the University exacerbate certain adverse effects of the University regulations on the School.

### **The "Bureaucratization" of Research**

The nature of the research itself has a direct bearing on the organizational form developed for a given project. A mathematical statistician who does his research in theoretical statistics doesn't need an organization. He just needs some paper, pencils, time and ideas. Thus at one extreme we have the person whose research would be hindered by an organization.

However, in a professional school such as the one studied many studies require empirical data. For this kind of research someone must collect the data. In many cases the professor does not collect the data himself, but employs graduate students to collect it for him. Then he has to worry about getting financial support for the graduate students

and getting a place for them to work. So the research leads to administrative problems.

In research where the data requirements are too great to be met by one professor and several graduate students, the data required often serve as a data bank for several separate though related research projects. A different group of persons may work on each project. To achieve continuity in the research, full-time professional researchers are added to the staff. In addition, a secretary and a clerk are hired to handle the paper work. Different kinds of technicians may also be needed. Because data are usually put on IBM cards for storage and processing, someone familiar with data processing equipment and procedures is needed. Some research projects involve large scale data collection over a long period of time and many require formal relations with other organizations. Here, a research center may be the most desirable organizational form. Soon a regular organization has been created and the "bureaucratization" of research has become a reality. And large numbers of persons neither faculty nor students have become members of the university community. In this study the 90 research grants of individual faculty members brought some 170 additional persons to the campus, excluding faculty and graduate students.

### **The Impact of University Rules**

Administrative rules, regulations, and procedures of the University have a major influence on how effectively a research organization, whatever its complexity, will function. First there is the matter of recruitment and retention of key staff. The University has a long list of job titles and associated salary schedules. Any person employed by the University must be hired under one of these job titles. The salary schedules have lagged behind in certain areas, for example, for persons who have computing and statistical skills. Thus, the faculty members are often unable to attract persons they want to work for the salaries which are allowed by the University. One result is that part of a re-

search project may be contracted to persons who have no connection with the University, i.e., the research goes "off campus."

A related point is that the University hasn't realized the need for full-time middle management. Because of the University job titles and salaries, it is difficult to hire a person who can handle the administrative chores of a research project, e.g., personnel matters, supplies and equipment, records and reports, and so forth. As a result, the professor must handle these things himself. This takes time away from his other duties.

A third consideration at the University is the low status of personnel in the professional research series *vis-a-vis* the faculty. (The same statement also applies to personnel in the clinical professor series and the lecturer series.) Suppose the professor is able to hire someone in the professional research category as a research physician, a research economist, or a research sociologist. A person in this professional research category soon realizes that he is a second-class citizen at the University. Unlike the faculty member, the professional researcher is not a member of the Academic Senate, has little to say about the conduct of the school or department in which he is working, and is not eligible for sabbatical leave. He doesn't even get a 10% discount on books at the University bookstore! After a period many professional researchers become increasingly dissatisfied with their low status. Some leave for other jobs.<sup>9</sup>

A final point about the influence of administrative regulations and procedures is the rule that makes it almost impossible for lecturers, clinical professors, and persons in the professional research category to be principal investigators on research grants. For reasons that will be discussed later, many individuals with these titles are in the School. Because a lecturer, clinical professor, or person in the professional research category can very rarely be a principal investigator, an individual in one of these categories who wishes to pursue a research idea must get some member of the faculty with the academic rank of assistant, associate, or full professor to act as principal investigator for his research project.

This creates problems for the individual. He may for several reasons not want to approach the faculty member who would be his logical choice for principal investigator. The faculty member might want to have the research proposal rewritten or revised to meet his requirements. Such revision might drastically change the nature of the research. Second, the lecturer, clinical professor, or person in the professional research category may not receive full credit for his research in terms of career advancement since he is not the principal investigator but rather is hidden in the research grant as project director or under some other title. Third, the faculty member who might be the individual's first choice for principal investigator may be too busy to be so designated even in name only. Thus in this study it became clear that University rules, regulations, and procedures have a hand in shaping the conduct of research, and in specific instances do not operate to the advantage of research effort or graduate education.

