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THE EFFECTS OF SEPARATELY BUDGETED RESEARCH EXPENDITURES

ON

FACULTY INSTRUCTIONAL PRODUCTIVITY IN UNDERGRADUATE

EDUCATION

by

Gary Tripp Ward

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A Dissertation Submitted to the Faculty of the

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In Partial Fulfillment of the Requirements
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As members of the Final Examination Committee, we certify that we have read the dissertation prepared by *Gary Tripp Ward*

entitled *"The Effects of Separately Budgeted Research Expenditures on Faculty Instructional Productivity in Undergraduate Education"*

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of *Doctor of Philosophy*

Larry L. Leslie — Date 4/1/97

Gary D. Rhoades — Date 4/1/97

Mary Lou Schmidt — Date 4/1/97

Date

Date

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Dissertation Director — Date 4/12/97

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DEDICATION

This dissertation is dedicated to my loving and supportive wife, Stacey Lucille Ward, and my daughter, Megan Alice Ward, without whose help, sacrifice, dedication, and prayers this document could not have been completed. And for Rod, I wish you could have been here.

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ABSTRACT

In the past five to ten years, state financial support for public colleges and universities has been reduced in relative terms. As direct state funding has declined, colleges and universities have sought alternate forms of support to replace the lost funds, mostly through an increased emphasis on securing contracts and grants. This increased grant seeking behavior has been accomplished through individual departments, the main economic and administrative units within higher education. Administrators at all levels actively encourage faculty members to seek out external sources of funding that will support research directly and sustain departmental administrative functions indirectly through overhead charges.

Pfeffer & Salancik's (1978) resource dependency theory is the conceptual framework used to examine whether changes in departmental revenue support patterns affect undergraduate education at major public research universities. Specifically, whether faculty undergraduate productivity is reduced in proportion to the amount of external research financing acquired by academic departments. Resource dependency might explain the behavior of faculty involving changes in productivity, revealing that external agents of resource supply and rewards have a significant impact on undergraduate instructional production.

To test the theory that resource dependency can explain variation in departmental undergraduate instructional productivity, data from the 1994 survey results of the National Study of Instructional Costs and Productivity (NSICP) are examined. This

sample data contain information on 27 Research I and II institutions, 93 departments, and 955 data points. Traditional statistical procedures explore the interrelationships between research spending and student credit hours/class sections taught on a per faculty member basis.

The primary finding is that the resource dependency framework linking separately budgeted research expenditures (a proxy for external resource provider influence) and faculty undergraduate instructional productivity (a proxy for internal organizational behavior) is not supported. Other factors not evaluated by this study, such as faculty training, faculty and departmental culture within higher education, departmental power and influence, and internal reward structures of departments may hold greater weight in determining faculty undergraduate instructional productivity.

CHAPTER 1

INTRODUCTION

Problem

In the past twenty years, and particularly in the last five to ten years, financial support of colleges and universities has undergone dramatic change. The changes in university funding have taken two forms: 1) the proportion of total financial support provided to colleges and universities by federal and state governments has slowly been reduced, and 2) as direct state funding has been reduced proportionately, alternate forms of funding, particularly in contracts and grants (National Center for Education Statistics [NCES], 1995; Slaughter & Leslie, in press), have accounted for an increased share of funding.

These changes may have affected how undergraduate education is conducted at research universities. Specifically, the amount of time spent on teaching, faculty workload, and the number of credit hours or class sections taught (per faculty member) may have been reduced in some proportion to the amount of research dollars garnered by individual university departments. According to James Fairweather's recent research (Faculty Work and Public Trust, 1996), there is some evidence that research and teaching at institutions of higher education have an inverse relationship; that is, if faculty research activities are increased, faculty instructional activities are decreased. This conclusion is supported by previous empirical research (Fox, 1992; Jauch, 1976; Linsky & Straus, 1975).

Resource dependency may explain faculty behavioral changes involving time allocations for research and teaching at departmental and university levels. If an exchange relationship exists between teaching and research, then an emphasis on research by universities and colleges may cause undergraduate education to become less prominent in the work of faculty in higher education. Any de-emphasis of undergraduate education in America's research universities has important consequences for how institutions of higher learning will conceive themselves in the 21st century.

Background

> We all know what "research university" means: To hell with the undergraduates. (faculty member at a research university; Wilshire, 1990, p. 280)

Higher education in the United States serves diverse purposes: the production of knowledge (research), the transmission of knowledge and culture (teaching), public service, and professional training (Fairweather, 1989). Well into the middle of the 19th century, colleges and universities were solely institutions of teaching and training; research played only an incidental role to their primary mission (Husen, 1991). However, with the founding of the modern German research university by Wilhelm von Humboldt in the early 19th century, the primary mission began to change for many American colleges. The research model for higher education developed in Germany was quickly emulated across the United States, particularly in private institutions such as Johns Hopkins, Harvard, Stanford, and the University of Chicago (Husen, 1991). With the development of the American land grant colleges in the latter half of the 19th century, service was added to the mix of the university mission (Dressel, 1987).

Although public service is considered important to most colleges and universities in America today, the vast majority of faculty time and effort is spent on teaching and research. Based on the National Survey of Post-Secondary Faculty (NSOPF, 1988), faculty at four-year institutions in the United States (on average) spend about half their time on teaching, about 25 percent of their time on research, 14 percent on administration, and less than 5 percent on service (Fairweather, 1996). Time spent on teaching and research vary directly with type of institution. No doubt in part because of departmental research requirements, faculty at research universities spend the least amount of time on instruction, followed by doctoral-granting institutions, comprehensive colleges, and liberal arts colleges (Fairweather, 1996). Time that is not spent on teaching is invested in research and vice versa (time spent on service at research universities is a nominal 1.6 percent; Fairweather, 1996).

Research universities are perceived by the public to be the premier institutions in higher education, with significant prestige being garnered from their research activities (Bowen, 1980; Fairweather, 1996). Outside of two-year colleges, research universities have the largest number of faculty and enroll the largest number of students in American higher education (Allen, 1996; NCES, 1995). It is to the research university that parents hope to send their children in order to receive the finest teaching available from the best scholars in America:

> ...it is the instructional function of higher education, not the research and service missions, that most endears higher education to the public. There is no evidence that the public believes the benefits of college are independent of what is taught and learned there. (Hearn, 1992, p. 21)

The reality within research universities, in some ways, is at odds with public perceptions. Research university faculty spend the least amount of time teaching, compared to faculty at other four-year institutions, and the trends are disturbing. In 1987, faculty at public research universities spent 43 percent of their time teaching and 29 percent conducting research. Just five years later, in 1992, faculty were spending only 36 percent of their time teaching (a share reduction of seven percent and a teaching rate decline of 16 percent) and 33 percent of their time doing research, almost an even split between teaching and research duties (Allen, 1996). Put in hourly terms, faculty at public research universities spent four and one-half hours less per week in instructional work than they did just five years before. Total mean hours worked per week per faculty member at public research universities actually declined by one hour from 57 (1987) to 56 (1992) (Allen, 1996).

This shift in the allocation of time away from teaching and towards research in public research universities has not been completely substantiated. When faculty report classroom hours of instruction and student contact hours, they actually spent more time in the class and more time with students in 1992 than they did in 1987 (Allen, 1996). Thus, the picture is somewhat mixed as to how faculty are spending their time between teaching and research.

The de-emphasis of undergraduate teaching in research universities in the United States has had a particular chilling effect in the sciences. In a recent report, the National Science Foundation (NSF) found that "undergraduate programs in science and engineering have failed to provide non-majors with a basic understanding of the sciences" (Bajaj, 1996, A18). The reason: "A 'culture of high science' that places too much emphasis on research" and a university environment that perpetuates "the culture by rewarding faculty members based on the grant money they bring in" (Bajaj, 1996, A18).

Many state legislators and other stakeholders perceive an imbalance between the university functions of research and teaching:

> State officials believe that many colleges and universities, particularly research institutions, have lost sight of their essential mission--the teaching of undergraduate students--as faculty members spend more time away from the classroom engaged in research and other professional activities.
> (Massy & Wilger, 1992, p. 363)

Faculty at research institutions are perceived by the public to devote themselves to their own pursuits and not to the public good (Clark, 1987; Kerr, 1963). As Fairweather states, "The cost of this devotion to research and publishing is teaching, especially undergraduate instruction" (1996, p. xii). Calls for higher education to reclaim the public trust by encouraging more faculty involvement in undergraduate education can be heard on campus, in the halls of legislatures, and in other public forums (Association of American Colleges, 1985; Boyer, 1987; Jacobson, 1992; Study Group on Conditions of Excellence in American Higher Education, 1984).

Dwindling faculty time devoted to teaching is only one symptom of the perceived second-class status of undergraduate education at research universities. Increasing specialization of teaching disciplines, decreasing involvement of students in their own undergraduate programs, and reward structures that negate the importance of instruction in promotion and tenure decisions all signal potential problems in undergraduate education (Fairweather, 1989). Boyer puts it succinctly:

> Professors are expected to function as scholars, conduct research, and communicate results to colleagues. Promotion and tenure hang on research and publication. But undergraduate education also calls for a commitment to students and effective teaching. (1987, p. 4)

The demands for both teaching and research place severe burdens on faculty at research universities, and to some degree, even faculty at other four-year institutions of higher learning. Martin & Berry (1969) describe the quandary and anxiety associated with these demands as "the teaching-research dilemma." A number of theoretical frameworks attempt to describe why faculty find themselves in this dilemma and why, too often, faculty members choose to emphasize research over teaching.

Theoretical Frameworks

One model exploring the teaching-research dilemma stems from the very nature of the university. Despite its seemingly 19th century roots, the current philosophy of university research is tied explicably to the governing concepts of knowledge and truth which have come down to us from a much earlier period (Wilshire, 1990). Thus, according to A. N. Whitehead, "the 20th century university is organized according to principles of 17th century scientific thought" (1943, p. 55). The tension lies in the theoretical base (research, knowledge) for the university's existence versus the utilitarian (teaching) mission demanded by the public, theoria versus praxis (Husen, 1991). Faculty attempt to juggle their loyalties between these competing ideological demands, but end up favoring research over teaching because of these long-standing empiricist underpinnings begun in the 17th century and strengthened during the rise of the German model in the 1860s (Veysey, 1965).

A second framework, closely aligned to the first, is that faculty tend to favor research over teaching because of cosmopolitan versus local pressures on the professorate (Jencks & Reisman, 1968; Martin & Berry, 1969). Generally speaking, the public demands that the transmission of knowledge (teaching) within institutions of higher learning take precedence over that of generating knowledge (research). However, the professor is a member of a world-wide association of scholars that recognizes excellence through publication (research) over that of teaching. Identification with a group of scholars by the vast majority of university faculty often transcends the restricted teaching boundaries and instructional needs of the local college organization (Jencks & Reisman, 1968; Martin & Berry, 1969).

Many faculty members thus find themselves caught between two different, competing demands: to teach for the public in the local university setting, and to conduct research (publish) for the cosmopolitan profession as a whole (Martin & Berry, 1969). Few can meet both obligations well. In addition, publication of research builds up reputational value that can be traded on the open market; teaching excellence is not very marketable outside the campus mall (Barnett, 1992; Fairweather, 1996).

A third conceptual framework for why faculty members tend to favor research over that of teaching is the specific normative behaviors that university faculty acquire during their graduate training (Barnett, 1992; Fairweather, 1996; Reynolds, 1992).

Graduate training serves as the major agent of socialization for university faculty (Barnett, 1992; Fairweather, 1996; Reynolds, 1992). It is in graduate training that new faculty learn the accepted values, attitudes, norms, knowledge, and skills required by faculty members to survive in the research-oriented university setting.

The normative expectations that research is more important than teaching among university faculty may have developed in the graduate years, but what fosters the permanent continuance of that behavior in the university setting? Fairweather (1996), Behymer (1974), and Finkelstein (1984) discuss one explanation: faculty behavior is primarily a function of intrinsic rewards that internalize the value of research and publication achievement over teaching responsibilities. "This view is consistent with that of an inevitable progression of faculty toward a single behavioral norm, based on research and publishing, incapable of being altered by outside forces" (Fairweather, 1996, p. 45). Fairweather (1996) and Tien & Blackburn (1996) dispute that the major force behind the favoritism of research is primarily intrinsic rewards because this explanation ignores the historical evolution of institutional types; the measurement of intrinsic, motivational reward structures is imprecise; and because such behavior on the part of faculty is ultimately self-defeating.

A second explanation by Fairweather (1996) for why faculty concentrate more on research than teaching puts forth the fourth conceptual framework that addresses Martin & Berry's (1969) research/teaching dilemma. In Fairweather's view, extrinsic reward structures favor research over teaching and "thus serve to sway faculty interests for educating students toward research and publishing instead" (Fairweather, 1996, p. 45). The external faculty reward structure, according to Allpert (1985), acts as a device to ensure the continuation of research norms in all institutions of higher education and in all disciplines. Faculty behavior is influenced by what Fairweather (1996) calls institutional incentives: direct faculty rewards (compensation, promotion, tenure) and secondary rewards (such as workload, work assignment, advising loads, research support, and number of support staff).

The claim that external rewards motivate faculty to conduct research over teaching is supported by the work of Massy & Zemsky (1994). Their theory of the "academic ratchet" puts forth the external motivating factors that impel faculty towards research and away from teaching (Massy & Zemsky, 1994). In the academic ratchet, "individual faculty members increase their discretionary time (time for pursuing professional and personal goals) largely by loosening their institutional ties and responsibilities...faculty place greater value on discretionary time; undergraduate teaching is accorded less importance" (Massy & Zemsky, 1994, p. 2). The academic ratchet produces "output creep," the gradual change in the research and teaching mix at colleges and universities (Massy & Wilger, 1992). What drives the ratchet that causes output creep?

> A reduction in teaching load won by one member of the department because of an outside offer, a research grant, or another external opportunity becomes the new norm against which all members of the department measure their own required commitments and gauge their own discretionary time.
> (Massy & Zemsky, 1994, p. 3)

Thus, external rewards, such as grants and contracts, mold faculty behavior into emphasizing research over that of teaching because the collective conduct of university departments directly impacts individual faculty behavior. The modern university is organized around departments. It is the department that hires, promotes, retains, fires, and rewards their individual members (Massy & Wilger, 1992; Massy & Zemsky, 1994). As the basic unit of academic life outside the individual professor (Kogan & Becher, 1980), the subunits of university organization (departments) in many ways are more powerful than the larger organizational culture in which they reside (Volkwein & Carbone, 1994).

Do departments make organizational decisions based on an internal set of goals and objectives, or does the external environment of rewards exert a greater influence on departmental and faculty behavior? Fairweather's (1996) and Barnett's (1992) conclusions regarding the significance of external reward structures in driving internal organizational behavior are somewhat analogous to Pfeffer & Salancik's (1978) resource dependency theory. Resource dependency can be used to explore the teaching-research dilemma and the effects of changes in funding sources upon internal university department operations. This framework was chosen as the conceptual basis for the current research for two reasons: 1) changing resource patterns in higher education offer a chance to test the explantory power of resource dependency regarding organizational response to external control, and 2) personal research interests of the author.

Conceptual Framework

Pfeffer & Salancik's The External Control of Organizations explores how the external environment drives the internal decisions which organizations and their sub-units make on a daily basis. Organizations survive if they are effective, and their effectiveness derives from the management of competing interest group demands (Pfeffer & Salancik, 1978). These interest groups, either directly or indirectly, dictate organizational form, mission, goals, and objectives because the organization depends upon them for resources and support (Pfeffer & Salancik, 1978). The key to survival is the ability of the organization to acquire and maintain resources (Pfeffer & Salancik, 1978).

The above external control of organizational life would be problematic if stable supplies of resources were readily available. However,

> Problems arise not merely because organizations are dependent on their environment, but because this environment is not dependable. Environments can change, new organizations enter and exit, and the supply of resources becomes more or less scarce. When environments change, organizations face the prospect either of not surviving or of changing their activities in response to these environmental factors...(Thus) a good deal of organizational behavior, the actions taken by organizations, can be understood only by knowing something about the organization's environment and the problems it creates for obtaining resources. (Pfeffer & Salancik, 1978, p. 3)

This "contextual perspective" for understanding organizational behavior leads to a sociopolitical definition of organizational effectiveness (Pfeffer & Salancik, 1978). Organizations are effective if they have the ability to create acceptable outcomes and actions (Pfeffer & Salancik, 1978). Effectiveness, as defined by the authors, differs from efficiency, which is an internal perspective on organizational life. Organizational effectiveness is an external standard of "how well an organization is meeting the demands of the various groups and organizations that are concerned with its activities" (Pfeffer & Salancik, 1978, p. 11).

The interdependence among organizations for their mutual survival and growth is a major constraint upon individual organizational behavior. "Interdependence is important to an organization because of the impact it has on the ability of the organization to achieve its desired outcomes" (Pfeffer & Salancik, 1978. p. 41). This external environmental constraint on organizational-environment relationships places a greater organizational imperative on maintaining external resource flow than on internal efficiency standards (Pfeffer & Salancik, 1978). Pfeffer & Salancik explain further:

> The argument that the organization is a coalition of support implies that an important factor determining the organization's behavior is the dependencies on the various coalition participants. An organization's attempts to satisfy the demands of a given group are a function of its dependence on that group relative to other groups and the extent to which the demands of one group conflict with the demands of another. (1978, p. 45)

Three factors determine the degree of organizational dependency: 1) the importance of the resource, the relative magnitude of the resource and its criticality relative to the operation and survival of the organization; 2) the degree to which the interest group controlling the needed resource has discretion over its allocation and use; and 3) the number of alternative resource providers; the extent of control by a single organization over the required resource (Pfeffer & Salancik, 1978).

When the availability of resources and their providers are in a state of flux, the organization receiving the resources finds itself in an unstable environment (Pfeffer &

Salancik, 1978). The instability of the external environment causes destabilization within the organization (Pfeffer & Salancik, 1978). In an attempt to regain organizational equilibrium in a period of resource fluctuation, organizations experience internal pressure to modify their behaviors to counteract external variation in resource flows (Pfeffer & Salancik, 1978; Slaughter & Leslie, in press).

Purpose

In the past ten years the resources that colleges and universities depend upon have become unstable. Total financial support provided to colleges and universities by federal and state governments has declined on a share basis and the nature of that support has changed from largely unrestricted, block grant funding to that of single project, specific-purpose funding (NCES, 1995; Slaughter & Leslie, in press).

In response to these external funding changes, universities are experiencing destabilization as described by Pfeffer & Salancik (1978). That is, university resources are now in a state of transition and the organizational stability of most publicly-funded colleges is threatened. To regain organizational equilibrium in this period of resource instability, universities modify their behaviors to align themselves more closely to those interest groups that have control over needed resources (Barnett, 1992; Pfeffer & Salancik, 1978; Silva & Slaughter, 1980; Slaughter & Leslie, in press).

The behavior modification that universities are making appears in several forms. Under pressure to replace lost funds from state and federal block grants, university administrators drive department heads to develop alternative sources of internal funding

(Slaughter & Leslie, in press). Department heads, in turn, exhort their faculty to greater efforts in producing grants and contracts to replace revenues lost to the departments. Thus, a reduction in state block-grant revenues may cause an internal reallocation of faculty's time spent on teaching, research, and service.

The allocation of time by faculty within these three functional areas is variable. It is dependant upon workload requirements of the college and/or department, any teaching workload stipulations mandated by the state legislature, and university reward structures. To understand how American undergraduate education has changed, we must discern the relationship between external resource modifications and the transformation of faculty time spent at teaching, research, and service.

The purpose of this study is to investigate how modifications in university resource dependance have directly affected faculty productivity in undergraduate instruction. If faculty have re-allocated their time in response to external changes in university revenue sources, then the current complaints by some constituents surrounding undergraduate education (that faculty are doing less teaching and more research) may be a direct result of these external funding changes. Information gained from an investigation into this area may have a profound effect on current and future higher education financial support policies of individual states and the federal government.

Research Questions

This study will investigate the number of undergraduate student credit hours taught and class sections offered in relation to research spending at universities and colleges classified by the Carnegie Commission as Research I and II institutions. The unit of analysis will be individual departments. The study will investigate the relationship of research spending by these departments and the number of undergraduate student credit hours produced per faculty member and the number of class sections taught per faculty member. Specifically, the following research questions will be asked:

1a. Do departments in Research I and II universities with greater research expenditures (on a per faculty member basis and as a percent of total research, teaching, and public service expenditures) produce fewer undergraduate student credit hours and/or fewer undergraduate class sections taught per tenure/tenure-track faculty member?

1b. Do greater research expenditures affect the number of undergraduate student credit hours and class sections taught per other regular faculty members, supplemental faculty members, and teaching assistants?

2. Are there faculty undergraduate instructional productivity differences among academic fields?

3. Are there differences between public and private institutions in faculty undergraduate instructional productivity?

These questions are relevant within the resource dependency reference framework and are meant to explore the potential influence of a single external resource (research spending) upon a single internal aspect of organizational work (faculty instruction). As such, these questions do not address the possible influence of graduate training upon individual faculty preference for research or teaching; the dynamics of faculty and departmental culture within higher education as they influence faculty time allocations among teaching, research, and service; the effects of departmental power upon faculty workload assignments; and the internal reward structures of departments as it affects faculty undergraduate instructional productivity.

The questions, answers, and interpretations that these other perspectives might pose are addressed in Chapter 3 under the Limitations section. In addition, a more complete analysis of resource dependency effects using multiple external influences and internal responses, especially regarding public versus private institutional status, would have been possible if sufficient private university data had been available (only data from four private universities were available for analysis). Again, these limitations, as well as others, are discussed in Chapter 3.

From the conceptual basis of resource dependency, we would expect an inverse relationship between research spending and undergraduate instructional productivity. As research spending increases, whether in departmental magnitude (total spending per faculty member) or in departmental criticality (research expenditures as a share of the total budget), faculty should tend to spend more of their time in related research activities to ensure this steady stream of funding into their respective departments. Since research and teaching appear to have an exchange relationship (Fairweather, 1996), the amount of instructional output should be cocomintantly reduced as faculty devote more of their efforts to maintain these revenue sources (research grants and contracts) and away from instruction. Thus, departmental research spending would tend to depress faculty undergraduate instructional productivity. In resource dependencey terms, an external agent of control (research grants and contracts) influences and reorganizes internal organizational structures (faculty instructional productivity).

If little or no relationship exists between departmental research expenditures and faculty undergraduate instructional productivity, then Pfeffer & Salancik's (1978) resource dependendecy model may be excluded as an explanatory therom for variation in faculty undergraduate instructional production. As noted earlier, faculty training, culture, power & influence, and internal reward structures within university departments would then need to be explored to explain productivity variance in undergraduate instruction.

Assumptions

The successful completion and appropriate interpretation of this study depend upon a number of assumptions. The data set that will be used is the National Study of Instructional Costs and Productivity (NSICP). This study was conducted in 1993, 1994, and 1995 by the University of Delaware and is an ongoing longitudinal data collection project. Underwritten by a grant from the Fund for the Improvement of Postsecondary Education (FIPSE), this database contains detailed departmental measures of faculty teaching workloads; research, instructional, and service expenditures; and faculty instructional productivity. The study involves over 160 colleges and universities, including 32 research I and II universities.

The information contained in the NSICP is self-reported by individual departments within the university or college setting. As a general rule, self-reported data often are suspect because preference falsification may take place; that is, individuals may distort data in an attempt to preserve their reputation (Kuran, 1995). The act of data falsification has genuine value or "reputational utility" to those misleading others about the true conditions within university departments (Coughlin, 1995). Nevertheless, we must assume that the information reported by individual departments in this data set (and aggregated by the university or college) is a true representation of what actually occurred, or that bias is systematic.

Another assumption of this research is that the number of student credit hours taught by tenure/tenure-track faculty and the number of class sections offered by individual departments act as proxies for the time faculty spend on undergraduate education, and that in-class instructional time is an underlying indicator of commitment to undergraduate education. This may be an inadequate measure of faculty commitment since the time spent by faculty members outside the classroom interacting with students is sometimes of greater significance to undergraduate education than the time spent within the classroom.

Since quality is virtually impossible to define in higher education, this study will apply Baumol, Blackman, and Wolff's (1989, p. 235) definition of gross productivity to institutions of higher learning: "The number of units of output produced per unit of input, with no attempt to adjust for any accompanying changes in product quality." What this study will measure directly is a modified economic model of productivity, the relationships among student credit hours taught, class sections offered, and research dollars expended by specific firm (university departments) activities (research and teaching). The conceptual framework for this productivity model is based on the economic theory of the firm (Hanushek, 1979; Hopkins, 1986; Wallhaus, 1975). The joint production of teaching and research in institutions of higher education, the personal utility of research and teaching, and whether the production of research benefits undergraduate education will be explored thoroughly in this study.

For the purposes of this study it is assumed that the fewer undergraduate credit hours and class sections taught per tenure/tenure-track faculty member is a general indication that research takes primacy over faculty instructional productivity in undergraduate education. Nevertheless it is recognized that fewer credit hours produced by a department on a per faculty member basis may indicate a strengthening commitment to a quality undergraduate education rather than a weakening; the importance that faculty places on quality instruction over that of quantity. Although this may be the case, fewer student credit hours produced by full-time faculty (or alternately fewer classes offered) would be interpreted by most stake holders outside the university as a decline in the production of the product "teaching." Without this assumption, this study has little value to the higher education community or policy makers at the local, state, and federal government levels.

Definition of Terms

Research I and II Universities

These institutions offer a full range of baccalaureate programs, are committed to graduate education through the doctorate, and give high priority to research. They award 50 or more doctoral degrees each year. Research I institutions receive $40 million or more in federal support annually; Research II universities receive between $15.5 million to $40 million in annual federal support. (Carnegie Classification)

Tenure/Tenure-track Faculty

Tenured and tenure-eligible faculty (usually full, associate, and assistant professors) who either hold tenure or are on a tracked slot for tenure within the department. (NSICP, 1994)

Other Regular Faculty

Instructors, lecturers, and other full-time, non-tenure track personnel, including any visiting faculty, distinguished faculty, emeritus faculty, and permanent part-time teaching personnel. (NSICP, 1994)

Supplemental Faculty

Any part-time (non-permanent) faculty, adjunct faculty, and administrators/staff that teach. (NSICP, 1994)

Teaching Assistants

Any student that receives a stipend at an institution of higher learning strictly for teaching activity. These will include instructors of record, discussion section leaders, recitation section leaders, laboratory section leaders, and other types of organized class sections. Graduate research assistants are specifically excluded from this category. (NSICP, 1994)

Faculty Workload

The number of course hours or class sections assigned to an instructor (professor) to teach.

Time Allocation

The percentages of time spent by an instructor on teaching, research, and public service.

Productivity

In economic terms, the ratio of output to input in an organization, or the value of outputs relative to the value of inputs (Wallhaus, 1975). Quality of the outputs, however, must be maintained otherwise no real changes in productivity have occurred (Corrallo, Gilmore, & To, 1988). In higher education, defining and determining "quality" is difficult because no agreement on a definition can be reached by all the stakeholders. Thus, in most studies a gross measure of productivity is determined by counting the number of students taught, number of degrees awarded, student credit hours taught, class sections taught, or the number of scholarly publications produced per faculty member. In this study, faculty productivity will be defined narrowly in one dimension only (teaching) and will be measured by student credit hours and class sections taught per faculty member.

Production Function

The process whereby a college or university transforms inputs (faculty time and effort, student time and effort, etc.) into outputs (student enrollment, degrees awarded, etc.).

Joint Production

The concurrent production of multiple products (teaching, research, and service) by a department, college, or university.

Utility

In economic terms, the quality or property of being useful; the power to satisfy the needs or wants of individuals.

Economies of Scale

Circumstances, conditions, etc. that encourage the mass production of a good by lowering its unit cost as greater quantities are produced. Economies of scale are assumed to exist if, as production is expanded, total costs increase proportionately less than total output.

Ray Economies of Scale

Measurement of the overall economies of scale.

Product-specific Economies of Scale

Those economies of scale that are differentially exhibited for specific multi-product outputs, such as undergraduate education, graduate education, and research.

Economies of Scope

The cost savings accruing to firms producing two or more outputs jointly as against specializing in the production of a single output.

Global Economies of Scope

Measurement of the overall economies of scope; whether the cost of jointly producing two (or more) products will be less expensive than the cost of producing each separately.

Product-specific Economies of Scope

The specific, individual cost advantage of producing each single output jointly with other outputs. For example, the joint production of one output (undergraduate education) with another output (graduate education) is considered to demonstrate product-specific economies of scope if it is less expensive to produce undergraduate education and graduate education together rather than to produce each of them independently. The degree of product-specific economies of scope is the measurement of the proportional increase or decrease in costs resulting from producing all of the outputs except for one that is excluded.

Production Output

In higher education, output has been variously defined as the products produced by college and university activities, usually narrowed to research and teaching (service activities are normally excluded because of the difficulty in measurement and relative level of interest). There is no consensus in higher education of what constitutes appropriate measures of research and teaching outputs. For research, output may be defined as the number of publications produced (books, articles, reviews), quality of publications (percent of articles in refereed journals), quality of research (evaluated by university peers or some outside rating service), citations, research activity (the number of faculty engaging in research), research reports, public lectures, patents, sponsored research expenditures, number of research contracts, number of grants received, or the total amount of grants. Instructional output may be defined as credit hours produced, total student contact hours, class sections offered, total student enrollment, student enrollment expressed in FTE terms, number of earned degrees produced, percent of students graduating, instructional objectives met, graduate exit scores on standardized student achievement exams, or percent employed in field upon graduation. The above teaching output may be delineated further into undergraduate and graduate levels. Undergraduate output may be separated into two tiers: first two years and final two years. Graduate instruction may be further specified as master or doctoral instructional output.

Summary

In the past five to ten years, state financial support for public colleges and universities has been reduced. The reduction has occurred in relative terms, with colleges and universities seeing the proportion of their total financial support provided by federal and state governments being diminished. As direct state funding has declined, colleges and universities have sought alternate forms of support to replace the lost funds, mostly through an increased emphasis on securing and maintaining a variety of contracts and grants. This increased contract and grant seeking behavior has been accomplished through individual departments, the main economic and administrative units of colleges and universities. Administrators at all levels actively encourage faculty members to seek out external sources of funding that will support research directly and sustain departmental administrative functions indirectly through the billing of overhead charges.

Resource dependency may explain how alterations in revenue support have subtly affected undergraduate education at major public research universities. Specifically, the number of credit hours and/or class sections taught per faculty member (faculty productivity) may have been reduced directly in proportion to the amount of external research financing acquired by university departments. Fewer hours may be spent in the classroom and fewer classes may be taught as higher education faculty devote more of their discretionary time seeking and acquiring resources to replace lost state revenues, and then performing the associated work. Resource dependency might explain the behavior of faculty in this regard, revealing that external agents of resource supply and rewards have a greater impact on university organizational mission and goals than many imagine.

In the following chapter, a review of the literature examines the teaching-research dilemma, whether there are benefits in having research and teaching performed simultaneously at the same institution, the utility that professors derive from teaching and research, and the relationship (if any) between teaching effectiveness and research productivity at institutions of higher education.

CHAPTER 2

REVIEW OF THE LITERATURE

Reasons

> There are perceptions out there that the faculty doesn't teach enough, that the faculty spends too much time doing research, that the faculty is overpaid. (Spoken by Stephen M. Jordan, deputy executive director for finance and planning, Arizona Board of Regents; from Jacobson, 1992, p. A1)

The publicly perceived imbalance between teaching and research at major institutions of higher education is not a new phenomenon. As early as 1909, concerns were raised about the parity between research and teaching at select colleges and universities. In that year, the Carnegie Foundation for the Advancement of Teaching asked Frederick Taylor to "write an economic study of college output, applying to college administration insights from the new field of factory shop management" (Schacter, 1991, p. 85). Taylor was busy so he suggested that the Foundation ask Morris Cooke (a colleague who had assisted Taylor on numerous assignments) to conduct the study (Schacter, 1991). As a true believer in scientific management, Cooke was interested in increasing production, objects made per hour (Schacter, 1991). In the field of education, that meant increasing teaching.

Current complaints that undergraduate teaching is being short-changed in favor of research are the same complaints made by Cooke in his 1910 report. Cooke discovered that faculty demanded light teaching loads because promotion decisions were made on production of research and not on teaching (Cooke, 1910). Large introductory courses were assigned to teaching assistants who also quickly discovered that research was more important than teaching (Cooke, 1910). Cooke saw the problem in simplified terms: "A research-dominated system was inefficient because faculty scholarship had little relevance to undergraduate education" (Schacter, 1991, p. 86).

This alleged lack of relevance is still being questioned today by parents, students, and legislators. With many state economies in a troubled condition and the increasing pressure placed on state governments to solve public health and welfare problems, faculty productivity (defined by most of the public as teaching workload) at public colleges and universities are being examined anew (Layzell, 1992). In the public's mind, the reasons are straight-forward:

> Faced with tight finances, state governments are concerned with achieving the highest quality "outcomes" possible in the main areas of faculty activity, that is, instruction, research, and public service. An analysis of faculty workload is the logical starting point in assessing productivity and effectiveness. (Layzell, 1992, p. 2)

Major Review Studies

Exploring faculty productivity issues is not as simple as Cooke (1910), Layzell (1992), or others would imagine. A review of the major studies in this area involve three distinct yet overlapping areas of content. First, issues of faculty productivity should be grounded in the literature of higher education production functions. Without an examination of higher education production functions and the potential for economies of scale and scope, policy decisions that attempt to improve teaching productivity will be futile. Second, the personal utility of research and teaching must be explored to understand faculty preference decisions and substitution effects between these two functions. Finally, the influence of research on teaching effectiveness should be investigated to discern whether being a productive university researcher is a necessary and sufficient condition for undergraduate teaching excellence.

Higher Education Production Functions

College and university faculty have historically been charged with three functions: to teach, to conduct research, and to perform service. These three functions (teaching, research, service) are what college and university faculty produce for society. The framework for such societal production is based on the economic theory of the firm (Hanushek, 1975; Hopkins, 1986; Wallhaus, 1975). In this theory of the firm, production decision rules are developed based on the linkage between input prices, input-output relationships, and output prices (Hanushek, 1975). On the surface, this industrial production model appears to fit higher education because universities purchase inputs (faculty, staff, equipment) and produce outputs (occupational preparation of students, new knowledge from research, community development) (Hanushek, 1975; Wallhaus, 1975).

However, a major problem arises in this model as it applies to higher education: How do we measure the inputs? How do we measure the outputs? How is the relationship between inputs and outputs defined? In the industrial firm, the problem of measurement is quite simple because the values of the inputs and outputs can be evaluated by using prices (Wallhaus, 1975). In addition, the relationship between inputs and outputs can be described by using the specific production function of the firm (Hanushek, 1975; Hopkins and Massy, 1981; Hopkins, 1986).

In higher education, the inputs and outputs are quite varied and their coefficients cannot be assessed with any mathematical precision (Hopkins, 1986; Wallhaus, 1975). The technologies of teaching, research, and public service are poorly understood and the interactions among these three elements are hard to depict in mathematical terms (Hopkins, 1986). Finally, estimating the proper form of the production function within higher education is problematic (Brinkman, 1986; Hopkins, 1986).

These problems are only compounded when considering joint production at colleges and universities. At institutions of higher education, the resources expended in joint production of teaching, research, and service cannot be divided simply among the outputs (Hanushek, 1975). Even very precise attempts at measuring time and expenditures devoted to these several outputs would not be sufficient to capture the full resources used (Hanushek, 1975). Complementarity and substitution effects among teaching, research, and service cannot be ignored, thus complicating any analysis of joint production processes (Hanushek, 1975).

Despite these reservations, there have been at least two theoretical attempts at evaluating joint production in higher education. Nerlove examined the joint production of undergraduate education and graduate education combined with research (1972). He envisioned a production possibility curve in joint space with regions of complementarity and substitution in undergraduate and graduate education (Hopkins, 1986; Nerlove, 1972). Another theoretical model proffered by Simpson (1982) used a geometric concept in describing joint production in higher education. The major feature of this model was that a discrete mathematical relationship linking inputs to outputs was not necessary for analysis of joint production (Simpson, 1982).

On the empirical side, Southwick (1969) and Sengupta (1975) were unsuccessful in fitting numerous joint production models to available statistical data sets from several colleges and universities. Examining the issue of economies of scale with more success, the Carnegie Commission (1972), Verry & Layard (1975), Verry & Davies (1976), and Bowen (1980) found constant returns to scale in higher education. Maynard (1971) and Brinkman (1981) found economies of scale in higher education as did Brinkman & Leslie (1986) from a detailed meta-analysis.

Recently, Cohn, Rhine, & Santos (1989); de Groot, McMahon, & Volkwein (1991); Nelson & Hevert (1992), and Dundar & Lewis (1995) have investigated scale and scope issues of research and teaching at institutions of higher education. In the case of Cohn et al. (1989), Higher Educational General Information Survey (HEGIS) data from 1981-1982 were used (1,887 institutions sampled); de Groot et al. (1991) utilized the same data set from 1982-1983, but with a smaller sub-sample of institutions (147 doctorate-granting universities). Nelson & Hevert (1992) studied 31 departments at a single university. Dundar & Lewis (1995) examined scale and scope issues on the departmental level using the American Association of University Data Exchange (AAUDE, 1985-1986) data set sampling 17 science departments in 18 research universities.

All of the above studies examined university and college cost functions as they relate to economies of scale of operation (size) and economies of scope of operation (undergraduate instruction, graduate instruction, and research) based on the seminal work on production function economies by Baumol, Panzar, & Willig (1982). In addition to Nelson & Hevert (1992) and Dundar & Lewis's (1995) research, Gander (1995) explored productivity issues at the departmental level, but his research concentrated on the effects of faculty and department size on inter-departmental production functions rather than on a multi-product cost function. All three of these studies (Nelson & Hevert, 1992; Dundar & Lewis, 1995; Gander, 1995) will be explored further in the Proposed Study section of this chapter.

The results of these recent studies in joint production costs are varied. Cohn et al. (1989) found economies of scale at public colleges and universities but only at the mean output level. At output levels exceeding 100 percent of the mean, ray dis-economies of scale existed along with product-specific dis-economies of scale for undergraduate education. Economies of scope (joint production of undergraduate instruction, graduate instruction and research) were not demonstrated until production exceeded 200 percent of the output means (Cohn et al., 1989). Private colleges and universities exhibited somewhat opposite behavior in that ray economies of scale were present through all production levels; product-specific dis-economies of scale were demonstrated for undergraduate education at all levels except between 300 and 350 percent of mean output; and economies of scope were observed throughout all levels of production (Cohn et al., 1989)

De Groot et al. (1991) contradicted some but not all of Cohn et al.'s (1989) findings by demonstrating public university economies of scale at the mean output and at all levels beyond. Economies of scope existed between undergraduate and graduate instruction at the mean (de Groot et al., 1991). University sector (private vs. public institution) did not change the scale and scope results, a conclusion opposite that of Cohn et al. (1989). De Groot et al. also found some evidence that graduate education is subsidized by undergraduate costs, and that research expenditures may be subsidized by non-research revenues (1991). This finding is supported by the earlier work of James (1978) and by the more recent research of Nelson & Hevert (1992).

Nelson & Hevert's (1992) study found no economies of scale nor scope at the departmental level if class size was controlled. The authors noted that studies investigating economies of scale and scope that do not control for class size are upwardly biased (Nelson & Hevert, 1992). There were two other significant findings from this study: 1) educational cost functions of undergraduate and graduate education should not be considered separable outputs; thus formula funding schemes that apply to graduate students a fixed multiple of undergraduate costs may be inappropriate; 2) research expenditures increase the cost of undergraduate education. Thus as in de Groot et al. (1991) and James (1978), undergraduate education may be said to subsidize faculty research efforts (Nelson & Hevert, 1992).

Dundar & Lewis's 1995 study of departmental cost functions confirmed de Groot et al.'s (1991) earlier conclusions of economies of scale/scope. These two studies, in addition to Cohn et al., did not control for class size as did Nelson & Hevert (1992). Dundar & Lewis's (1995) research found ray and specific-product economies of scale and scope in the science departments they investigated suggesting "that the departmental costs of producing undergraduate teaching along with graduate education, and the costs of producing graduate education along with departmental research, are significantly less than producing them separately" (Dundar & Lewis, 1995, p. 143).

The significance of all the above contemporary research on scale and scope production functions to the proposed study is threefold: 1) higher education production functions define the broad inputs and outputs to be considered for any study concerned with undergraduate instructional productivity; 2) the above research suggests the general modeling techniques necessary to examine the subtle relationship between research and teaching at institutions of higher education; and 3) it brings issues of substitution effects between research and teaching to the forefront of discussion about undergraduate education.

There remains some question whether undergraduate education can be produced less expensively when coupled with graduate education and research (James, 1978; Nelson & Hevert, 1992), but if class size is allowed to vary, economies of scale and scope can be achieved (Cohn et al., 1989; de Groot et al., 1991; Dundar & Lewis, 1995). Further, the research suggests that undergraduate education subsidizes (to some degree) graduate education, and non-research activities subsidize research production (de Groot et al., 1991; James, 1978; Nelson & Hevert, 1992). And although the beneficial aspects of economies of scope may be evident, production function research does not address whether faculty are spending time on research to the detriment of undergraduate teaching. That is, despite the possible advantage of joint production within a university setting, undergraduate education may still be receiving the short-end of the stick regarding faculty time and effort. Why?

Analyzing personal utility functions within higher education may help in understanding how joint production decisions are made by individual departments and institutions. In looking at joint production, two facets of the multi-product problem arise: 1) the objective function that drives the production process, and 2) the performance of the process, that is, the actual productivity that occurs within institutions of higher education (Hanushek, 1975). The objective function is the incentive structure or set of values that exists within each department, college, or university (Hanushek, 1975). These values determine the weights that are placed on teaching and research. Without evaluating the preference structures of all the role players involved, questions about what is produced are irrelevant.

We are thus left with the following questions: What are the weights of instruction, research, and service across institutions? What are the values of these three outputs to different groups within the institution? How does the external environment affect these values and the weightings of the different outputs? (Hanushek, 1975). Some of these questions can be answered by analyzing how personal utility affects the joint production output of teaching, research, and service. In that regard, the next section will survey the literature of personal utility within higher education.