### **Differences in Values**

Probably the most interesting point which came out of the study involved the difference in emphasis placed on the School's field between the federal government and the University establishment. (The University establishment is defined here as the chief administrative officer, his key advisors, and the powerful members of the tenured faculty.) As stated earlier, the federal government has shown its interest in the School's field by making available large amounts of money to such schools throughout the United States. At the University, the School has taken advantage of this federal money to enlarge its program.

However, from this study it became evident that the University establishment does not value the School's field as highly as does the federal government. Concrete evidence of this is that the establishment has not allocated to the School any new tenured positions of professor or associate professor during the period 1954 to 1966.<sup>10</sup> (It should be noted that once these tenured positions are given, state money follows.



Thus, the important consideration is the number of tenured positions allocated to the School rather than the amount of state funds provided to the School.) Because of this lack of balance—a rapid increase in federal funds, but no increase in the number of tenured positions—the School has had to resort to devices such as hiring lecturers, clinical professors, and persons in the professional research series to build staff. Out of this necessity many of the problems faced by the School have arisen. Two major problems are (1) the difficulty in attracting and retaining high quality faculty when these persons often have to be hired as lecturers, clinical professors, or professional researchers, and (2) the uncertainty of continued federal support of important teaching and research programs. In contrast to state funds which carry no restriction on the School's programs, federal funds are for specific programs which must be spelled out in the grant proposals and are limited to a fixed period of time.

In such fields as physics the federal government and the University establishment agree on the high value of the field. The government has poured large sums of money into physics and the University establishment has shown its support by almost doubling the number to tenured positions from 1954 to 1966.

In summary, two important considerations in studying the management of research on a university campus are (1) the degree of balance between the value given to a discipline or subject area by the federal government and the value given it by the university establishment and (2) the impact of university rules and regulations on the recruitment and retention of personnel for teaching and research projects.

### **Conclusion**

Most of the federal funds for the School come from a mission-oriented agency. Through its grants to universities, state agencies, and local groups the federal agency is building a profession in the United States. Federal funds have unquestionably played a major role in the develop-

ment of the field and in its professionalization.

At the university level the federal agency has a variety of programs to promote the general welfare through the support of professional schools in its field. The great inflow of federal funds has many desirable results. By funding individual research grants and by allocating block research grants to the professional schools the agency supports study of problems of national importance thereby advancing the field and improving its service to the public. By supporting these schools in respected universities the agency enhances the image of the field. By providing generous fellowships for students the agency encourages persons working in the field to return to school for graduate work thus upgrading the field. These fellowships also permit the professional schools to compete for students on favorable terms with other parts of the university. By paying the salaries of professors, by paying the salaries of clerical, secretarial, and other support personnel, and by providing facilities, supplies, and equipment the agency helps the professional schools educate the increased number of students who are drawn to the field as a result of the agency's programs.

To some extent, however, the seeming unity of purpose of the federal agency is fragmented by federal policies and regulations and by university policies and regulations. In this study it was obvious that the different values placed on the School's field by the university establishment and by the federal government created serious problems for the School. Some university rules and regulations, particularly in the matter of the denial of certain privileges to faculty and researchers supported by federal funds and in the area of university job titles and associated salary schedules, raise issues which are as yet unresolved. In addition, federal regulations which make it difficult to use federal funds to hire administrators for research projects, which place a one year limit on fellowships, and which prevent students with fellowships from enriching their education by working as research assistants create still another set of problems for the School. The very number of federal grants with their

differing rules and periodic changes in rules and the uncertainty of continuity of federal grants create administrative problems for the School. Thus in several ways the unity of purpose which is the desired result of the many federal programs may not be fully achieved.