Personal Utility of Research and Teaching

When discussing the joint production process of institutions of higher education, the allocations of time by faculty to teaching, research, and service become the inputs for the production function. Issues surrounding the quality or value of college and university output necessitate an examination of how the mix of instruction, research, and service impacts what the university produces (output). Information about how the mix of university production (output) is determined is scarce. The preference or value efficiency (also known as personal utility) of individual participants in higher education has been studied theoretically but few empirical personal utility studies exist. Thus, we have very little data about the preference structures (personal utility) that are relevant to higher education (Wallhaus, 1975). We also do not have a good understanding of whose preferences should be considered paramount: university administration, faculty, students, or those who supply the funds for college education such as parents, philanthropic foundations, and government (Wallhaus, 1975)?

Although little is known about the personal utility of all the stakeholders in higher education, at least a few researchers have developed a conceptual framework for the personal utility of university professors. McKenzie (1972), Needham (1975), and Becker (1975, 1979, 1982a, 1982b) have set forth various personal utility models that attempt to describe the behavior of college faculty towards teaching and research. Although the component of service is left out in all of these models, the economic and mathematical frameworks described can easily be extended to include the service element, if needed.

In 1972, McKenzie examined the impact of teaching load reductions on faculty teaching and research levels. Mckenzie's model concentrated on the personal utility of teaching and research for college faculty, ignoring the problems of evaluation and measurement and focusing instead on the theoretical construct only (McKenzie, 1972). He assumed basic time constraints for these two activities, either more time could be expended on teaching and less on research or vice versa. Limited amounts of research and teaching would yield positive utility to a faculty member, but beyond some fixed level, any additional research or teaching would detract from overall utility (incur disutility) (McKenzie, 1972).

Needham (1975) criticized McKenzie's work as being invalid because McKenzie set the marginal utility of faculty leisure time equal to zero. Thus leisure time, often referred to as consumption activity, was considered irrelevant by McKenzie's model, a fatal flaw identified by Needham and expanded upon by Becker (1975, 1979). Becker (1975) saw university faculty as utility maximizers and producers of three products: learning, research, and income (faculty consumption). His assumptions about faculty behavior were straight forward:

1) Faculty members derive utility not only from consumption activity but also from professional activities.

2) The amount of time spent in teaching and research activity will affect, respectively, production of teaching and research.

3) The time spent on either of these activities affects the other in some way (joint production).

4) The professor receives income on the basis of teaching and research output (however research output is defined).

5) The university, in remunerating the faculty member, weights teaching and research with non-negative values.

6) The faculty member attempts to maximize utility subject to the production functions of teaching, research, and consumption (leisure time); the income determination function (university weighting); and the total time available (time constraint). (Becker, 1975)

In 1979, Becker expanded this model further by noting that the equilibrium of teaching, research, and consumption outputs for university faculty depends upon the marginal rate of substitution for the above functions. The value of teaching versus research (the preference efficiency, value efficiency, or personal utility) for individual faculty members can now be explained as being a function of two elements:

1) the weights (whether perceived or actual) that are placed upon teaching and research by college administration (or others) determine the value of teaching or research for faculty members as a whole, and

2) the amount of time spent on either teaching or research by individual faculty members depends upon the marginal rate of substitution (tradeoffs) for these two activities. (Becker, 1979)

The amount of time professors spend in teaching, research, and service is therefore a function of the values or weights of such activities and their marginal rates of substitution. How these activities are balanced by individual faculty members in the classroom, laboratory, and community will be a function of reward structures (weights) and the personal utility derived from those weights (values).

To a large degree, then, it is the reward structure of American colleges and universities that determines how much time is spent by faculty on teaching and research. Teaching effectiveness

> depends upon the degree to which the professor applies himself to this particular activity...the intensity of his teaching effort is related to rewards afforded teaching by the salary structure as opposed to rewards to alternative activities competing for the professor's scarce time. (Siegfried & White, 1973a, p. 309)

Faculty will spend more time on teaching if it is rewarded more than research and vice-versa, given general time constraints and individual utilities for such activities. It is clear from the literature that faculty are more handsomely rewarded in salary, promotion, and tenure for performing research rather than teaching (Bohrer & Dolphin, 1985; Browne & Becker, 1985; Boya & Robicheaux, 1992; Burnett, Amason, & Cunningham, 1989; Daly, 1994; Diamond, 1993; Fairweather, 1989, 1995, 1996; Fry, Walters, & Scheurmann, 1985; Glover, 1993; Hancock, Lane, Ray, & Glennon, 1992; Konrad & Pfeffer, 1990; Luke & Doke, 1987; Massy & Zemsky, 1994; McCullough, Wooten, &

Ryan, 1981; Siegfried & White, 1973a, 1973b; Tien & Blackburn, 1996; Tong & Bures, 1987; Tuckman, 1979; Tuckman, Gapinski, & Hagemann, 1977; Tuckman & Hagemann, 1976). Even if given more discretionary time to spend on teaching because of technological improvements, professors will not automatically allocate more time to the teaching task but may instead simply diminish teaching time to the minimum necessary in favor of rewarded research activities (Becker, 1975).

Faculty time spent on research (and away from teaching) at institutions of higher education may also be affected by the changing nature of research support. As noted earlier in Chapter 1, changes in the funding of higher education away from unstipulated block grants have led many colleges and universities to seek out alternate funding sources, usually in the form of restricted grants and contracts:

> Collectively and individually, faculty perceive their greatest potential source of additional revenues to be in grants and contracts with government and with the private sector. Taking government block grants (as well as student tuition revenues) as a given, they focus their marginal efforts on proposal writing and developing and maintaining relations with potential funders. (Slaughter & Leslie, in press, chapter 2 working draft, p. 8)

These revenue changes usually devolve toward the departmental level where "relatively modest revenue changes are translated into major alterations in how academics spend their time" (Slaughter & Leslie, in press, chapter 2 working draft, p. 7). These behavioral changes were predicted fairly accurately by Bredahl, Bryant, & Ruttan's (1980) research and confirmed by Becker (1982b). Their analyses suggest that a move from internal, non-competitive research funding to external, competitively-determined project grant funding results in an increase in faculty time devoted to external grant seeking (Becker, 1982b; Bredahl et al., 1980). Thus, external macroeconomic changes in university financing affect faculty behavior at the microeconomic, departmental level:

> The end result is a measurable shift in faculty effort from activities financed by government block grants and tuition, specifically instruction and related activities, to generating revenues in competitive, "market-like" areas and satisfying the condition of those awards. (Slaughter & Leslie, in press, chapter 2 working draft, p. 8)

Such fundamental changes in faculty behavior towards more research and less teaching would not present a major problem if research efforts directly benefited undergraduate education, an idea many in academia have held for some time. As will be seen in the next section, however, such a belief appears ill-founded as there is little empirical evidence in support of such a position.

The Influence of Research on Teaching Effectiveness

Engaging in scholarly research has long been thought to improve university teaching (Faia, 1976; Friedrich & Michalak, 1983), and a variety of rationales have been advanced to support the idea:

1. Scholarship makes a professor more knowledgeable, and this knowledge base makes for a better teacher (Abelson, 1967; Feldman, 1987; Friedrich & Michalak, 1983; Gaff & Wilson, 1971; Linsky & Straus, 1975; Marsh, 1984; McCullagh & Roy, 1975; McDaniel & Feldhusen, 1970).
2. Scholarship promotes intellectual involvement and liveliness of the instructor, thus leading to interesting and/or enthusiastic teaching (Abelson, 1967; Centra, 1983; Feldman, 1987; Friedrich & Michalak, 1983; Gaff & Wilson, 1971; Harry & Goldner, 1972; Jencks & Reisman,

1968; Linsky & Straus, 1975; Marsh, 1984; McCullagh & Roy, 1975; Schmitt, 1965).

3. Research improves course organization because professors who regularly conduct research organize their thoughts in a more efficient manner (Feldman, 1987; Friedrich & Michalak, 1983; Michalak & Friedrich, 1981).

4. Research leads to clearer presentations of course material giving students a better understanding of class requirements (Feldman, 1987; Friedrich & Michalak, 1983; Jauch, 1976; Michalak & Friedrich, 1981).

5. Scholarship places high standards of performance on professors. These internal expectations and challenges carry over to high expectations and challenges for students (Feldman, 1987; Friedrich & Michalak, 1983; Harry & Goldner, 1972; Hoyt & Spangler, 1976; Michalak & Friedrich, 1981).

6. Professors who conduct research reason critically and independently, thus engendering these "qualities of mind" in students (Abelson, 1967; Bresler, 1968; Feldman, 1987; Friedrich & Michalak, 1983; McCullagh & Roy, 1975).

7. Research productivity leads professors to introduce more relevant material into the classroom (Feldman, 1987; McCullagh & Roy, 1975).

Most of the studies above were empirical in nature and attempted to substantiate the benefits of research on teaching effectiveness. Since 1950, at least forty-six studies have been conducted investigating the effect of professorial research on teaching effectiveness. The circumstances under which the research was performed and the measurement instruments used have varied:

Research Setting

1. Ten studies were conducted in one department in a single college or university (Lasher & Vogt, 1974; Marsh & Overall, 1979; Plant & Sawrey, 1970; Ratz, 1975; Rushton, Murray, & Paunonen, 1983; Siegfried & White, 1973; Stavridis, 1972; Usher, 1966; Wood & DeLorme, 1976; Wood, 1978).
2. Fourteen studies were conducted at a single college (non-research university) with multiple departments (Aiken, 1975; Clark, 1973; Dent & Lewis, 1976; Frey, 1978; Friedrich & Michalak, 1983; Harry & Goldner, 1972; Hicks, 1974; Hoffman, 1984; Marquardt, McGann, & Jakubauskas, 1975; Maslow & Zimmerman, 1956; Michalak & Friedrich, 1981; McCullagh & Roy, 1975; Riley, Ryan, & Lifshitz, 1950; Rossman, 1976).
3. Sixteen studies were conducted at a single research university with multiple departments (Aleamoni & Yimer, 1973; Bausell & Magoon, 1972; Braunstein & Benston, 1973; Bresler, 1968; Cope, McMillin, & Richardson, 1972; Freedman, Stumpf, & Aguanno, 1979; Goldsmid,

Gruber, & Wilson, 1977; Grant, 1971; Hayes, 1971; Hoyt, 1974; Hoyt & Spangler, 1976; McDaniel & Feldhusen, 1970; Stallings & Singhal, 1970; Stallings & Spencer, 1967; Teague, 1981; Voeks, 1962).

4. Five studies were conducted at a mix of research universities and liberal arts colleges (Ahern, 1969; Centra, studies 1 & 2, 1983; Faia, 1976; Linsky & Straus, 1975); and one study covered a single department in multiple schools (Cornwell, 1974).

Measurements of Research Productivity

1. Total publications were used as the sole measure of research productivity in the following studies: Ahern (1969), Aleamoni & Yimer (1973), Centra A & B (1983), Clark (1973), Faia (1976), Goldsmid et al. (1977), Hicks (1974), Marquardt et al. (1975), McCullagh & Roy (1975), McDaniel & Feldhusen (1970), (1970), Riley et al. (1950), Siegfried & White (1973), and Wood & DeLorme (1976).
2. Citations were used in the following studies: Frey (1978), Linsky & Straus (1975), and Rushton et al. (1983).
3. Research support (as expressed by total dollars of research spending) was used in the following studies: Bausell & Magoon (1972), Bresler (1968), Hayes (1971), Hoffman A & B (1984), and Wood (1978).

4. Peer research evaluations were used in the following studies: Braunstein & Benston (1973), Hoyt & Spangler (1976), Maslow & Zimmerman (1956), Rossman (1976), and Usher (1966).
5. Research activity (engaging in any form of research) was used as a measure in the following studies: Cornwell (1974), and Lasher & Vogt (1974).
6. One study used an external research rating of individual professors to gauge research productivity (Ratz, 1975); one used ACE departmental rankings as a measure of research quality (Cope, et al., 1972), and another used internal faculty self-rating of research (Marsh & Overall, 1979).
7. A number of studies used combinations of the above to evaluate research productivity: Publications and citations (Dent & Lewis, 1976); publications and research support (Plant & Sawrey, 1970; Teague, 1981); citations and peer research evaluations (Friedrich & Michalak, 1983).

Measurement of Teaching Effectiveness

1. All but six of the studies (87 percent; 40 total) used current student evaluations of professors to measure teaching effectiveness.
2. Of the six that did not use student evaluations, five used teaching awards as the proxy for teaching excellence (Ahern, 1969; Faia, 1976; Goldsmid et al., 1977; Rossman, 1976; and Teague, 1981) and one used instructional objectives as the measure of effective teaching (Hoyt, 1974).

The results of these research efforts have been disappointing to those who offer the notion that a professor's research productivity informs and improves his teaching ability. Very few of these studies showed any connection between research productivity and teaching effectiveness. Those that did demonstrate some correlation were mixed as to whether the relationship was positive or negative. In almost all cases, the correlations that were found were statistically insignificant.

Feldman (1987) conducted a meta-analysis on the above forty-six studies and found that on first viewing "the relationship between research or scholarly productivity and overall evaluation of the teacher is not statistically significant" (p. 229). Although the majority of studies indicated zero-order correlations between scholarly productivity and students' perceptions of a teacher's overall instructional effectiveness, Feldman's (1987) meta-analytic technique with its attendant large sample size yielded a small (+.12) positive correlation that was statistically significant. The most that can be said, therefore, about professorial research activities in relation to teaching effectiveness is that there is a small positive relationship.

Higher education production functions that are unclear and economies of scope that are uncertain; personal utility, reward structures, and the changing nature of research funding that push faculty towards research and away from teaching; the absence of a strong linkage between research activities and teaching excellence--all bring into question the importance and relevance of academic research to undergraduate education. The next section will address the significance of pursuing new research into this area and exploring if, how, or why research expenditures in higher education affect instructional productivity of faculty.

Proposed Study

Nelson & Hevert (1992), Dundar & Lewis (1995), and Gander (1995), used the department as the unit of analysis when investigating outputs in higher education. Nelson & Hevert (1992) examined class size effects on scale and marginal costs in higher education utilizing 31 departments at a single university. Dundar & Lewis (1995) evaluated departmental multiproduct cost functions to determine scale and scope issues of research and teaching output using data from the American Association of University Data Exchange (AAUDE, 1990). They used the latest complete data set (1985-1986), consisting of 18 participating institutions of higher education (seventeen of these institutions were among the top 30 research universities in the nation) (Dundar & Lewis, 1995). Data on expenditures (costs) and enrollments (student credit hours at the undergraduate, master, and doctorate levels) were gathered from 17 types of departments in the sciences (social sciences, engineering sciences, and physical sciences) (Dundar & Lewis, 1995).

Gander's research (1995) looked at departmental productivity in one university (University of Utah) and, as in Dundar & Lewis's work (1995), concentrated on the sciences (33 departments). Gander's (1995) research explored "the underlying relationships between faculty research (particularly funded research) and teaching productivities and the internal structure of a university" (Gander, 1995, p. 311) using cross-sectional and longitudinal data from the academic years of 1991-1992 through 1993-1994. Gander (1995) was interested in the returns to scale of teaching and research production, "the effect of department size on research output relative to teaching output (or research intensity), and the time effect on productivities" (Gander, 1995, p. 312). Teaching output was measured in student credit hours for undergraduate and graduate work, with graduate work weighted higher (3x) than undergraduate hours (Gander, 1995).

Each of these three studies has data limitations. In the case of Nelson & Hevert (1992), 136 observations were analyzed using information gathered from a single university (University of Delaware). Dundar & Lewis's research (1995) employed only a small subset of universities (18) and their departments (17) in the U. S. As in Nelson & Hevert (1992), Gander's (1995) study involved a single university (University of Utah) with limited departments (33). The Dundar & Lewis (1995) and Gander (1995) studies focused almost exclusively on science, math, and engineering departments. Nelson & Hevert (1992) did not identify which departments were studied at the University of Delaware.

Of the three studies identified above as being the most relevant to the proposed research, only Hevert & Nelson (1992) use a measure of research productivity (designated as "research intensity" and defined as the "percentage of faculty time devoted to research"; p. 474) as a variable input to their cost function. Although Dundar & Lewis (1995) attempted to isolate the effects of general departmental expenditures (inputs) on undergraduate student credit hours (outputs), separately budgeted research expenditures as a data input to their quadratic cost function model were excluded. Gander's (1995) production functions separately measured the effects of faculty size and enrollments on the outputs of research expenditures and credit hours taught. He, too, ignored research expenditures as a possible input that could affect student credit hours taught.

The proposed study goes beyond Nelson & Hevert (1992), Dundar & Lewis (1995), and Gander (1995) in data utilization by exploring a broader range of departments in more research universities than the previous studies. This study will examine how the external support of separately budgeted research expenditures affects undergraduate student credit hours and class sections taught using Pfeffer & Salancik's (1978) model of resource dependency. The data set used will be the National Study of Instructional Costs and Productivity (NSICP), which is collected by the University of Delaware. This data contain detailed departmental measures on faculty teaching workloads; research, instructional, and service expenditures; and faculty instructional productivity. The NSICP raw data involves 97 departments in 160 colleges and universities including 32 Research I and II universities.

The number of colleges and universities sampled, the large number of departments the sample contains, the first-time use of research expenditures as a discrete input variable to model external stress on measures of teaching productivity, the first-time use of organized class sections as an independent measure of faculty productivity, the singular emphasis on undergraduate measures of output, and the close examination of the effects of research expenditures on undergraduate education make this study a unique contribution to the literature of faculty productivity.

Summary

> The current wave of economically driven concern about undergraduate teaching has attached itself to long-standing suspicions among nonacademic constituencies that many college-level academics would rather wallow about in expensive and esoteric research projects than undertake the less glamorous and often grinding business of educating the future workforce and citizenry. (Daly, 1994, p. 2)

For most ordinary citizens the primary production function of higher education is to teach undergraduates. Students, legislators, and the general public may view research as a secondary benefit arising from the joint production of the two products, but academic research is by no means generally perceived as the major function of colleges and universities in the U.S.

There is considerable debate in the literature on whether undergraduate teaching and research are compliments to one another or are substitutes. Economies of scope and personal utility examine the relationship between research and teaching on a macro and micro level respectively. Economies of scope between undergraduate teaching and research at public and private universities are problematic, especially if class size is not allowed to vary with teaching load (Nelson & Hevert, 1992). Among the vast majority of professors, the personal utility of research is greater than that of teaching. Professors allocate more discretionary time to research rather than teaching as a direct result of both the internal reward system currently in place at institutions of higher education and by the influence of external resource providers.

The linkage between research and teaching in higher education is a tenuous one. The age-old wisdom that good researchers make good teachers is not well-grounded in empirical analysis. For the most part, research and teaching are separate functions of the academy, and what affects research productivity may not necessarily affect teaching productivity (Barnett, 1992; Fox, 1992; Gander, 1995; Volkwein & Carbone, 1994).

The generalized impact of departmental research expenditures on undergraduate education within the United States has never been explored systematically. The proposed study will examine the relationship between separately budgeted research and undergraduate teaching productivity at a sample of research universities in America. As its framework, it will use resource dependency (Pfeffer & Salancik, 1978) as a potential explanatory theory for the effects of departmental research expenditures on teaching productivity in undergraduate education.

CHAPTER 3

METHOD

Analysis

The proposed study will look at the influence of separately budgeted research expenditures upon faculty instructional productivity in undergraduate education. The unit of observation will be departments in a sample of Research I and II universities in the United States. The theoretical framework for the analysis will be Pfeffer & Salancik's (1978) resource dependency. Resource dependency states that organizational behavior of the firm or its subunits (in this case, the academic departments within a university) is more a function of interdependent external economic influences than internal organizational decisions. As block grant funding for higher education is reduced, university departments seek new sources of funds to replace lost revenues. In an attempt to gain more resources, faculty within university departments align themselves more closely with their external resource providers (suppliers of specific private or government contracts and grants). As they do so, faculty behavior favors research activities that maintain the steady stream of support over that of teaching responsibilities.

For those readers who may be unfamiliar with productivity and/or production functions, a review of the generalized model is presented. The standard equation for examining production processes is described by one or more functions of this type:

$$Q = f(X)$$

where Q is the number of outputs that is derived as a function of X inputs (Gander, 1995; Hopkins, 1986). For ease of data modeling, this equation is usually transformed to an additive regression design (Pindyck & Rubinfeld, 1991). The above equation, with slight modification, has also been used as the cost function equation within higher education. Brinkman (1986) explains:

> The...production function specifies the maximum output obtainable from every possible input combination. The cost function relates the production function and input prices in such a way as to specify the minimum cost for a given level of output. In other words, cost minimization and an explicit mathematical relationship with the production function are part of the definition of the term "cost function." Indeed, it has been shown that the total cost function is dual to the production function (Shepard, 1953), i.e., the two functions are different but equivalent ways of looking at the production phenomenon. (Brinkman, 1986, p. 4)

The cost function form of the equation has been used in the recent research on economies of scale and scope by Cohn et al. (1989), de Groot et al. (1991), Nelson & Hevert (1992), and Dundar & Lewis (1995). The production function form of the equation was used by Gander (1995) to explore the relationships among funded research, teaching productivities, and internal department structure in the joint production of research and teaching.