It is not the intent of this paper to suggest that federal support be curtailed. Given the cost of higher education and the demand for it together with the tax structure in the United States, federal support is essential to the survival of most universities. This means that federal programs to support various fields will no doubt continue to proliferate. Now seems to be the time for systems analysts to make a significant contribution to higher education by studying the consequences of federal and university policies and their interactions and ascertaining what these consequences mean in terms of the achievement of federal agency goals and university goals.

#### FOOTNOTES

1. This study was supported in part by the National Aeronautics and Space Administration under General Grant #NSG-243 under the University of California.

The author benefited greatly from discussions with his colleagues, Frederick Betz and Carlos E. Kruytbosch, about the problems of higher education. In addition, Mr. Kruytbosch read and commented on an earlier draft of this paper.

The paper grew from a presentation made at the joint meeting of The Operations Research Society of Japan and The Institute of Management Sciences, August 14-18, 1967, Kyoto and Tokyo, Japan.

2. Among the disciplines using quantitative methods to study the educational field (apart from the field of education itself), economics has produced perhaps the largest number of studies. Blaug [33] pointed out that the rapidly expanding economics of education literature seems to advocate three different approaches among which educational planners may choose. One approach views the educational process as fulfilling

desired manpower needs, a second treats education as a consumer good, while the third sees investment in education as similar to an investment in a capital good. Other surveys of the economics of education literature are contained in [34, 35]. A session of the 1965 annual meeting of the American Economic Association was devoted to the economics of education [36].

Several studies have dealt with the allocation of doctoral scientists and engineers between teaching and research and the feedback of persons with doctoral degrees into higher education to produce more doctoral degrees [37, 38, 39, 40].

Other studies have built models of the entire educational process in states or countries. Typically these macro studies concentrate on the flow of persons through the educational system [41, 42, 43, 44].

3. In this paper operations research is used synonymously with systems analysis. Although some writers prefer to use operations research to refer to studies of well structured, middle management problems and to use systems analysis to refer to ill structured, top management problems of broader scope, such usage is not adopted here.

4. Problems caused by the use of traditional accounting data and categories were pointed out by Veblen over 50 years ago [45], and recent events in higher education testify to his foresight [46].

5. American educators, of course, have written about the problems of higher education and have suggested changes [47, 48, 49, 50]. These studies help the researcher to understand the problems facing university administrators as the university's environment has changed and as public expectations of the university have changed.

6. The readers to this journal have seen many interesting mathematical models devised for various industrial situations and transportation problems [51, 52, 53, 54, 55, 56]. The application of operations research in these areas is much further advanced than in higher education. One reason is that industrial and transportation problems are well-structured problems which have been studied for some time. Another reason is

that in these areas models based on technological considerations alone yield answers which administrators find useful. In contrast, the "technology" of higher education is not well known and its problems are not well structured. Arguments about what kinds of problems are suitable for analysis by operations research and at what level within an organization these problems should be attacked are old ones in operations research [57, 58, 59].

7. The degree of federal support presently varies among academic fields. The physical and life sciences receive much more federal money than the social sciences which in turn receive more than the humanities.

8. There is nothing new in the idea that research effort creates administrative problems. The literature does discuss the creation and expansion of administrative subunits caused by complex research activities in universities [60, 61, 62]. However, little empirical research has been done on the administration of higher education let alone on the administration of research within a university setting. A survey of the university administration literature is contained in [63.] A survey of the uses of modern management techniques by university administrators is found in [64].

9. Kruytbosch and Messinger [65] have studied professional researchers at the University. The results of their study showed that although many of the researchers believed their positions were desirable because of opportunities for self-selected work and stimulating work environment, practically all of them thought they should be granted many rights and privileges now denied them: the right to be principal investigator, some formal guarantee of job security, the right to have sabbatical leave, the right to serve on university and departmental committees, the right to participate in appointment and promotion of professional people, recognition of current teaching function, and parking and library privileges equal to those of regular faculty.

10. The year 1954 was the earliest year for which the author could get data. Because 1954 preceded the rapid rise in federal research and student

support grants to the School it was used as the base year. There is no implication that the number of tenured positions in the School was "right" or "wrong" in 1954.

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