Traditionally constructed cost function and/or production function forms of the equation are not appropriate for this study for two reasons: 1) Economies of scale and scope will not be investigated in the proposed research, and 2) Separately-budgeted research expenditures are used as an input and not as an output in the proposed regression design.[1] Because this study focuses on some of the influences affecting

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[1] Research expenditures can be used as both an input and as an output in production function analyses, much like student credit hours. This goes back to the

instructional productivity and excludes research as a joint production output in undergraduate education, the regression equation that is proposed should be considered a productivity function and not a production function.

To examine what effect separately budgeted research has upon faculty productivity in undergraduate education (Research Questions 1, 2, and 3), two standard regression equations using the ordinary least-squares method will be used:

$$UGSCH = a + b_1T\_FACPER + b_2INST\_FTE + b_3RES\_TFAC + b_4RES\_PER + b_5T\_GRSCH + b_6SVC\_FTET + b_7DV1 + b_8DV^{*}... + e_1 \quad (1)$$

$$UGOCS = A + B_1T\_FACPER + B_2INST\_FTE + B_3RES\_TFAC + B_4RES\_PER + B_5T\_GROCS + B_6SVC\_FTET + B_7DV1 + B_8DV^{*}... + e_2 \quad (2)$$

UGSCH is the number of undergraduate student credit hours produced per full-time equivalent (FTE) tenure/tenure-track (T-TT) faculty member, and in separate analyses, the number of undergraduate student credit hours produced per FTE, "other" regular faculty members, supplemental faculty members, and teaching assistants; UGOCS is the number of undergraduate organized class sections produced per FTE T-TT

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major problem of higher education production functions: determining and defining the proper variables to consider as inputs and outputs. In higher education, the outputs can be viewed as the inputs, and the inputs can be viewed as the outputs. No information in the literature points to the "best" model of designating which inputs/outputs should be used when examining higher education production/cost functions. As previously noted, Nelson & Hevert (1992) used "research intensity" as an input variable to their model. For whatever reasons, research expenditures have thus far been ignored as a potential input variable to higher education production function models.

faculty member, and in separate analyses, "other" FTE regular faculty members, supplemental faculty members, and teaching assistants; a is a constant; T_FACPER is the percentage of tenure/tenure-track (T-TT) faculty within the department; INST_FTE is the direct instructional expenditures by the department per FTE student; RES_TFAC is the separately budgeted research expenditures per FTE T-TT faculty member; RES_PER is the separately budgeted research expenditures as a percent of total research, instructional, and public service expenditures; T_GRSCH (alernatively T_GROCS) is the number of graduate student credit hours taught by faculty members (official graduate class sections taught in the second equation); SVC_FTET is the separately budgeted public service expenditures per FTE T-TT faculty member; DV1 is a dummy variable with a value of 1 for public universities and a value of zero otherwise; DV* represents multiple dummy variables (DV2, DV3, DV4, ...) with a value of 1 for a selected field of study and a value of zero otherwise; and e is the error term.

Using the standard linear form of these equations, we are unable to measure the potential for diminishing returns within the model; therefore, a logarithmic transformation of the data will be performed. Additional regression modeling will be performed on an as-needed basis to identify potential resource dependency effects on faculty productivity.

Variables

UGSCH--Undergraduate student credit hours taught per FTE tenure and tenure-track faculty member

Undergraduate student credit hours taught during the fall semester per full-time equivalent faculty who are tenured or on the tenure track. Separate analyses will examine student credit hours produced per FTE, *other* regular faculty, supplemental faculty, and teaching assistants. Fall semester enrollment is used because although the total number of student credit hours for the full academic year is known, the data set only reveals the actual proportion of those hours taught by faculty during the fall term. An estimation of the annual mean student credit hours taught per T-TT faculty member could be made by multiplying the total number of student credit hours produced by the proportion of T-TT faculty in each department; however, since most departments employ graduate teaching assistants, and since these teaching assistants are often assigned large classes that generate many student credit hours, any approximation (such as the one suggested) would be flawed.

It is doubtful whether large swings of student credit hours per tenure/tenure-track faculty member occur between fall and spring terms of a typical academic year. However, even if variation does occur from term to term by individual faculty members, mean credit hours taught by the entire department should tend to be evenly distributed between the fall and spring terms of the academic year.

As mentioned earlier in the Definitions section of Chapter 1, an agreed upon measure of what constitutes higher education output is not available. In addition, measurements of student output such as knowledge obtained or skills acquired are the more appropriate yardstick of teaching output, but these outputs are very difficult to assess. Also note that the quality of instruction cannot be assessed through measures of student credit hours. Thus, student credit hours act only as an intermediate output indicator (or proxy) for instructional output. Nelson & Hevert (1992), Dundar & Lewis (1995), and Gander (1995) all used student credit hours as a measure of teaching output. Cohn et al. (1989) and de Groot et al. (1991) used a similar proxy for teaching output, total student FTE enrollment. Student credit hours taught per tenure/tenure-track faculty member does not measure student contact outside of the classroom. There is some indication that average contact hours with students have actually increased over time (Allen, 1996). Further, faculty interact with students in many areas outside the classroom. These teaching interactions are not captured by the student credit hours variable.

UGOCS--Undergraduate organized class sections taught per FTE T-TT faculty member

Undergraduate organized class sections taught during the fall semester per full-time equivalent faculty who are tenured or on the tenure track. Separate analyses will examine organized class sections taught per FTE *other* regular faculty, supplemental faculty, and teaching assistants. Fall semester classes are used because the number of total classes taught for the entire academic year was not available in the data set used. Organized class sections are defined by the survey as all academic courses for credit that meet at a regular time and on a regular basis. These include lecture, discussion, recitation, seminar, or lab courses that are taught by the four faculty groups.

With the exception of Massy & Zemsky's (1994) research on the academic ratchet, previous work did not examine the number of class sections taught as a measure of faculty productivity. Total student credit hours produced per faculty member in institutions of higher education may have risen in recent years through the introduction of larger classes. The number of classes taught per faculty member offers a second assessment of faculty productivity not confounded by student credit hours.

T_FACPER--Percent of tenure and tenure-track (T-TT) faculty within the department

The number of T-TT faculty as a percent of total faculty within the department. The percent of T-TT faculty within a department may impact the number of student credit hours taught or class sections offered, or may covary with the amount of departmental research expenditures. Those departments with a small percentage of tenure or tenure-track faculty may rely upon graduate teaching assistants to produce the majority of student credit hours or class sections taught. Alternately, large percentages of T-TT faculty may engender more faculty teaching productivity than the norm or perhaps less if (as a group) their collective experience in acquiring private grants and contracts is greater than the norm. Few studies have systematically explored what effect the percent of T-TT faculty within departments has on faculty productivity. Analyzing the effects of tenure status on instructional productivity (comparing tenured faculty members with those who are on the tenure-track but not yet tenured) would prove interesting to explore. Unfortunately, the data set does not allow for that disaggregation because tenured faculty members are combined in the same group with those who are on the tenure track.

INST_FTE--Direct instructional expenditures per FTE student

The amount of instructional funding per FTE student provided by the university through the individual department. The level of instructional funding is a standard input variable in measures of higher education output (Brinkman, 1981, 1986; Brinkman & Leslie, 1986; Hopkins, 1986) and often acts as a proxy for institutional or departmental quality (Brinkman, 1981, 1986; Leslie, 1994; Schmitz, 1993). Those departments with relatively high per student funding levels for instruction may be able to afford the production of fewer student credit hours or class sections taught on a per faculty member basis. The per student instructional funding level is a critical variable here because direct measures of faculty quality through departmental or institutional ratings are unavailable (institutions in the University of Delaware data set are identified with code numbers only).

RES_TFAC--Separately budgeted research expenditures per FTE T-TT faculty member

The amount of separately budgeted research expenditures per departmental FTE tenure and tenure-track faculty member. As noted in the Proposed Study section of Chapter 2, research expenditures have never been used as an input variable to determine its effect upon faculty productivity. This variable will measure part A of Pfeffer & Salancik's (1978) first major factor influencing resource dependency: the relative magnitude of the resource (research expenditures) in sustaining current levels of departmental operation and long-term survival.

RES_PER--Separately budgeted research expenditures as a percent of total research, instructional, and public service expenditures

The percent of total departmental funding that is represented by research monies. Again, this is the first time that the effects of research expenditures upon undergraduate teaching productivity have been explored. This is the second part (part B) of Pfeffer & Salancik's (1978) primary element controlling resource dependency and will measure the criticality of the resource (research expenditures) to the organization's ongoing maintenance and survival.

T_GRSCH; T_GROCS--Graduate student credit hours/class sections taught per FTE T-TT faculty member

The number of student credit hours and official class sections taught at the graduate level per FTE tenure and tenure-track faculty member. Faculty effort at the graduate level is likely to have an impact on how much time faculty have available to spend producing undergraduate student credit hours and class sections.

SVC_FTET--Separately budgeted public service expenditures per FTE T-TT faculty member

The amount of separately budgeted research expenditures per departmental FTE tenure and tenure-track faculty member. Teaching, research, and service are the three main activities of higher education faculty. Public service is particularly important to those institutions operating under the Land Grant mandate, even though faculty at research universities allocate less than three percent of their time to service activities (Allen, 1996; Fairweather, 1996). Public service performed by faculty members is probably more difficult to document and measure than either the production of research or teaching. The data set contains direct expenditures for separately budgeted public service activities. These expenditures capture only a small portion of what faculty consider service to college and community. It is important, however, to test empirically public service expenditure effects on faculty instructional productivity in part because previous research has completely ignored this issue.

DV1--Dummy variable representing institutional status

This dummy variable has a value of 1 for public universities and a value of zero otherwise. Structural organizational differences in private and public universities were found to influence faculty productivity by Cohn et al. (1989) but not by de Groot et al. (1991). The variable is included here to further explore this issue.

DV*--Multiple dummy variables (DV2, DV3, DV4, ...) representing aggregate departmental groupings

This dummy variable has a value of 1 when it represents one of seven aggregate fields of study and zero otherwise. It would unnecessarily complicate the model to use dummy variables to test for instructional productivity variation among all sampled departments (a total of 93 departments are used for data analysis). Aggregation was established on the basis of departmental groupings of previous research (Dundar & Lewis, 1995; Gander, 1995) and past traditional groupings of departments into general fields of study. Table 1 contains CIP departmental codes and the aggregate fields of study used for this dummy variable.

Both Gander (1995) and Dundar & Lewis (1995) tested for productivity variations among departmental groupings using dummy variables. In the case of Gander (1995), production technology differences were detected by some academic groupings when compared to a social sciences academic reference group. Dundar & Lewis (1995) also found productivity differences between broad academic fields, though not necessarily among departments within a given field.

Departmental aggregate groupings are included in the regression analysis to explore further potential instructional productivity variation among fields of study. The departments used as the reference group include the social sciences, English, communications, education, philosophy, and select humanities departments. This reference group of departments was chosen based on Gander's (1995) research and to more easily measure any potential variability that science, math, and engineering departments may have in departmental productivity.

Sample

The universe of data for this study is contained in the 1994 survey results of the NSICP, a longitudinal project conducted by the University of Delaware. Data from the initial 1993 survey contained significant methodological, definitional, and data collection problems (these problems were outlined to the author in a personal conversation with Paul Brinkman and from information gleaned from the FIPSE internet web site). The 1995 NSICP survey (forthcoming) utilized different definitions for faculty types, student credit hours, and official class sections offered than the 1993 and 1994 surveys. The sample for the present study came from the 1994 survey of 32 Research I and II institutions (Carnegie Classification) of higher education in the United States (of which six were private institutions), 97 departments, and 1,148 data points (N = 1,148).

After incomplete data are excluded from analysis, 27 institutions (of which four were private universities), 93 departments, and N = 955 data points remained. The high attrition rate of data points because of missing data (approximately 17 percent of the original sample is not included) is a direct result of the nature of the survey. The survey was voluntary and many colleges failed to provide complete data on all information requested. Exclusion of those institutions and departments with missing data help to eliminate potential bias in the results.

The anonymity of individual colleges and universities was protected in the sample; however, the names of the participating colleges and universities were identified prior to the research (see Table 2). Of the 32 institutions participating in the survey, 13 were in the top 50 for research and development spending in the United States (Office of Institutional Research, University of Arizona, 1989). Five of the universities are located in the western United States, five in the east, thirteen in the south, and nine are located in the midwest.

Data Analysis

To answer Research Questions 1, 2, and 3, regression procedures were used (using the equations noted earlier in this chapter) on the sample (N = 955). Logarithmic model transformations of the data were performed to measure percentage change effects upon the variables. A second regression analysis was performed excluding those departments without any separately funded research expenditures. This procedure was followed because departments without research funding of any kind could bias the results significantly and conceal what the proposed research is exploring: the effects of the magnitude and criticality of research funding on instructional productivity.

Limitations

As with any study, the reader must consider a number of limitations to the data and the model. Most of the limitations concern the use and definitions of the variables in the analyses. This section will briefly outline those stipulations and others that may apply to the model as a whole.

Gander (1995) points out that the assumption regarding inputs as being exogenous to the model "is always a problem in estimating any production function (or any other economic function, for that matter)" (Gander, 1995, p. 313). The productivity function model used here presumes that all input variables are exogenous to the model itself (with the possible exception of graduate instructional productivity) and are true measures of their attendant fields and are not correlated with residual (error) terms.

Since faculty productivity may be considered a comprehensive measure of teaching responsibilities inside and outside the classroom, the variable "student credit hours" can be criticized as too narrow a measure of instructional productivity. From a data modeling point of view, the "use of any enrollment-based measure for the teaching output may be objectionable because it may be considered an input rather than an output" (Cohn et al., 1989, p. 284).

Previous research has used both FTE enrollment and output of degrees to measure faculty instructional productivity (Cohn et al., 1989; de Groot et al., 1991). The drawback of the former is that FTE enrollment is usually derived from student credit hours and aggregated at the institutional level. Degree production, although considered by many to be a more accurate representation of what faculty produce, also is flawed as an alternative to enrollment measures. Degrees are awarded over a period of time, between four to six years from first enrollment. Any attempt to allocate rationally various faculty or departmental inputs over this period to the production of degrees would prove impossible. For simplification, de Groot et al. (1991) assigned the number of degrees awarded to the year that input data was collected, but found no significant differences in predictive value between degrees earned and enrollment measures in defining faculty productivity. The data set used for this study did not contain degrees earned as a potential element for regression analysis. Nelson & Hevert (1992) and Dundar & Lewis (1995) used student credit hours as the most accurate measure of faculty productivity on a departmental basis, and this study will do the same.

The sample used for this study consists of a select group of Research I and II institutions that participated in the 1994 NSICP, representing 26 percent of Research I and II universities (32 out of 125 total) in the United States. Because the NSICP is a voluntary survey, the problem of selection bias may exist. Those institutions that did not participate in the study may have provided useful information that was not captured by the current research. Additionally, only two of the universities listed in the sample of Research I institutions are in the top 25 for research spending (Office of Institutional Research, University of Arizona, 1989). The Research I universities that are sampled in this study probably are more similar to upper tier Research II universities, when focusing on actual research expenditures. Thus, the inferences that can be made by this study to the top Research I universities in the United States may be limited. Philpott (1994) noted that universities with a strong tradition in basic or fundamental research might not engage heavily in entrepreneurial activities (such as increased private grant and contract seeking behavior) because of the loss of staff time to these activities. He noted that "mainline" and "stable" research universities are less involved in entrepreneurial activities than are those universities that necessarily must raise additional revenues. The Research I and II universities in this sample may be more appropriate to study changes in organizational behavior from resource dependency effects than those institutions with large, established research budgets.

The universities participating in the NSICP were guaranteed anonymity. The regression model proposed for this study, therefore, cannot contain a quality variable based on departmental, program, or institutional rankings in analyzing undergraduate instructional productivity. Instructional expenditures per FTE student, however, will be used as a proxy for departmental quality.

Although the issue of instructional quality is a pervasive one in higher education, the majority of published undergraduate quality rankings have shown little power in discriminating between instructional programs of high and low quality because institutional selectivity is often used as the main proxy for undergraduate program quality (Dundar & Lewis, 1995; Schmitz, 1993). Quality rankings of graduate education may also fare poorly in differentiating superior undergraduate instruction in institutions of higher education. For example, as evaluated by the National Research Council (NRC) in its study "Research-doctorate Programs in the U.S.: Continuity and Change" (1996), the quality of university graduate departments equates to a prestige ranking based almost solely on research productivity and national research reputation. The inferences that could be drawn from such a quality ranking to undergraduate education would be questionable because a positive connection between research productivity/quality and teaching excellence is not supported by a myriad of research (see Chapter 2 and Feldman's 1987 meta-analysis for complete details). In addition, previous higher education production function research that did include quality as an input variable (de Groot et al., 1991; Dundar & Lewis, 1995) found that quality had no affect upon teaching productivity, scale, or scope issues.

This study uses a cross-sectional approach because the previous 1993 NSICP data set had significant data collection errors and the forthcoming 1995 NSICP data set altered a number of faculty, student credit hour, and official class section categories. According to FIPSE, "The initial 1992-93 instrumentation and methodology were completely overhauled, and more consistent, valid, and useful definitions and program taxonomies were established" beginning with the 1993-94 survey instrument (FIPSE Program Book, 1995, p. de2.html). Unfortunately, this appears to be an ongoing process and similar changes occurred again in the 1994-95 survey. These significant modifications among all three data sets make comparisons across time problematic.

Massy and Zemsky (1994) note that "cross-sectional data cannot directly illuminate a dynamic phenomenon" (p. 3) such as the rise or decline of faculty instructional productivity over time. However, such a cross-sectional approach "when analyzed with an appropriate model...can shed light on the behavior that drives the dynamic process" (Massy & Zemsky, 1994, p. 3).

The model used in this research should not be interpreted as a strict cost or production function paradigm but rather a productivity function. The regression equation proposed reflects a statistical attempt to measure the relationship between departmental research expenditures and undergraduate teaching productivity. The regression model, reflecting resource dependency theory in part, allows testing of this relationship; but the results from the analyses should not necessarily be interpreted to mean that the framework used is the sole, direct causal paradigm for changes in faculty productivity. The history and tradition of higher education institutions, academic departments, and programs are major influences on how undergraduate instruction is produced. Factors such as how faculty are trained, the cultural environment they experience at institutions of higher education and how this affects personal preferences regarding teaching and research, the relative power and influence wielded by select departmental sub-units within the institution, and the internal reward structure of departments may have significant impacts on faculty productivity in research and teaching. It should be emphasized, however, that at least some of these no doubt interact with resource dependency (e.g., power and reward systems).

How could we test for these alternative hypotheses as opposed to the acceptance of resource dependency as the major explanatory theorem? Of those mentioned above, the internal reward structure, the power of departments, and individual faculty preference probably represent the strongest alternate frameworks for exploring the relationship between research expenditures and instructional productivity.

Internal institutional reward structures (salary, promotion, tenure, work assignment, work load, etc.) can certainly drive faculty behavior regarding time spent on teaching, research, service, and other activities. An analysis of shifts in faculty time in these areas coupled with changes in salary, promotion, or tenure decisions along with external grant/contract activity (the interaction with resource dependency) would be needed to explore this alternate hypothesis. However, faculty time allocation and reward structure data are not available and cannot be deduced from the data set used for this study. In addition, reward structures may not be a separate, competing framework to that of resource dependency, as Leslie & Slaughter (forthcoming) point out:

> ...it may be argued that if the faculty reward system is the major cause, we should be able to document some major, recent changes in that system, because institutional expenditure allocations have changed importantly and recently. Although we know of no such documentation, our own perceptions are that faculty incentives (salaries, tenure, promotion) increasingly do include the ability to secure grants. However, if this is correct, we would see this as a direct outgrowth of changes in resource dependencies, i.e., the need to replace lost revenues. (Forthcoming, working draft, p. 15)

A department's relative power and influence within a university could also explain changes in faculty undergraduate instructional productivity in relation to variation in instructional and research expenditures over time. In "Organizational decision making as a political process: The case of a university budget," Pfeffer & Salancik argue that

> organizational decision making, particularly with respect to decisions that allocate resources within the organization, are political in nature and that to understand resource allocation within organizations considerations of relative power of the subunits, as well as of bureaucratic criteria, are necessary. (1974, p. 138).

The authors used department head interviews and archival records of departmental representation on major university committees to examine the relationship between departmental power and budget allocation. (Pfeffer & Salancik, 1974). They found that "the more powerful the department, the less the allocated resources are a function of departmental work load and student demand for course offerings" (Pfeffer & Salancik, 1974, p. 135). In their research, power was "found to be significantly related to the proportion of the budget received, even after statistically controlling for such universalistic bases of allocation as work load of the department, national rank, and number of faculty" (Pfeffer & Salancik, 1974, p. 135).

It can be observed, then, that the major driving force behind subunit power in a university is the ability of the department to obtain resources. However, the authors caution that "it is plausible to hypothesize that subunit power will influence organizational decisions only to the extent that such decisions are not otherwise constrained" (Pfeffer & Salancik, 1974, p. 149).

> Further, there is more likely to be a greater use of political power in decision making in those universities that have relatively more flexibility because they have discretionary resources to allocate. Since extra funds are often provided by grants or contracts, one might predict that the higher the proportion of outside funding and money, the more power would be used in resource allocation. (Pfeffer & Salancik, 1974, p. 150)

Money is power. The ability of a department to gain greater resources through grant seeking behavior, for example, returns us to resource dependency as a central theme in resource allocation. It would be valuable to contrast a department's relative power within a university with its ability to obtain outside research funds. Once again, however, the data set that is the basis for the current study does not contain these measures.

Finally, individual faculty preference for teaching or research would impact faculty undergraduate productivity regardless of any additional external forces previously identified. As Becker (1975, 1979) points out, a complex array of factors determines whether a professor prefers research over teaching or vice versa. Briefly summarized, the value that is placed upon teaching and research by college administration determines the importance of teaching or research for faculty members as a whole, and the amount of time spent on either teaching or research by individual faculty members depends upon the marginal rate of substitution for these two activities (Becker, 1979).

Whether professors prefer teaching or research is therefore a function of the values or weights of these two activities and their marginal rates of substitution (personal utility). The personal utility of teaching and research can be explored theoretically, but attempts to translate the theoretical concept of personal utility within higher education into concrete data would be problematic. The difficulty in this is clear: How does one correctly interpret the generalized actions of the professorate regarding their preference for teaching or research given that utility is individualized and personal? How could we measure a professor's rate of substitution of one student credit hour of instruction to one research dollar, paper, article, or some other form of research activity? It would be enlightening if we could answer those questions with qualitative or quantitative data, but the data set used here does not allow us that opportunity.

Summary

This study is the first of its kind to explore the relationship of the magnitude and criticality of separately budgeted university research expenditures upon tenured and tenure-track faculty instructional productivity in undergraduate education. The method used is based upon a higher education productivity function concept. Traditional statistical procedures explore the interrelationships among the independent and dependent variables. Coupled with resource dependency theory (Pfeffer & Salancik, 1978), the analysis proffers one causal model for observed variations in undergraduate faculty teaching productivity at research universities in the United States.

TABLE 1

Aggregate Departmental Groupings for Dummy Variables DV2-DV8

Agriculture, Plant, and Soil Sciences; Dummy Variable 2

CIP	
1.00	Agricultural business and production
2.01	Agriculture/agricultural sciences
2.02	Animal sciences
2.03	Food sciences and technology
2.04	Plant sciences
2.05	Soil sciences
3.00	Conservation and renewal natural resources

Engineering and Computer Sciences; Dummy Variable 3

CIP	
4.00	Architecture and related programs
11.00	Computer and information sciences
14.01	Engineering, general
14.02	Aerospace, aeronautical and astronautical engineering
14.03	Agricultural engineering
14.04	Architectural engineering
14.05	Bioengineering and biomedical engineering
14.07	Chemical engineering
14.08	Civil engineering
14.09	Computer engineering
14.10	Electrical, electronics and communications engineering
14.11	Engineering mechanics
14.17	Industrial/ manufacturing engineering
14.18	Materials engineering
14.19	Mechanical engineering
14.20	Metallurgical engineering
14.21	Mining and mineral engineering
14.23	Nuclear engineering
14.25	Petroleum engineering
14.28	Textile sciences and engineering
14.30	Engineering/industrial management
14.32	Polymer/plastics engineering

TABLE 1
(Continued)

Aggregate Departmental Groupings for Dummy Variables DV2-DV8

Home Economics, Family Studies, and Recreation; Dummy Variable 4

CIP	
19.01	Home economics, general
19.03	Family and community studies
19.04	Family/consumer resource management
19.05	Foods and nutrition studies
19.06	Housing studies
19.07	Individual and family studies
19.09	Clothing/apparel and textile studies
31.03	Parks, recreation and leisure facilities management
31.04	Parks, recreation, leisure, and fitness studies, other
31.05	Health and physical education/fitness

Physical Sciences and Math; Dummy Variable 5

CIP	
26.00	Biological sciences/life sciences
27.00	Mathematics
40.02	Astronomy
40.04	Atmospheric sciences and meteorology
40.05	Chemistry
40.06	Geological and related sciences
40.08	Physics

TABLE 1
(Continued)

Aggregate Departmental Groupings for Dummy Variables DV2-DV8

Social Sciences, English, Communications, Education, and Philosophy
Reference Group

CIP	
9.00	Communications
13.00	Education
16.00	Foreign languages and literature
23.00	English language and literature/letters
25.00	Library science
38.01	Philosophy
38.02	Religion/religious studies
38.99	Philosophy and religion
42.00	Psychology
44.00	Public administration and services
44.02	Community organization, resources and services
44.04	Public administration
44.05	Public policy analysis
44.07	Social work
45.01	Social sciences, general
45.02	Anthropology
45.04	Criminology
45.06	Economics
45.07	Geography
45.08	History
45.09	International relations and affairs
45.10	Political science and government
45.11	Sociology
45.12	Urban affairs/studies

TABLE 1
(Continued)

Aggregate Departmental Groupings for Dummy Variables DV2-DV8

Fine Arts; Dummy Variable 6

CIP	
50.01	Visual and performing arts
50.02	Crafts, folk art and artisanry
50.03	Dance
50.04	Design and applied arts
50.05	Dramatic/theatre arts and stagecraft
50.06	Film/video and photographic arts
50.07	Fine arts and art studies
50.09	Music

Nursing, Pharmacy, and Communication Disorders; Dummy Variable 7

CIP	
51.02	Communication disorders sciences and services
51.16	Nursing
51.20	Pharmacy

Business; Dummy Variable 8

CIP	
52.01	Business
52.02	Business administration and management
52.03	Accounting
52.04	Administrative and secretarial services
52.06	Business/managerial economics
52.07	Enterprise management and operation
52.08	Financial management and services
52.09	Hospitality services management
52.10	Human resources management
52.11	International business
52.12	Business information and data processing services
52.13	Business quantitative methods and management science
52.14	Marketing management and research
52.15	Real estate

TABLE 2

Research I and II Institutions Participating in the 1994-95
National Study of Instructional Costs and Productivity (NSICP)

Research I

Duke University
Georgia Institute of Technology
Louisiana State University
Michigan State University
Temple University
Texas A&M--College Station
University of Georgia
University of Iowa
University of Kansas
University of Maryland--College Park
University of Massachusetts--Amherst
University of Miami
University of Utah
Utah State University
Virginia Commonwealth University
Virginia Polytechnic Institute and State University

Research II

George Washington University
Kansas State University
Mississippi State University
Northeastern University
Ohio University
Oklahoma State University
Southern Illinois University at Carbondale
St. Louis University
SUNY--Albany
Texas Tech University
Tulane University
University of Arkansas--Fayetteville
University of Delaware
University of Idaho
University of Oregon
University of Wyoming

CHAPTER 4

RESULTS

The Plan of the Study

This study investigates the influence of separately budgeted research expenditures upon faculty instructional productivity in undergraduate education using a sample of Research I and II universities in the United States. The unit of analysis is the department. The sample is derived from the 1994 survey results of the NSICP (National Study of Instructional Costs and Productivity), a longitudinal project conducted by the University of Delaware. The sample consists of 27 (Carnegie Classification) Research I and II institutions of higher education (23 public and four private), 93 departments, at 955 data points (in time).

The data are analyzed using standard regression procedures in an attempt to answer the following research questions:

1a. Do departments in Research I and II universities with greater research expenditures (on a per faculty member basis and as a percent of total research, teaching, and public service expenditures) produce fewer undergraduate student credit hours and/or fewer undergraduate class sections taught per tenure/tenure-track faculty member?

1b. Do greater research expenditures affect the number of undergraduate student credit hours and class sections taught per *other* regular faculty members, supplemental faculty members, and teaching assistants?

2. Are there faculty undergraduate instructional productivity differences among academic fields?

3. Are there differences between public and private institutions in faculty instructional productivity?

Procedures

The following two regression equations were analyzed using a standard statistics software package:

$$UGSCH = a + b_1T\_FACPER + b_2INST\_FTE + b_3RES\_TFAC + b_4RES\_PER + b_5T\_GRSCH + b_6SVC\_FTET + b_7DV1 + b_8DV^{*}... + e_1 \quad (1)$$

$$UGOCS = A + B_1T\_FACPER + B_2INST\_FTE + B_3RES\_TFAC + B_4RES\_PER + B_5T\_GROCS + B_6SVC\_FTET + B_7DV1 + B_8DV^{*}... + e_2 \quad (2)$$

<u>Variables</u>

T_UGSCH	Undergraduate student credit hours taught per FTE tenure & tenure-track faculty member
T_UGOCS	Undergraduate official class sections taught per FTE tenure & tenure-track faculty member
R_UGSCH	Undergraduate student credit hours taught per FTE *other* regular faculty member (instructors, lecturers, and other full-time, non-tenure track personnel, including any visiting faculty, distinguished faculty, emeritus faculty, and permanent part-time teaching personnel. NSICP, 1994)
R_UGOCS	Undergraduate official class sections taught per FTE *other* regular faculty member
S_UGSCH	Undergraduate student credit hours taught per FTE supplemental faculty member (any part-time [non-permanent] faculty, adjunct faculty, and administrators/staff that teach. NSICP, 1994)

S_UGOCS	Undergraduate official class sections taught per FTE supplemental faculty member
TA_UGSCH	Undergraduate student credit hours taught per FTE teaching assistant (any student who receives a stipend at an institution of higher learning strictly for teaching activity. These will include instructors of record, discussion section leaders, recitation section leaders, laboratory section leaders, and other types of organized class sections. Graduate research assistants are specifically excluded from this category. NSICP, 1994)
TA_UGOCS	Undergraduate official class sections taught per FTE teaching assistant
T_FACPER	Percent of tenure & tenure-track faculty within department
INST_FTE	Direct instructional expenditures per FTE student
RES_TFAC	Separately budgeted research expenditures per FTE tenure & tenure-track faculty member
RES_PER	Separately budgeted research expenditures as a percent of total research, instructional, and public service expenditures
T_GRSCH	Graduate student credit hours taught per FTE tenure & tenure-track faculty
T_GROCS	Graduate official class sections taught per FTE tenure & tenure-track faculty member
SVC_FTET	Separately budgeted public service expenditures per FTE tenure & tenure-track faculty member
DV1	Dummy variable representing institutional status (1=public; 0=private)
DV2	Dummy variable representing the aggregate departmental grouping of Agriculture, Plant, and Soil Sciences
DV3	Dummy variable representing the aggregate departmental grouping of Engineering and Computer Sciences
DV4	Dummy variable representing the aggregate departmental grouping of Home Economics, Family Studies, and Recreation

DV5	Dummy variable representing the aggregate departmental grouping of Physical Sciences and Math
DV6	Dummy variable representing the aggregate departmental grouping of Fine Arts
DV7	Dummy variable representing the aggregate departmental grouping of Nursing, Pharmacy, and Communication Disorders
DV8	Dummy variable representing the aggregate departmental grouping of Business

Modeling

On the first iteration of the regression model, UGSCH and UGOCS took on the value of undergraduate student credit hours and undergraduate official class sections taught per tenure/tenure-track faculty member (undergraduate instructional productivity). In subsequent iterations of the regression, these two variables took on the values of *other* regular faculty productivity, supplemental faculty productivity, and teaching assistant productivity in turn. All other variables maintained their initial values throughout the regression procedures.

After ordinary least squares regression was performed on the full data set, a second regression analysis was conducted that excluded those departments that did not have any research expenditures. This procedure was followed because departments without research funding of any kind could bias the results significantly and conceal the main focus of this study: the possible effects of the magnitude and criticality of research expenditures on undergraduate instructional productivity. An additional regression iteration consisted of separating private universities from public instituions to examine the potential differential effects of resource dependency based on instituional status.

Finally, a log transformation was performed on the entire data set to investigate elasticities of the variables.

Descriptive Statistics

Table 3 contains the descriptive statistics data. Note that, at the mean, regular faculty taught more undergraduate student credit hours than did tenure/tenure-track faculty, supplemental faculty, or teaching assistants. Anecdotal statements in the media to the effect that teaching assistants teach more student credit hours than tenured or tenure-track faculty is not supported by the data, on a per member basis. Teaching assistants teach fewer undergraduate student credit hours on average than do all other faculty members; however, teaching assistants do teach more undergraduate class sections than all of the other faculty groups.

As can be seen by the standard deviations and the minimum/maximum of each variable, there is wide variability in the data. The data set gives clear evidence that faculty productivity and departmental expenditures on instruction, research, and public service are not homogenous.

Tenure/tenure-track Faculty Undergraduate Instructional Productivity

Table 4 contains the regression output for undergraduate student credit hours taught per tenure or tenure-track faculty. Table 5 lists the comparable results for undergraduate official class sections taught by the same faculty group. The adjusted R^2 of .2381 for T_UGSCH and .2245 for T_UGOCS is small in absolute terms, but probably

TABLE 3

DESCRIPTIVE STATISTICS

Variable	Mean	Std Dev	Minimum	Maximum	N
T_UGSCH	181.38	103.70	.00	781.00	955
T_UGOCS	1.82	1.04	.00	8.10	955
T_GRSCH	33.02	30.41	.00	225.00	955
T_GROCS	.65	.51	.00	5.00	955
R_UGSCH	241.11	332.62	.00	3416.00	955
R_UGOCS	2.25	2.88	.00	40.00	955
S_UGSCH	192.09	333.06	.00	2740.00	955
S_UGOCS	2.28	4.92	.00	116.70	954
TA_UGSCH	145.84	249.60	.00	3036.00	954
TA_UGOCS	2.42	2.95	.00	30.20	953
T_FACPER	68.796	17.130	.000	100.000	955
INST_FTE	6132.53	6879.45	727.00	168001.00	955
RES_TFAC	50587.50	106928.64	.00	1123556.00	955
RES_PER	18.167	22.433	.000	95.715	955
SVC_FTET	5174.30	19549.30	.00	250834.00	955

TABLE 4

Dependent Variable: T_UGSCH

Multiple Regression

Multiple R = .4993 sig. of R = .0000
Multiple R Square = .2493
Adjusted R square = .2381

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	2557113.0612	182650.9329	22.292	.000
Residual	940	7702088.9848	8193.7117		

Equation: T_UGSCH = 163.9786 + (-.4950 T_GRSCH)
+ (.5437 T_FACPER) + (-.003400 INST_FTE) + (.00007158 RES_TFAC)
+ (-.3034 RES_PER) + (-.00003541 SVC_FTET) + (56.5390 DV_1)
+ (-77.5334 DV_2) + (-74.6900 DV_3) + (-15.9804 DV_4)
+ (-.8436 DV_5) + (-68.6928 DV_6) + (-72.9173 DV_7)
+ (-29.7463 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GRSCH	-0.495	0.1015	-0.662	to	-0.3279	0.9019
T_FACPER	0.5437	0.1793	0.2485	to	0.839	0.9102
INST_FTE	-0.0034	0.0004632	-0.004163	to	-0.002637	0.8458
RES_TFAC	0.000071580	0.000053160	-0.000015950	to	0.000159100	0.265800000
RES_PER	-0.3034	0.2471	-0.7102	to	0.1035	0.2795
SVC_FTET	-0.000035410	0.000178500	-0.000329300	to	0.000258500	0.705300000
DV_1	56.539	10.0401	40.0084	to	73.0696	0.9591
DV_2	-77.5334	15.0879	-102.3749	to	-52.6919	0.6607
DV_3	-74.69	9.4072	-90.1786	to	-59.2014	0.6182
DV_4	-15.9804	13.9193	-38.8978	to	6.9371	0.8925
DV_5	-0.8436	10.0516	-17.393	to	15.7059	0.6996
DV_6	-68.6928	11.2065	-87.1438	to	-50.2417	0.8337
DV_7	-72.9173	18.6742	-103.6634	to	-42.1711	0.929
DV_8	-29.7463	10.4271	-46.9141	to	-12.5785	0.7932

TABLE 4

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GRSCH	-0.1451	0.0298	-0.1609	-0.1378	-0.1571	23.7860	0.0000*
T_FACPER	0.0898	0.0296	0.0249	0.0857	0.0984	9.1930	0.0025*
INST_FTE	-0.2256	0.0307	-0.3286	-0.2074	-0.2328	53.8800	0.0000*
RES_TFAC	0.0738	0.0548	-0.0849	0.0381	0.0439	1.8130	0.1785
RES_PER	-0.0656	0.0535	-0.0827	-0.0347	-0.0400	1.5070	0.2199
SVC_FTET	-0.0067	0.0337	-0.0400	-0.0056	-0.0065	0.0390	0.8428
DV_1	0.1625	0.0289	0.1862	0.1591	0.1807	31.7120	0.0000*
DV_2	-0.1787	0.0348	-0.0746	-0.1452	-0.1653	26.4070	0.0000*
DV_3	-0.2854	0.0359	-0.2854	-0.2244	-0.2507	63.0380	0.0000*
DV_4	-0.0343	0.0299	0.0582	-0.0324	-0.0374	1.3180	0.2512
DV_5	-0.0028	0.0338	0.1170	-0.0024	-0.0027	0.0070	0.9331
DV_6	-0.1897	0.0310	-0.0875	-0.1732	-0.1960	37.5730	0.0000*
DV_7	-0.1145	0.0293	-0.0862	-0.1103	-0.1263	15.2470	0.0001*
DV_8	-0.0905	0.0317	-0.0102	-0.0806	-0.0926	8.1380	0.0044*

* Significant at the 95th percentile.

TABLE 5

Dependent Variable: T_UGOCS

Multiple Regression

Multiple R = .4857 sig. of R = .0000
Multiple R Square = .2359
Adjusted R square = .2245

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	244.3312	17.4522	20.727	.0000
Residual	940	791.4871	.8420		

Equation: T_UGOCS = 1.3585 + (-.2783 T_GROCS) + (.006007 T_FACPER)
+ (-.00002577 INST_FTE) + (.000001614 RES_TFAC)
+ (-.008836 RES_PER) + (.000003359 SVC_FTET) + (.2925 DV_1)
+ (.5531 DV_2) + (.2315 DV_3) + (.6301 DV_4)
+ (-.01243 DV_5) + (1.1976 DV_6) + (-.3984 DV_7)
+ (-.2306 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GROCS	-0.2783	0.05979	-0.3767	to	-0.1798	0.9589
T_FACPER	0.006007000	0.001820000	0.003010000	to	0.009003000	0.908100000
INST_FTE	-0.000025770	0.000004695	-0.000033490	to	-0.000018040	0.846200000
RES_TFAC	0.000001614	0.000000539	0.000000727	to	0.000002502	0.265700000
RES_PER	-0.008836	0.002503	-0.01296	to	-0.004716	0.28
SVC_FTET	0.000003359	0.000001812	0.000000375	to	0.000006342	0.703400000
DV_1	0.2925	0.1019	0.1246	to	0.4603	0.9559
DV_2	0.5531	0.1525	0.3021	to	0.8042	0.6649
DV_3	0.2315	0.09513	0.07485	to	0.3881	0.6213
DV_4	0.6301	0.141	0.398	to	0.8623	0.8939
DV_5	-0.01243	0.1019	-0.1802	to	0.1553	0.6996
DV_6	1.1976	0.1133	1.011	to	1.3842	0.8375
DV_7	-0.3984	0.1895	-0.7103	to	-0.08642	0.9275
DV_8	-0.2306	0.1039	-0.4015	to	-0.05957	0.8217

TABLE 5

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GROCS	-0.1355	0.0291	-0.1304	-0.1327	-0.1501	21.6560	0.0000*
T_FACPER	0.0987	0.0299	0.1059	0.0941	0.1070	10.8930	0.0010*
INST_FTE	-0.1701	0.0310	-0.1510	-0.1565	-0.1762	30.1210	0.0000*
RES_TFAC	0.1657	0.0553	0.0508	0.0854	0.0972	8.9680	0.0028*
RES_PER	-0.1902	0.0539	-0.0390	-0.1007	-0.1144	12.4650	0.0004*
SVC_FTET	0.0630	0.0340	0.1161	0.0528	0.0603	3.4360	0.0641
DV_1	0.0837	0.0292	0.1185	0.0818	0.0932	8.2300	0.0042*
DV_2	0.1269	0.0350	0.1335	0.1034	0.1175	13.1610	0.0003*
DV_3	0.0880	0.0362	-0.0365	0.0694	0.0791	5.9210	0.0151*
DV_4	0.1348	0.0302	0.1121	0.1274	0.1442	19.9730	0.0000*
DV_5	-0.0042	0.0341	-0.1028	-0.0035	-0.0040	0.0150	0.9029
DV_6	0.3292	0.0312	0.3158	0.3013	0.3258	111.6420	0.0000*
DV_7	-0.0622	0.0296	-0.1078	-0.0599	-0.0684	4.4210	0.0358*
DV_8	-0.0698	0.0315	-0.1299	-0.0633	-0.0722	4.9290	0.0267*

* Significant at the 95th percentile.

not in relative (for comparable issues) terms. The independent variables in the regression equation explain about 25 percent of the variability in undergraduate student credit hours produced and about 24 percent of the variability of undergraduate class sections taught per tenure/tenure-track faculty member.

Most of the variables were significant at the 95th percentile in the two equations, with nine variables out of fourteen being significant in the T_UGSCH regression and twelve variables out of fourteen in the T_UGOCS regression. A visual inspection of the scatter plots of the residuals indicates no heteroscedasticity. The principal finding (related to the research questions) of the T_UGSCH regression is the unanticipated result that the amount of research expenditures (RES_TFAC) and the share of research spending in departmental budgets (RES_PER) are not significant with regard to faculty undergraduate student credit hour productivity (tenure and tenure-track). Departmental research spending (RES_TFAC) and its share of the departmental budget (RES_PER) appear to have no relationship to a tenure/tenure-track faculty member's student credit hour production.

However, research as a percent of total departmental expenditures (RES_PER) was significant and negative in undergraduate class section productivity (coefficient of -.008836), albeit a rather small effect. If research funding (as a share of departmental expenditures; RES_PER) should increase by 10 percentage points, the number of undergraduate class sections taught per tenure/tenure-track faculty member would be associated with a decrease of .08 of a class section. Counter balancing this modest negative effect was the equally moderate, positive, and significant effect of research spending per tenure/tenure-track FTE faculty (RES_TFAC; coefficient of +.000001614). For every $100,000 spent by a department on research per FTE tenure/tenure-track faculty member (RES_TFAC), a .16 *increase* in the number of undergraduate class sections taught per tenured or tenure-track faculty member might be expected.

The independent variables that have the highest correlation with tenured and tenure-track faculty undergraduate student credit hour productivity (holding constant the effects of the other variables; all values are listed below as partial correlations) are the amount of instructional dollars spent per FTE student (INST_FTE; -.2328), the number of graduate student credit hours taught per faculty member (T_GRSCH; -.1571), and whether the faculty member teaches in agriculture (DV2; -.1653), engineering/computer science (DV3; -.2507), fine arts (DV6; -.1960), or nursing/pharmacy (DV7; -.1263). Relatively high partial correlations are demonstrated by most of these same variables in undergraduate class section productivity, with the addition of RES_PER (research expenditures as a percent of departmental instruction, research, and public service spending).

Looking at instructional dollars spent per student (INST_FTE; an indirect measure of quality), for every $1,000 spent on instruction per FTE student, faculty teach 3.4 *fewer* undergraduate student credit hours per tenure/tenure-track instructor (or approximately one less student per three-credit class) and .02 *fewer* undergraduate classes per instructor. As the number of graduate student credit hours (T_GRSCH) and class sections taught (T_GROCS) per tenure/tenure-track instructor *rise*, the number of undergraduate student credit hours and class sections taught per faculty member *falls*. For every graduate student credit hour taught per tenure or tenure-track faculty member, the number of undergraduate student credit hours produced is *reduced* by 1/2 hour per instructor (coefficient of -.4950). For every graduate class section taught per tenure/tenure-track faculty member, the number of undergraduate official class sections taught per instructor *decreased* by .28 class sections.

The above two results make intuitive sense. The total amount of time allocated to teaching is divided between graduate and undergraduate students. The number of graduate student credit hours and class sections taught per faculty member substitutes for and reduces the number of undergraduate student credit hours and class sections that individual faculty produce. In a similar vein, as more money is spent on instruction per FTE student (increased pay per faculty member and/or a higher faculty-to-student ratio), departments can afford to have faculty teach fewer undergraduate students and classes.

In regard to the above effects of graduate student credit hours and class sections being taught per tenure and tenure-track faculty (T_GRSCH and T_GROCS) on undergraduate instructional productivity, a note of caution is warranted. The number of graduate student credit hours/class sections taught and the number of undergraduate student credit hours/class sections taught may be jointly determined. If causation goes both ways, then the regression results regarding these two variables may suffer from simultaneous equations bias; that is, this is an identification problem. If these two variables are jointly determined, we cannot know whether we are estimating the equation for the undergraduate student credit hours/class sections taught or the equation for graduate student credit hours/class sections taught.

One method for resolving this dilemma is to use instrumental variables estimation.

> The method of instrumental variables involves the search for a new variable (Z) which is both highly correlated with the independent variable X and at the same time uncorrelated with the error term in the equation (as well as the errors of measurement of both variables.) (Pindyck & Rubinfeld, 1991, p. 131)

In practical terms, that means selecting a substitute variable to place in the equation that would affect the dependent variable being investigated (here, undergraduate student credit hours/class sections taught; T_UGSCH and T_UGOCS) but not affect the variable that is causing the identification problem (in this case, graduate student credit hours/class sections taught; T_GRSCH and T_GROCS). "In practice one must search for a suitable *proxy variable* to replace the original. The proxy variable should be highly correlated with the original variable, and uncorrelated with the error in the equation..." (Pindyck & Rubinfeld, 1991, p. 131). Unfortunately, there are no variables from the NSICP data set which fit that criteria, so an instrumental variables estimation to resolve this potential simultaneity problem is not possible. As noted by Pindyck & Rubinfeld (1991), "In any given situation it is conceivable that no such instruments will exist..." (p. 131).

The number of tenure/tenure-track faculty as a percent of total faculty within a department (T_FACPER) has a positive and significant effect on the number of undergraduate student credit hours and the number of class sections taught per faculty member (for student credit hours, coefficient = +.5437; for class sections, coefficient = +.006007). For every 10 percentage point gain in tenure/tenure-track faculty (as a percent of total faculty), at the mean, the number of undergraduate student credit hours produced per faculty member should *rise* by 5.4 hours and the number of undergraduate class sections taught per instructor should *increase* by .06 sections. As their numbers increase as a percent of all instructors, tenure/tenure-track faculty appear to demonstrate some form of synergism within their own ranks regarding undergraduate instructional productivity.

Whether the institution is public or private (DV1) is significant in considering undergraduate productivity per faculty member. Tenure/tenure-track faculty members within public institutions teach 56.5 *more* undergraduate student credit hours and almost one-third *more* undergraduate class sections per instructor than their counter parts in private universities. This finding is important particularly because the regression equation controls for at least one gauge of departmental quality: instructional expenditures per FTE student (INST_FTE). When the measure of quality is controlled, it appears that public universities get more "bang for the buck" from their tenure and tenure-track faculty members in producing undergraduate education than private universities get from their faculty.

Departmental expenditures in the public service area (SVC_FTET) have no significant effect upon tenure/tenure-track faculty instructional productivity. Public service dollars spent per any FTE faculty member (including expenditures per *other* regular faculty, supplemental faculty, and teaching assistants) have no significant effect on measures of undergraduate faculty productivity. Public service expenditures (SVC_FTET) do have an extremely small effect upon tenure/tenure-track and *other* regular faculty instructional productivity when a log transformation is performed on the data; however, the adjusted R^2 of the log regression output on *other* regular faculty productivity is very small, as are the individual public service coefficients (SVC_FTET) in the regular and tenure/tenure-track faculty log regression results (see Tables 12 & 13 and Appendix B). Departmental dollars spent on public service (SVC_FTET) thus appear not to be associated with faculty undergraduate instructional productivity as measured in this study.

Dummy variables 2, 3, 6, 7, and 8 are significant and negative in evaluating the effects of faculty undergraduate student credit hour productivity within academic groupings. Tenure/tenure-track faculty within agriculture sciences (DV2; -77.5), engineering/computer science (DV3; -74.7), fine arts (DV6; -68.7), nursing/pharmacy (DV7; -72.9), and business (DV8; -29.7) produce *fewer* undergraduate student credit hours per instructor than the social science/humanities reference group. The broadly defined academic areas of home economics (DV4) and physical sciences & math (DV5), although also demonstrating negative coefficients, are not significantly different than the reference group in tenure/tenure-track faculty production of undergraduate student credit hours. In sum, put simply, with the exception of home economics and physical sciences

& math, the other fields of study demonstrated *lower* instructional productivity than did the social sciences.

In the number of undergraduate class sections taught per tenure/tenure-track faculty member (T_UGOCS), all the academic field dummy variables are significant but one (physical sciences & math; DV5). For four of the groups, the number of undergraduate class sections taught per tenure/tenure-track faculty member is *greater* than the social science/humanities reference group: agriculture (DV2; +.55), engineering/computer science (DV3; +.23), home economics (DV4; +.63), and fine arts (DV6; +1.2). Faculty in these academic areas taught *fewer* undergraduate student credit hours but *more* classes per instructor than did the social science/humanities reference group. Faculty in fine arts (which includes the visual and performing arts, dance, drama, film, photography, and music) taught almost 69 *fewer* undergraduate student credit hours and 1.2 *more* undergraduate class sections per faculty member than the social science/humanities reference group. This result can be expected because of the very small student enrollments but numerous classes normally offered by fine arts departments.

For the four academic fields noted above, the combination of fewer student credit hours and more class sections taught per tenure/tenure-track instructor translates into smaller than average undergraduate class size than the social science/humanities reference group; however, in two academic fields, nursing/pharmacy (DV7; -72.9 student credit hours; -.40 class sections) and business (DV8; -29.7 student credit hours;

-.23 class sections), faculty not only produce *fewer* undergraduate student credit hours but also teach relatively *fewer* undergraduate class sections per faculty member (than the social science/humanities reference group). These two undergraduate academic areas appear to be labor intensive and have some resource limitation in either the total number or the variety of classes that they offer; that is, undergraduate students enrolling in these two academic fields may be limited in either the assortment of classes that can be taken and/or in the total number of students that can be enrolled in individual classes (enrollment capitation).

Other Regular Faculty Undergraduate Instructional Productivity

Table 6 comprises the regression output for undergraduate student credit hours taught per *other* regular faculty. Table 7 records the results for undergraduate official class sections taught per the same faculty group. The adjusted R^2 of .0734 for R_UGSCH and .0188 for R_UGOCS are relatively small. The independent variables in the regression equations explain only seven percent of the variability in undergraduate student credit hours and less than two percent of the variability in the number of undergraduate class sections taught per *other* regular faculty member.

Although seven out of the fourteen variables in the R_UGSCH equation are significant, only one variable is significant in the R_UGOCS equation (INST_FTE). Given the modest explanatory power of this set of equations and the attendant non-significance of most of the variables, we can assume that undergraduate instructional

TABLE 6

Dependent Variable: R_UGSCH

Multiple Regression

Multiple R = .2949 sig. of R = .0000
Multiple R Square = .0870
Adjusted R square = .0734

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	9180542.1175	655753.0084	6.397	.0000
Residual	940	96365778.1171	102516.7852		

Equation: R_UGSCH = 169.6290 + (-.3977 T_GRSCH) + (1.0212 T_FACPER)
+ (-.005152 INST_FTE) + (-.00008310 RES_TFAC)
+ (-.1746 RES_PER) + (.00007085 SVC_FTET) + (73.2240 DV_1)
+ (-118.3160 DV_2) + (-70.8682 DV_3) + (-14.7706 DV_4)
+ (124 3852 DV_5) + (-128.5704 DV_6) + (-174.5665 DV_7)
+ (66.5515 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GRSCH	-0.3977	0.359	-0.9887	to	0.1933	0.9019
T_FACPER	1.0212	0.6343	-0.02317	to	2.0656	0.9102
INST_FTE	-0.005152	0.001638	-0.00785	to	-0.002455	0.8458
RES_TFAC	-0.000083100	0.000188000	-0.000392700	to	0.000226500	0.265800000
RES_PER	-0.174600000	0.874100000	-1.613800000	to	1.264600000	0.279500000
SVC_FTET	0.000070850	0.000631400	-0.000968700	to	0.001110000	0.705300000
DV_1	73.224	35.5138	14.7522	to	131.6957	0.9591
DV_2	-118.316	53.3687	-206.1849	to	-30.447	0.6607
DV_3	-70.8682	33.2751	-125.654	to	-16.0823	0.6182
DV_4	-14.7706	49.2351	-95.8337	to	66.2926	0.8925
DV_5	124.3852	35.5542	65.8469	to	182.9235	0.6996
DV_6	-128.5704	39.6395	-193.835	to	-63.3058	0.8337
DV_7	-174.5665	66.054	-283.3213	to	-65.8118	0.929
DV_8	66.5515	36.8827	5.8259	to	127.2772	0.7932

TABLE 6

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GRSCH	-0.0364	0.0328	-0.0269	-0.0345	-0.0361	1.2270	0.2682
T_FACPER	0.0526	0.0327	0.0120	0.0502	0.0524	2.5920	0.1077
INST_FTE	-0.1066	0.0339	-0.1556	-0.0980	-0.1020	9.8890	0.0017*
RES_TFAC	-0.0267	0.0605	-0.0694	-0.0138	-0.0144	0.1950	0.6587
RES_PER	-0.0118	0.0590	-0.0393	-0.0062	-0.0065	0.0400	0.8417
SVC_FTET	0.0042	0.0371	-0.0490	0.0035	0.0037	0.0130	0.9107
DV_1	0.0656	0.0318	0.0699	0.0643	0.0671	4.2510	0.0395*
DV_2	-0.0850	0.0383	-0.0815	-0.0691	-0.0721	4.9150	0.0269*
DV_3	-0.0844	0.0396	-0.1228	-0.0664	-0.0693	4.5360	0.0335*
DV_4	-0.0099	0.0330	0.0081	-0.0093	-0.0098	0.0900	0.7642
DV_5	0.1304	0.0373	0.1601	0.1090	0.1134	12.2390	0.0005*
DV_6	-0.1107	0.0341	-0.0986	-0.1011	-0.1052	10.5200	0.0012*
DV_7	-0.0855	0.0323	-0.0884	-0.0824	-0.0859	6.9840	0.0084*
DV_8	0.0631	0.0350	0.0876	0.0562	0.0588	3.2560	0.0715

* Significant at the 95th percentile

TABLE 7

Dependent Variable: R_UGOCS

Multiple Regression

Multiple R = .1823 sig. of R = .0041
Multiple R Square = .0332
Adjusted R square = .0188

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	262.3016	18.7358	2.307	.0041
Residual	940	7632.7045	8.1199		

Equation: R_UGOCS = 2.5931 + (-.2673 T_GROCS) + (-.002127 T_FACPER)
+ (-.00005087 INST_FTE) + (5.5666E-7 RES_TFAC)
+ (-.01041 RES_PER) + (.000006475 SVC_FTET) + (.1826 DV_1)
+ (.8668 DV_2) + (.3509 DV_3) + (.7976 DV_4)
+ (.5735 DV_5) + (.1690 DV_6) + (-.9355 DV_7)
+ (.1647 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GROCS	-0.2673	0.1857	-0.5731	to	0.03838	0.9589
T_FACPER	-0.002127	0.005652	-0.01143	to	0.007179	0.9081
INST_FTE	-0.000050870	0.000014580	-0.000074870	to	-0.000026860	0.846200000
RES_TFAC	0.000000557	0.000001674	-0.000002199	to	0.000003313	0.265700000
RES_PER	-0.01041	0.007772	-0.02321	to	0.002382	0.28
SVC_FTET	0.000006475	0.000005627	-0.000002790	to	0.000015740	0.703400000
DV_1	0.1826	0.3166	-0.3387	to	0.7038	0.9559
DV_2	0.8668	0.4735	0.08727	to	1.6464	0.6649
DV_3	0.3509	0.2954	-0.1354	to	0.8373	0.6213
DV_4	0.7976	0.4379	0.07672	to	1.5185	0.8939
DV_5	0.5735	0.3164	0.05251	to	1.0945	0.6996
DV_6	0.169	0.352	-0.4105	to	0.7485	0.8375
DV_7	-0.9355	0.5884	-1.9042	to	0.03316	0.9275
DV_8	0.1647	0.3225	-0.3663	to	0.6956	0.8217

TABLE 7

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GROCS	-0.0472	0.0327	-0.0511	-0.0462	-0.0469	2.0730	0.1503
T_FACPER	-0.0127	0.0337	-0.0160	-0.0121	-0.0123	0.1420	0.7068
INST_FTE	-0.1216	0.0349	-0.1213	-0.1119	-0.1131	12.1740	0.0005*
RES_TFAC	0.0207	0.0622	-0.0085	0.0107	0.0108	0.1110	0.7396
RES_PER	-0.0812	0.0606	-0.0265	-0.0430	-0.0437	1.7960	0.1806
SVC_FTET	0.0440	0.0382	0.0388	0.0369	0.0375	1.3240	0.2502
DV_1	0.0189	0.0328	0.0413	0.0185	0.0188	0.3330	0.5643
DV_2	0.0720	0.0393	0.0482	0.0587	0.0596	3.3520	0.0675
DV_3	0.0483	0.0407	-0.0396	0.0381	0.0387	1.4110	0.2351
DV_4	0.0618	0.0339	0.0579	0.0584	0.0593	3.3180	0.0688
DV_5	0.0695	0.0383	0.0316	0.0581	0.0590	3.2850	0.0702
DV_6	0.0168	0.0350	0.0030	0.0154	0.0157	0.2310	0.6312
DV_7	-0.0530	0.0333	-0.0737	-0.0510	-0.0518	2.5280	0.1121
DV_8	0.0181	0.0354	0.0055	0.0164	0.0167	0.2610	0.6098

* Significant at the 95th percentile

TABLE 8

Dependent Variable: S_UGSCH

Multiple Regression

Multiple R = .2124 sig. of R = .0001
Multiple R Square = .0451
Adjusted R square = .0309

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	4773006.5211	340929.0372	3.171	.0001
Residual	940	101054716.5533	107505.0176		

Equation: S_UGSCH = 161.1194 + (-.2888 T_GRSCH) + (.9871 T_FACPER)
+ (-.002490 INST_FTE) + (.00007194 RES_TFAC)
+ (-.4636 RES_PER) + (-.0008108 SVC_FTET) + (39.3431 DV_1)
+ (-185.3899 DV_2) + (-95.9299 DV_3) + (37.2942 DV_4)
+ (24.6117 DV_5) + (-54.4013 DV_6) + (-88.4741 DV_7)
+ (-60.6947 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GRSCH	-0.2888	0.3676	-0.894	to	0.3164	0.9019
T_FACPER	0.9871	0.6496	-0.08241	to	2.0566	0.9102
INST_FTE	-0.00249	0.001678	-0.005253	to	0.000272	0.8458
RES_TFAC	0.000071940	0.000192600	-0.000245100	to	0.000389000	0.265800000
RES_PER	-0.4636	0.8951	-1.9374	to	1.0102	0.2795
SVC_FTET	-0.0008108	0.0006466	-0.001875	to	0.0002538	0.7053
DV_1	39.3431	36.3675	-20.5343	to	99.2205	0.9591
DV_2	-185.3899	54.6516	-275.3712	to	-95.4085	0.6607
DV_3	-95.9299	34.075	-152.0328	to	-39.827	0.6182
DV_4	37.2942	50.4187	-45.7178	to	120.3061	0.8925
DV_5	24.6117	36.4089	-35.3338	to	84.5573	0.6996
DV_6	-54.4013	40.5925	-121.2349	to	12.4322	0.8337
DV_7	-88.4741	67.6419	-199.8433	to	22.8951	0.929
DV_8	-60.6947	37.7694	-122.8801	to	1.4907	0.7932

TABLE 8

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GRSCH	-0.0264	0.0336	-0.0459	-0.0250	-0.0256	0.6170	0.4323
T_FACPER	0.0508	0.0334	0.0061	0.0484	0.0495	2.3090	0.1290
INST_FTE	-0.0514	0.0347	-0.0925	-0.0473	-0.0484	2.2030	0.1381
RES_TFAC	0.0231	0.0618	-0.0826	0.0119	0.0122	0.1400	0.7088
RES_PER	-0.0312	0.0603	-0.0670	-0.0165	-0.0169	0.2680	0.6046
SVC_FTET	-0.0476	0.0380	-0.0845	-0.0400	-0.0409	1.5720	0.2102
DV_1	0.0352	0.0325	0.0329	0.0345	0.0353	1.1700	0.2796
DV_2	-0.1330	0.0392	-0.1187	-0.1081	-0.1100	11.5070	0.0007*
DV_3	-0.1141	0.0405	-0.0999	-0.0897	-0.0914	7.9260	0.0050*
DV_4	0.0250	0.0337	0.0548	0.0236	0.0241	0.5470	0.4597
DV_5	0.0258	0.0381	0.0740	0.0215	0.0220	0.4570	0.4992
DV_6	-0.0468	0.0349	-0.0063	-0.0427	-0.0437	1.7960	0.1805
DV_7	-0.0433	0.0331	-0.0325	-0.0417	-0.0426	1.7110	0.1912
DV_8	-0.0575	0.0358	-0.0226	-0.0512	-0.0523	2.5820	0.1084

* Significant at the 95th percentile

TABLE 9

Dependent Variable: S_UGOCS

Multiple Regression

Multiple R = .1681 sig. of R = .0187
Multiple R Square = .0283
Adjusted R square = .0138

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	652.1088	46.5792	1.951	.0187
Residual	939	22412.7163	23.8687		

Equation: S_UGOCS = 1.2737 + (-.1724 T_GROCS) + (.004967 T_FACPER)
+ (-.00002407 INST_FTE) + (-.000001124 RES_TFAC)
+ (-.008172 RES_PER) + (-.000004021 SVC_FTET)
+ (.8212 DV_1) + (-.2688 DV_2) + (.3002 DV_3)
+ (1.1120 DV_4) + (1.4315 DV_5) + (1.6629 DV_6)
+ (.4227 DV_7) + (-.4643 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GROCS	-0.1724	0.3184	-0.6966	to	0.3517	0.9589
T_FACPER	0.004967	0.009707	-0.01102	to	0.02095	0.9074
INST_FTE	-0.000024070	0.000025000	-0.000065220	to	0.000017080	0.846200000
RES_TFAC	-0.000001124	0.000002870	-0.000005849	to	0.000003602	0.265700000
RES_PER	-0.008172	0.01333	-0.03011	to	0.01377	0.2801
SVC_FTET	-0.000004021	0.000009648	-0.000019910	to	0.000011860	0.703400000
DV_1	0.8212	0.5429	-0.07263	to	1.7149	0.9558
DV_2	-0.2688	0.8118	-1.6054	to	1.0677	0.6649
DV_3	0.3002	0.5065	-0.5337	to	1.134	0.6214
DV_4	1.112	0.7507	-0.124	to	2.348	0.8939
DV_5	1.4315	0.5425	0.5383	to	2.3247	0.6997
DV_6	1.6629	0.6061	0.6651	to	2.6608	0.8393
DV_7	0.4227	1.0087	-1.2382	to	2.0835	0.9275
DV_8	-0.4643	0.5529	-1.3747	to	0.446	0.8218

TABLE 9

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GROCS	-0.0178	0.0329	-0.0238	-0.0174	-0.0177	0.2930	0.5882
T_FACPER	0.0173	0.0338	-0.0094	0.0165	0.0167	0.2620	0.6090
INST_FTE	-0.0337	0.0350	-0.0445	-0.0310	-0.0314	0.9270	0.3358
RES_TFAC	-0.0244	0.0624	-0.0656	-0.0126	-0.0128	0.1530	0.6955
RES_PER	-0.0373	0.0608	-0.0525	-0.0197	-0.0200	0.3760	0.5399
SVC_FTET	-0.0160	0.0384	-0.0483	-0.0134	-0.0136	0.1740	0.6769
DV_1	0.0498	0.0329	0.0491	0.0487	0.0493	2.2880	0.1307
DV_2	-0.0131	0.0395	-0.0582	-0.0107	-0.0108	0.1100	0.7406
DV_3	0.0242	0.0408	-0.0324	0.0191	0.0193	0.3510	0.5536
DV_4	0.0504	0.0340	0.0401	0.0477	0.0483	2.1940	0.1389
DV_5	0.1015	0.0385	0.0736	0.0849	0.0858	6.9620	0.0085*
DV_6	0.0963	0.0351	0.0909	0.0883	0.0892	7.5280	0.0062*
DV_7	0.0140	0.0334	-0.0038	0.0135	0.0137	0.1760	0.6753
DV_8	-0.0298	0.0355	-0.0523	-0.0270	-0.0274	0.7050	0.4012

* Significant at the 95th percentile

productivity of individual *other* regular faculty is influenced primarily by factors not included in the regression model.

Supplemental Faculty Undergraduate Instructional Productivity

Table 8 includes the regression output for undergraduate student credit hours taught per supplemental faculty. Table 9 specifies the results for undergraduate official class sections taught per the same faculty group. The adjusted R^2 of .0309 for S_UGSCH and .0138 for S_UGOCS are very small. Clearly, other factors account for the instructional productivity of supplemental faculty. The independent variables in the regression equations explain only three percent of the variability in undergraduate student credit hours and about one percent of the variability in the number of undergraduate class sections taught per supplemental faculty member.

Only two variables out of fourteen in both the S_UGSCH and S_UGOCS equations are significant (DV2, Agriculture; and DV3, Engineering/computer science in S_UGSCH; DV5, Physical Science & Math; and DV6, Fine Arts in S_UGOCS) . Given the minor explanatory power of this set of equations and the attendant non-significance of almost all of the variables, we can speculate that undergraduate instructional productivity of supplemental faculty is not affected to any significant degree by the components within the regression model.

Teaching Assistant Undergraduate Instructional Productivity

Table 10 registers the regression output for undergraduate student credit hours taught per teaching assistant. Table 11 details the results for undergraduate official class sections taught per the same group.

The adjusted R^2 of .0815 for TA_UGSCH and .1240 for TA_UGOCS is low, but higher than that of *other* regular faculty and supplemental faculty. In addition, a majority of variables entered in the TA_UGOCS regression are significant at the 95th percentile, although the critical variables which are the primary focus of this investigation (research spending [RES_TFAC] and research expenditures as a percent of the total departmental budget [RES_PER]) are not significant in determining the undergraduate instructional productivity of teaching assistants.

One should note that as the percentage of tenure/tenure-track faculty *increases* within a department, the relative productivity in undergraduate class sections taught per teaching assistant *drops*. We may hypothesize from this that if a department's tenure/tenure-track faculty numbers (RES_PER) *increased* by 10 percentage points (as a percent of the department's total faculty), then we might expect that teaching assistants would teach .15 *fewer* undergraduate class sections per assistant. This partially supports an earlier finding that as the number of tenure/tenure-track faculty *rises* (as a percent of total faculty within a department), so also does individual undergraduate instructional productivity. They teach *more* undergraduate classes per instructor, thus reducing the number of undergraduate class sections that teaching assistants may be required to teach.

TABLE 10

Dependent Variable: TA_UGSCH

Multiple Regression

Multiple R = .3082 sig. of R = .0000
Multiple R Square = .0950
Adjusted R square = .0815

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	5640224.2448	402873.1603	7.040	.0000
Residual	939	53732714.9176	57223.3386		

Equation: TA_UGSCH = 139.5511 + (.3731 T_GRSCH) + (.1192 T_FACPER)
+ (-.003671 INST_FTE) + (-.00007098 RES_TFAC)
+ (.06767 RES_PER) + (-.0003348 SVC_FTET) + (78.4443 DV_1)
+ (-135.6899 DV_2) + (-141.3682 DV_3) + (-43.8752 DV_4)
+ (-87.0209 DV_5) + (-19.1357 DV_6) + (-121.5127 DV_7)
+ (-29.0458 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GRSCH	0.3731	0.2685	-0.06898	to	0.8151	0.9011
T_FACPER	0.1192	0.4785	-0.6685	to	0.907	0.9083
INST_FTE	-0.003671	0.001266	-0.005756	to	-0.001586	0.8467
RES_TFAC	-0.000070980	0.000140600	-0.000302400	to	0.000160500	0.265500000
RES_PER	0.06767	0.6531	-1.0076	to	1.1429	0.2796
SVC_FTET	-0.0003348	0.0004718	-0.001112	to	0.000442	0.7052
DV_1	78.4443	26.5635	34.7086	to	122.1799	0.957
DV_2	-135.6899	39.8766	-201.3448	to	-70.0349	0.6606
DV_3	-141.3682	24.8608	-182.3004	to	-100.436	0.6209
DV_4	-43.8752	36.7898	-104.4478	to	16.6975	0.8923
DV_5	-87.0209	26.5664	-130.7613	to	-43.2806	0.6996
DV_6	-19.1357	29.6257	-67.9131	to	29.6417	0.8332
DV_7	-121.5127	49.3573	-202.7772	to	-40.2483	0.9287
DV_8	-29.0458	27.5557	-74.4151	to	16.3234	0.7933

TABLE 10

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GRSCH	0.0454	0.0327	0.0277	0.0431	0.0453	1.9310	0.1650
T_FACPER	0.0081	0.0326	-0.0475	0.0077	0.0081	0.0620	0.8033
INST_FTE	-0.0978	0.0337	-0.1828	-0.0900	-0.0942	8.4030	0.0038*
RES_TFAC	-0.0304	0.0602	-0.1374	-0.0157	-0.0165	0.2550	0.6137
RES_PER	0.0061	0.0587	-0.1373	0.0032	0.0034	0.0110	0.9175
SVC_FTET	-0.0262	0.0370	-0.0668	-0.0220	-0.0231	0.5030	0.4782
DV_1	0.0937	0.0317	0.1064	0.0917	0.0959	8.7210	0.0032*
DV_2	-0.1300	0.0382	-0.0925	-0.1056	-0.1104	11.5790	0.0007*
DV_3	-0.2240	0.0394	-0.1951	-0.1765	-0.1825	32.3350	0.0000*
DV_4	-0.0392	0.0329	0.0236	-0.0370	-0.0389	1.4220	0.2333
DV_5	-0.1216	0.0371	-0.0496	-0.1017	-0.1063	10.7300	0.0011*
DV_6	-0.0220	0.0340	0.0481	-0.0201	-0.0211	0.4170	0.5185
DV_7	-0.0793	0.0322	-0.0455	-0.0764	-0.0801	6.0610	0.0140*
DV_8	-0.0367	0.0349	0.0598	-0.0327	-0.0344	1.1110	0.2921

* Significant at the 95th percentile

TABLE 11

Dependent Variable: TA_UGOCS

Multiple Regression

Multiple R = .3700 sig. of R = .0000
Multiple R Square = .1369
Adjusted R square = .1240

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	1137.3531	81.2395	10.624	.0000
Residual	938	7172.6619	7.6468		

Equation: TA_UGOCS = 2.3378 + (.3315 T_GROCS) + (-.01515 T_FACPER)
+ (-.00004367 INST_FTE) + (-.000001907 RES_TFAC)
+ (-.007027 RES_PER) + (-.000003940 SVC_FTET)
+ (1.2919 DV_1) + (.1087 DV_2) + (-.1890 DV_3)
+ (1.2708 DV_4) + (1.6546 DV_5) + (.9960 DV_6)
+ (-1.1711 DV_7) + (-.6483 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GROCS	0.3315	0.1805	0.0343	to	0.6287	0.9572
T_FACPER	-0.01515	0.005548	-0.02429	to	-0.006015	0.9051
INST_FTE	-0.000043670	0.000014640	-0.000067780	to	-0.000019560	0.846200000
RES_TFAC	-0.000001907	0.000001626	-0.000004584	to	0.000000769	0.265400000
RES_PER	-0.007027	0.007543	-0.01945	to	0.005392	0.2803
SVC_FTET	-0.000003940	0.000005461	-0.000012930	to	0.000005052	0.703300000
DV_1	1.2919	0.3077	0.7853	to	1.7984	0.9535
DV_2	0.1087	0.4595	-0.6479	to	0.8653	0.6648
DV_3	-0.189	0.2867	-0.661	to	0.283	0.6241
DV_4	1.2708	0.425	0.5712	to	1.9705	0.8937
DV_5	1.6546	0.3071	1.1489	to	2.1602	0.6997
DV_6	0.996	0.3431	0.4311	to	1.561	0.839
DV_7	-1.1711	0.571	-2.1113	to	-0.231	0.9273
DV_8	-0.6483	0.313	-1.1636	to	-0.133	0.8219

TABLE 11

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GROCS	0.0569	0.0310	0.0436	0.0557	0.0599	3.3730	0.0666
T_FACPER	-0.0871	0.0319	-0.1539	-0.0828	-0.0888	7.4560	0.0064*
INST_FTE	-0.0983	0.0330	-0.1557	-0.0905	-0.0969	8.8950	0.0029*
RES_TFAC	-0.0691	0.0589	-0.1311	-0.0356	-0.0383	1.3770	0.2410
RES_PER	-0.0534	0.0573	-0.1049	-0.0283	-0.0304	0.8680	0.3518
SVC_FTET	-0.0261	0.0362	-0.0843	-0.0219	-0.0235	0.5200	0.4709
DV_1	0.1304	0.0311	0.1523	0.1274	0.1358	17.6320	0.0000*
DV_2	0.0088	0.0372	-0.0710	0.0072	0.0077	0.0560	0.8130
DV_3	-0.0253	0.0384	-0.1472	-0.0200	-0.0215	0.4350	0.5098
DV_4	0.0960	0.0321	0.1083	0.0907	0.0972	8.9430	0.0029*
DV_5	0.1954	0.0363	0.1771	0.1634	0.1732	29.0250	0.0000*
DV_6	0.0961	0.0331	0.1073	0.0881	0.0944	8.4270	0.0038*
DV_7	-0.0646	0.0315	-0.0804	-0.0622	-0.0668	4.2060	0.0405*
DV_8	-0.0693	0.0335	-0.0770	-0.0628	-0.0675	4.2910	0.0386*

* Significant at the 95th percentile

Institutional status also appears to affect undergraduate instructional productivity of teaching assistants. Teaching assistants at public universities teach almost one and one third (1.29) *more* undergraduate classes and 78 *more* undergraduate student credit hours per assistant than their counterparts in private universities. Private universities appear either to utilize fewer teaching assistants in undergraduate education, require them to teach fewer undergraduate classes than public universities, or both. Although teaching assistants at public universities are financially subsidized to some degree (fee waivers, out-of-state tuition, etc.), their contribution to the production of undergraduate education in the public sector is important.

Teaching assistant instructional productivity regarding the number of undergraduate class sections taught per assistant is also significant in five of the seven academic groupings. Teaching assistants in the areas of home economics (DV4; +1.27), physical sciences & math (DV5; +1.65), and the fine arts (DV6; +.99) teach *more* undergraduate classes per assistant than the social science/humanities reference group (e.g., +1.27 more in home economics). Teaching assistants in the areas of nursing/pharmacy (DV7; -1.17) and business (DV8; -.65) teach relatively *fewer* undergraduate classes per assistant than those in the social science/humanities reference group. Teaching assistant instructional productivity in undergraduate student credit hours taught is also significant in four academic groups: agriculture (DV2; -135.69), engineering & computer sciences (DV3; -141.37), physical sciences & math (DV5; -87.02), and nursing/pharmacy (DV7; -121.51).

It may be hypothesized that the reason teaching assistants in home economics, physical sciences & math, and fine arts teach *more* undergraduate class sections is that class enrollments are smaller, in part because the variety of classes offered in those departments is greater. This is partially supported by the regression results for undergraduate student credit hours per teaching assistant in the field of physical sciences & math. The physical sciences & math group (DV5) teaches *fewer* undergraduate student credit hours per assistant (-87 credit hours, significant at the 95th percentile) yet teach *more* class sections (+1.65); however, similar results are not found in the academic areas of home economics (DV4) and fine arts (DV6). These two groups (home economics and fine arts) teach significantly *more* undergraduate classes per teaching assistant, but the number of undergraduate student credit hours they teach is not significantly different than the social science/humanities reference group.

Teaching assistants in nursing/pharmacy (DV7) and business (DV8) teach *fewer* undergraduate class sections per assistant than in the social science/humanities reference group. In the case of nursing/pharmacy (DV7) , teaching assistants also produce *fewer* undergraduate student credit hours (-121.51; significant at the 95th percentile). This finding partially supports the earlier reported result regarding tenure/tenure-track faculty productivity in these two academic areas. Nursing/pharmacy (DV7) and business (DV8) departments seem to be labor intensive and limited in the total number of classes that they offer, the variety of classes they offer, or the number of students they enroll. These limitations affect both tenure/tenure-track faculty and teaching assistants in the field of nursing/pharmacy (DV7); however, in the case of teaching assistants in business (DV8), notwithstanding they teach *fewer* undergraduate class sections, the number of undergraduate student credit hours produced per assistant is not significantly different from that of the social science/humanities reference group.

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

Since this study analyzes the possible effects of departmental research expenditures upon faculty undergraduate instructional productivity, departments that have no research expenditures may bias results for departments that do have research expenditures. Obviously, for departmental research expenditures to display some effect upon faculty instructional undergraduate productivity, research spending may need to be greater than zero. To investigate this possibility, a second round of regressions was conducted with the sample limited to values of RES_TFAC (departmental research expenditures per tenure/tenure-track faculty) greater than zero.

The R^2 results of these regressions, concerning instructional undergraduate productivity per tenure/tenure-track, *other* regular, and supplemental faculty, were less than the R^2 results of the primary regression model. R^2 was slightly greater regarding teaching assistant instructional undergraduate productivity, but individual coefficients and their respective correlations did not significantly differ from those in the original least squares regression model. Because this regression procedure did not improve notably on the predictive power of the original model, the results are not shown here. Interested parties may view the results of this analysis by referring to Appendix A.

Research Expenditure Effects Upon Private University Instructional Productivity

A separate regression iteration was conducted on faculty undergraduate instructional productivity for private universities. It may be argued that resource dependency would have differential impacts on undergraduate instructional productivity based upon the institutional status of the university. Academic departments in private universities derive their revenue from three main sources: un-subsidized tuition (that is, no taxpayer outlays with the exception of student Pell Grants and loans), research grant an contract revenue, and earnings from endowments. Private universities cannot call upon state or local taxing agencies to increase the flow of resources into their institutions in lean times. To survive, private universities must maintain a steady flow of endowment income, secure and preserve a consistent flow of revenue from research grants and contracts, and provide for student satisfaction with the undergraduate experience. Thus, in the case of private universities, no revenue source can be considered a given; but any effects of research expenditures upon undergraduate instructional productivity would be tempered by the importance of maintaining undergraduate satisfaction (tuition revenue).

Departmental research expenditures per tenure/tenure-track faculty member and research expenditures as a percent of departmental budget were not significant in determining private university undergraduate instructional production. It appears that resource dependency (as tested in this study) does not have differential impacts upon faculty undergraduate instructional productivity when considering institutional status.

Logarithmic Transformations

Logarithmic transformations were performed on the original data set (N=955) to obtain the elasticities for the variables. In a logarithmic model transformation, the natural log is taken of individual variables exclusive, of dummy variables. Coefficients of the independent variables undergoing this transformation may be interpreted as that percent change (elasticity) in the dependent variable resulting from a percent change in the given independent variable.

Tenure/tenure-track Faculty Undergraduate Instructional Productivity

Table 12 comprises the regression output for undergraduate student credit hours taught per tenure/tenure-track faculty with logarithmic transformation. Table 13 records the results of undergraduate official class sections taught. The correlation coefficient for T_UGSCH is .6129 and for T_UGOCS .5669. The adjusted R^2 for T_UGSCH is .3663 and for R_UGOCS .3113. The independent variables in the regression equation explain almost 37 percent of the variability in undergraduate student credit hours produced and about 31 percent of the variability in the number of undergraduate class sections taught per tenure/tenure-track faculty member. Note that this log transformation is not directly comparable to the linear specifications in the earlier model.

The independent variables measuring the effects of research expenditures per tenure/tenure-track faculty member (RES_TFAC) and research as a percent of departmental spending (RES_PER) upon faculty undergraduate productivity in student credit hours are significant in the logarithmic model, but are mixed.

TABLE 12
Log Transformation

Dependent Variable: T_UGSCH

Multiple Regression

Multiple R = .6129 sig. of R = .0000
Multiple R Square = .3756
Adjusted R square = .3663

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	292.6886	20.9063	40.393	.0000
Residual	940	486.5233	.5176		

Equation: T_UGSCH = 9.2233 + (-.1524 T_GRSCH) + (.7025 T_FACPER)
+ (-.8204 INST_FTE) + (.03954 RES_TFAC) + (-.1005 RES_PER)
+ (-.01217 SVC_FTET) + (.09800 DV_1) + (-.008443 DV_2)
+ (.1913 DV_3) + (-.06512 DV_4) + (.4347 DV_5)
+ (.02386 DV_6) + (.04810 DV_7) + (.1293 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GRSCH	-0.1524	0.02288	-0.1901	to	-0.1148	0.8714
T_FACPER	0.7025	0.06243	0.5997	to	0.8053	0.9391
INST_FTE	-0.8204	0.04949	-0.9019	to	-0.7389	0.6551
RES_TFAC	0.03954	0.01405	0.01642	to	0.06267	0.1353
RES_PER	-0.1005	0.04277	-0.1709	to	-0.03004	0.1203
SVC_FTET	-0.01217	0.006464	-0.02281	to	-0.001522	0.8214
DV_1	0.098	0.08394	-0.04021	to	0.2362	0.8668
DV_2	-0.008443	0.1137	-0.1957	to	0.1788	0.7346
DV_3	0.1913	0.08131	0.05744	to	0.3252	0.5227
DV_4	-0.06512	0.1115	-0.2487	to	0.1185	0.8785
DV_5	0.4347	0.08131	0.3008	to	0.5686	0.6754
DV_6	0.02386	0.09224	-0.128	to	0.1757	0.7774
DV_7	0.0481	0.1508	-0.2002	to	0.2964	0.9001
DV_8	0.1293	0.083	-0.00735	to	0.266	0.7907

TABLE 12
Log Transformation

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GRSCH	-0.1839	0.0276	-0.1333	-0.1717	-0.2123	44.3820	0.0000*
T_FACPER	0.2993	0.0266	0.2678	0.2900	0.3446	126.6500	0.0000*
INST_FTE	-0.5278	0.0318	-0.4863	-0.4272	-0.4756	274.7860	0.0000*
RES_TFAC	0.1972	0.0701	-0.0110	0.0726	0.0914	7.9240	0.0050*
RES_PER	-0.1745	0.0743	-0.0280	-0.0605	-0.0764	5.5160	0.0190*
SVC_FTET	-0.0535	0.0284	-0.0064	-0.0485	-0.0613	3.5420	0.0602
DV_1	0.0323	0.0277	0.1237	0.0301	0.0381	1.3630	0.2433
DV_2	-0.0022	0.0301	-0.0707	-0.0019	-0.0024	0.0060	0.9408
DV_3	0.0839	0.0356	-0.1799	0.0606	0.0765	5.5360	0.0188*
DV_4	-0.0161	0.0275	-0.0090	-0.0151	-0.0190	0.3410	0.5594
DV_5	0.1677	0.0314	0.1310	0.1378	0.1718	28.5840	0.0000*
DV_6	0.0076	0.0292	-0.0147	0.0067	0.0084	0.0670	0.7959
DV_7	0.0087	0.0272	-0.0725	0.0082	0.0104	0.1020	0.7498
DV_8	0.0452	0.0290	0.0172	0.0402	0.0507	2.4270	0.1196

* Significant at the 95th percentile

TABLE 13
Log Transformation

Dependent Variable: T_UGOCS

Multiple Regression

Multiple R = .5669 sig. of R = .0000
Multiple R Square = .3214
Adjusted R square = .3113

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	36.7890	2.6278	31.803	.0000
Residual	940	77.6698	.0826		

Equation: T_UGOCS = 2.0299 + (-.2722 T_GROCS) + (.1751 T_FACPER)
+ (-.2061 INST_FTE) + (.002985 RES_TFAC)
+ (-.03326 RES_PER) + (.006802 SVC_FTET) + (.01488 DV_1)
+ (.2796 DV_2) + (.1981 DV_3) + (.1831 DV_4)
+ (.05251 DV_5) + (.4160 DV_6) + (-.05872 DV_7)
+ (-.04422 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GROCS	-0.2722	0.03473	-0.3294	to	-0.2151	0.9616
T_FACPER	0.1751	0.0249	0.1341	to	0.2161	0.9426
INST_FTE	-0.2061	0.01977	-0.2386	to	-0.1735	0.6554
RES_TFAC	0.002985	0.005611	-0.006253	to	0.01222	0.1354
RES_PER	-0.03326	0.01704	-0.06132	to	-0.005202	0.121
SVC_FTET	0.006802	0.002583	0.00255	to	0.01105	0.8214
DV_1	0.01488	0.0334	-0.04011	to	0.06988	0.8739
DV_2	0.2796	0.04533	0.2049	to	0.3542	0.7382
DV_3	0.1981	0.03245	0.1446	to	0.2515	0.524
DV_4	0.1831	0.04443	0.11	to	0.2563	0.8833
DV_5	0.05251	0.03251	-0.001018	to	0.106	0.6745
DV_6	0.416	0.0365	0.3559	to	0.4761	0.7926
DV_7	-0.05872	0.06038	-0.1581	to	0.04069	0.8961
DV_8	-0.04422	0.03295	-0.09847	to	0.01004	0.8008

TABLE 13
Log Transformation

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GROCS	-0.2148	0.0274	-0.2243	-0.2106	-0.2477	61.4420	0.0000*
T_FACPER	0.1946	0.0277	0.1799	0.1889	0.2236	49.4530	0.0000*
INST_FTE	-0.3459	0.0332	-0.2578	-0.2801	-0.3219	108.6420	0.0000*
RES_TFAC	0.0388	0.0730	-0.0977	0.0143	0.0174	0.2830	0.5948
RES_PER	-0.1508	0.0772	-0.1025	-0.0524	-0.0635	3.8090	0.0513
SVC_FTET	0.0781	0.0296	0.1016	0.0708	0.0856	6.9360	0.0086*
DV_1	0.0128	0.0287	0.1090	0.0120	0.0145	0.1990	0.6560
DV_2	0.1929	0.0313	0.1013	0.1657	0.1972	38.0410	0.0000*
DV_3	0.2266	0.0371	-0.0307	0.1640	0.1953	37.2590	0.0000*
DV_4	0.1178	0.0286	0.0846	0.1107	0.1332	16.9850	0.0000*
DV_5	0.0528	0.0327	-0.0911	0.0434	0.0526	2.6090	0.1066
DV_6	0.3440	0.0302	0.2959	0.3062	0.3485	129.9100	0.0000*
DV_7	-0.0276	0.0284	-0.1218	-0.0261	-0.0317	0.9460	0.3311
DV_8	-0.0403	0.0300	-0.1278	-0.0361	-0.0437	1.8000	0.1800

* Significant at the 95th percentile

Research spending per tenure/tenure-track faculty member (RES_TFAC) has a small, positive effect upon the number of undergraduate student credit hours produced per instructor (coefficient of +.0395). Counter-balancing this modest, positive effect, is the equally modest, negative impact of research spending as a percent of total departmental expenditures in research, instruction, and public service (RES_PER; coefficient of -.1005).

This analysis indicates that if research spending per tenure/tenure-track FTE faculty member were to *increase* by 10 percent, we may expect a .4 percent *increase* in the number of undergraduate student credit hours taught per instructor. Additionally, if research spending as a percent of total departmental expenditures (research, instruction, and public service) were to *increase* by 10 percent, we may expect a one percent *decrease* in faculty undergraduate instructional productivity. Although significant at the 95th percentile, both of these elasticities are modest and for all practical purposes offset each other.

As in the initial regression model, the variables that have the greatest impact upon tenure/tenure-track faculty undergraduate instructional productivity are the number of graduate student credit hours/class sections taught per faculty member (T_GRSCH & T_GROCS; coefficient of -.1524 for T_UGSCH; coefficient of -.2722 for T_UGOCS), the percent of tenure/tenure-track faculty within the department (T_FACPER; +.7025 for T_UGSCH; +.1751 for T_UGOCS), and instructional expenditures per FTE student (INST_FTE; -.8204 for T_UGSCH; -.2061 for T_UGOCS). A 10 percent *increase* in the number of graduate student credit hours taught per faculty member (T_GRSCH) is associated with a *reduction* in the number of undergraduate student credit hours taught per instructor by 1.5 percent. Likewise, a 10 percent *increase* in the percent of tenure/tenure-track faculty (T_FACPER) is associated with a seven percent *increase* in undergraduate student credit hours taught per instructor. Finally, a 10 percent *increase* in instructional expenditures per FTE student (INST_FTE) is associated with an 8.2 percent *reduction* of the number of undergraduate student credit hours taught per instructor.

With regard to the number of undergraduate student credit hours taught per instructor, it appears that tenure/tenure-track faculty are more responsive to changes in the share of instructors (percent of tenure/tenure-track faculty within the department) and to instructional spending variability than to other factors in the model. Productivity response to changes along these two parameters is relatively elastic, compared to changes in graduate student credit hours taught, research expenditures per faculty member, or research spending as a percent of departmental budgets. Tenure/tenure-track faculty undergraduate student credit hour productivity responds in a relatively inelastic manner to changes in these latter factors.

In regard to official class sections taught, faculty response is relatively inelastic (a 10 percent *increase* in graduate class sections taught yields -2.7 percent change in undergraduate class sections taught). The response is also relatively inelastic when considering changes in the percent of tenure/tenure-track faculty within a department (a 10 percent *increase* yields a +1.7 percent change in class sections) and the number of instructional dollars spent per FTE student (a 10 percent *increase* in spending yields a -2.1 percent reduction in undergraduate class sections taught). Research expenditures per tenure/tenure-track faculty (RES_TFAC) and research spending as a percent of total departmental expenditures (RES_PER; research, instruction, public service) are non-significant at the 95th percentile for official class sections taught.

Other Regular and Supplemental Faculty Undergraduate Instructional Productivity

Appendix B contains the regression output for *other* regular and supplemental faculty undergraduate instructional productivity, measured in student credit hours and official class sections taught per instructor, log transformation. As with the primary regression analysis dealing with these two faculty groups, adjusted R^2 is low for both categories of faculty and for both dependent variables. For *other* regular faculty, adjusted R^2 is .1174 for undergraduate student credit hours and .0852 for undergraduate class sections taught. For supplemental faculty, adjusted R^2 is .0281 for undergraduate student credit hours and .0355 for undergraduate class sections taught.

Teaching Assistant Undergraduate Instructional Productivity

Table 14 lists the regression output for undergraduate student credit hours taught per teaching assistant, log transformation. Table 15 details the results for undergraduate official class sections taught by the same group. The logarithmic transformation adjusted R^2 of .1997 for TA_UGSCH and .1674 for TA_UGOCS, although modest, is relatively higher than the adjusted R^2 in either the *other* regular or supplemental log regression iterations.

TABLE 14
Log Transformation

Dependent Variable: TA_UGSCH

Multiple Regression

Multiple R = .4598 sig. of R = .0000
Multiple R Square = .2114
Adjusted R square = .1997

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	1450.3054	103.5932	18.003	.0000
Residual	940	5409.0653	5.7543		

Equation: TA_UGSCH = 13.7486 + (.5303 T_GRSCH) + (-.7932 T_FACPER)
+ (-1.1079 INST_FTE) + (.1032 RES_TFAC) + (-.2764 RES_PER)
+ (-.02228 SVC_FTET) + (.4401 DV_1) + (-1.2670 DV_2)
+ (-1.2176 DV_3) + (-.5606 DV_4) + (-.2464 DV_5)
+ (.7847 DV_6) + (-1.7808 DV_7) + (-.7272 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GRSCH	0.5303	0.0763	0.4047	to	0.656	0.8714
T_FACPER	-0.7932	0.2081	-1.1359	to	-0.4505	0.9391
INST_FTE	-1.1079	0.165	-1.3796	to	-0.8362	0.6551
RES_TFAC	0.1032	0.04684	0.0261	to	0.1803	0.1353
RES_PER	-0.2764	0.1426	-0.5113	to	-0.04163	0.1203
SVC_FTET	-0.02228	0.02155	-0.05777	to	0.01321	0.8214
DV_1	0.4401	0.2799	-0.02067	to	0.901	0.8668
DV_2	-1.267	0.3792	-1.8914	to	-0.6427	0.7346
DV_3	-1.2176	0.2711	-1.664	to	-0.7712	0.5227
DV_4	-0.5606	0.3718	-1.1728	to	0.05158	0.8785
DV_5	-0.2464	0.2711	-0.6927	to	0.2	0.6754
DV_6	0.7847	0.3075	0.2783	to	1.291	0.7774
DV_7	-1.7808	0.5028	-2.6086	to	-0.953	0.9001
DV_8	-0.7272	0.2768	-1.1828	to	-0.2715	0.7907

TABLE 14
Log Transformation

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GRSCH	0.2157	0.0310	0.1558	0.2013	0.2211	48.3170	0.0000*
T_FACPER	-0.1139	0.0299	-0.1181	-0.1104	-0.1233	14.5220	0.0001*
INST_FTE	-0.2403	0.0358	-0.3351	-0.1945	-0.2139	45.0790	0.0000*
RES_TFAC	0.1735	0.0787	-0.0734	0.0638	0.0717	4.8560	0.0278*
RES_PER	-0.1619	0.0835	-0.1095	-0.0561	-0.0631	3.7570	0.0529*
SVC_FTET	-0.0330	0.0320	-0.0233	-0.0299	-0.0337	1.0680	0.3016
DV_1	0.0489	0.0311	0.1328	0.0455	0.0512	2.4730	0.1162
DV_2	-0.1129	0.0338	-0.1114	-0.0968	-0.1083	11.1650	0.0009*
DV_3	-0.1799	0.0401	-0.2415	-0.1301	-0.1449	20.1690	0.0000*
DV_4	-0.0466	0.0309	0.0117	-0.0437	-0.0491	2.2730	0.1320
DV_5	-0.0320	0.0352	0.0298	-0.0263	-0.0296	0.8260	0.3637
DV_6	0.0838	0.0328	0.0941	0.0739	0.0829	6.5090	0.0109*
DV_7	-0.1081	0.0305	-0.0926	-0.1026	-0.1148	12.5460	0.0004*
DV_8	-0.0856	0.0326	0.0096	-0.0761	-0.0854	6.9040	0.0087*

* Significant at the 95th percentile

TABLE 15
Log Transformation

Dependent Variable: TA_UGOCS

Multiple Regression

Multiple R = .4238 sig. of R = .0000
Multiple R Square = .1796
Adjusted R square = .1674

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	115.2129	8.2295	14.698	.0000
Residual	940	526.3200	.5599		

Equation: TA_UGOCS = 3.4562 + (.3397 T_GROCS) + (-.1626 T_FACPER)
+ (-.2773 INST_FTE) + (.03169 RES_TFAC) + (-.1082 RES_PER)
+ (-.005818 SVC_FTET) + (.3369 DV_1) + (-.1544 DV_2)
+ (-.1161 DV_3) + (.03446 DV_4) + (.4909 DV_5)
+ (.2306 DV_6) + (-.4654 DV_7) + (-.2155 DV_8)

Variable	Coef.	SE Coef.	90% Confidence Level			Tolerance
T_GROCS	0.3397	0.09041	0.1909	to	0.4886	0.9616
T_FACPER	-0.1626	0.06481	-0.2693	to	-0.05585	0.9426
INST_FTE	-0.2773	0.05146	-0.362	to	-0.1926	0.6554
RES_TFAC	0.03169	0.01461	0.007637	to	0.05573	0.1354
RES_PER	-0.1082	0.04436	-0.1812	to	-0.03512	0.121
SVC_FTET	-0.005818	0.006724	-0.01689	to	0.005252	0.8214
DV_1	0.3369	0.08695	0.1937	to	0.48	0.8739
DV_2	-0.1544	0.118	-0.3486	to	0.03991	0.7382
DV_3	-0.1161	0.08447	-0.2551	to	0.02302	0.524
DV_4	0.03446	0.1157	-0.156	to	0.2249	0.8833
DV_5	0.4909	0.08463	0.3515	to	0.6302	0.6745
DV_6	0.2306	0.09501	0.07418	to	0.387	0.7926
DV_7	-0.4654	0.1572	-0.7242	to	-0.2066	0.8961
DV_8	-0.2155	0.08578	-0.3567	to	-0.07425	0.8008

TABLE 15
Log Transformation

(Continued)

Variable	Beta	SE Beta	Correlation	S-Part	Partial Cor.	F	Sig F
T_GROCS	0.1132	0.0301	0.0859	0.1110	0.1217	14.1220	0.0002*
T_FACPER	-0.0763	0.0304	-0.1102	-0.0741	-0.0815	6.2910	0.0123*
INST_FTE	-0.1966	0.0365	-0.2625	-0.1592	-0.1731	29.0330	0.0000*
RES_TFAC	0.1742	0.0803	-0.0362	0.0641	0.0706	4.7060	0.0303*
RES_PER	-0.2071	0.0849	-0.0592	-0.0720	-0.0793	5.9440	0.0150*
SVC_FTET	-0.0282	0.0326	-0.0202	-0.0256	-0.0282	0.7490	0.3871
DV_1	0.1224	0.0316	0.1769	0.1145	0.1254	15.0120	0.0001*
DV_2	-0.0450	0.0344	-0.0819	-0.0386	-0.0426	1.7110	0.1911
DV_3	-0.0561	0.0408	-0.1949	-0.0406	-0.0448	1.8880	0.1698
DV_4	0.0094	0.0314	0.0389	0.0088	0.0097	0.0890	0.7658
DV_5	0.2087	0.0360	0.2102	0.1714	0.1859	33.6430	0.0000*
DV_6	0.0805	0.0332	0.0880	0.0717	0.0789	5.8910	0.0154*
DV_7	-0.0924	0.0312	-0.1074	-0.0875	-0.0961	8.7670	0.0031*
DV_8	-0.0829	0.0330	-0.0701	-0.0742	-0.0817	6.3100	0.0122*

* Significant at the 95th percentile

The independent variables in the regression equation explain almost 20 percent of the variability in undergraduate student credit hours taught and about 17 percent of the variability in the number of undergraduate class sections taught per assistant.

For TA_UGSCH, the number of graduate student credit hours taught per tenure/tenure track faculty member (T_GRSCH; coefficient +.5303), the percent of tenure/tenure-track faculty within the department (RES_PER; -.7932), the instructional expenditures per FTE student (INST_FTE; -1.1079), the research expenditures per tenure/tenure-track FTE faculty (RES_TFAC; +.1032), and research expenditures as a share of departmental spending (RES_PER; -.2764) are all significant at the 95th percentile. Similar significant results occurred for the independent variable TA_UGOCS: coefficients +.3397, -.1626, -.2773, +.0316, and -.1082, respectively, for the above variables.

The log regression results for TA_UGSCH and TA_UGOCS indicate that a 10 percent *increase* in the number of graduate student credit hours/class sections taught per tenure/tenure track faculty (T_GRSCH and T_GROCS) is associated with a 5.3 percent *increase* in undergraduate student credit hours taught per teaching assistant and a 3.4 percent *increase* in the number of undergraduate class sections taught per assistant. It may be reasoned that as tenure/tenure-track faculty teach *more* graduate students and classes per instructor, the ability of these same faculty to teach more undergraduate students and classes is diminished, with the slack being picked up by teaching assistants.

As the percent of tenure/tenure-track faculty *rises* within the department (T_FACPER), the number of undergraduate student credit hours and class sections taught per teaching assistant *falls*. A 10 percent *increase* in the percent of tenure/tenure-track faculty share (T_FACPER) is associated with a *reduction* in the number of undergraduate student credit hours and class sections taught per assistant by 7.9 percent and 1.6 percent, respectively. As the share of tenure/tenure-track faculty *increases* within a department (T_FACPER), the instructional productivity of these same instructors *increases* and the number of undergraduate student credit hours and class sections taught per teaching assistant is subsequently *reduced* on a percentage basis.

Teaching assistant undergraduate student credit hour productivity is most elastic in regard to changes in instructional expenditures per FTE student (INST_FTE). A 10 percent *increase* in the amount of departmental instructional spending per student is associated with a *decrease* of 11 percent in the amount of undergraduate student credit hours produced per assistant. Changes to the number of undergraduate class sections taught per assistant is also *reduced*, but by a smaller percent (-2.8). We may surmise from this that as the faculty-to-student ratio *rises*, because of increased spending on instruction, the need for teaching assistants to teach undergraduate students may be *reduced* in a relative manner.

Responses to changes in research expenditures per FTE tenure/tenure-track faculty (RES_TFAC) and to the share of research spending within a department's budget (RES_PER; instruction, research, and public service) regarding teaching assistant undergraduate instructional productivity is significant but is mixed and relatively inelastic. A 10 percent *increase* in research expenditures per FTE tenure/tenure-track faculty (RES_TFAC) is associated with an *increase* the number of undergraduate student credit hours and class sections taught per assistant by one percent and .3 percent, respectively.

Counter balancing this modest, positive effect upon teaching assistant undergraduate instructional productivity is the equally small, negative effect resulting from changes in the share of the departmental budget composed of research spending (RES_PER). A 10 percent *increase* in the percent of research spending (research expenditure share) is associated with a 2.8 percent *decrease* in the number of undergraduate student credit hours taught per teaching assistant and a 1.1 percent *decrease* in the number of undergraduate class sections taught per assistant. It appears that the effects of research spending per FTE tenure/tenure-track faculty member (RES_TFAC) and research expenditures as a share of the departmental budget (RES_PER) upon teaching assistant undergraduate instructional productivity is mixed, modest, and relatively inelastic.

Summary

This study began as an exploration of the complex relationship between faculty undergraduate instructional productivity and the magnitude and criticality of separately budgeted departmental research expenditures. The method used is based upon a higher education productivity function concept using traditional regression procedures. The research questions for this study can now be reviewed.

Research Question 1a

1a. Do departments in Research I and II universities with greater research expenditures (on a per faculty member basis and as a percent of total research, teaching, and public service expenditures) produce fewer undergraduate student credit hours and/or fewer undergraduate class sections taught per tenure/tenure-track faculty member?

The principal finding of the T_UGSCH regression is that the amount of research expenditures (RES_TFAC) and the share of research spending in departmental budgets (RES_PER) are not significant with regard to undergraduate student credit hour productivity for tenure and tenure-track faculty. Departmental spending on research and its share of departmental budgets appear to have little impact on a tenure or tenure-track faculty member's student credit hour production. This result was unexpected and does not support the original hypothesis that the magnitude and criticality of research spending in Research I and II university departments would have a significant and negative effect upon faculty undergraduate instructional productivity as measured by student credit hours.

When examining the effects of the magnitude and criticality of departmental research expenditures upon tenure/tenure-track faculty undergraduate instructional productivity in the number of official class sections taught (T_UGOCS), the research finding is significant, but the effects are modest and counter-balancing. Research spending as a percent of total departmental expenditures (criticality) is negative in regard to undergraduate class section productivity as predicted; however, research spending per tenure/tenure-track FTE faculty member (magnitude) has an equally moderate but positive effect upon undergraduate class section productivity. These two factors appear to offset each other, at least partially, in determining faculty undergraduate instructional productivity, as measured by class sections taught. The most that can be said is that departmental research spending and research expenditures as a portion of the total departmental budget have a quite modest and mixed effect upon tenure/tenure-track faculty undergraduate instructional productivity as measured by official class sections taught.

Research Question 1b

1b. Do greater research expenditures affect the number of undergraduate student credit hours and class sections taught per *other* regular faculty members, supplemental faculty members, and teaching assistants?

The adjusted R^2 of .0734 for undergraduate student credit hour productivity of *other* regular faculty (R_UGSCH) and .0188 for undergraduate official class section productivity (R_UGOCS) are modest, suggesting that the variables, including research spending and research expenditures as a share of departmental budgets, are of little importance in explaining the undergraduate instructional productivity of individual *other* regular faculty.

The adjusted R^2 of .0309 for undergraduate student credit hour productivity of supplemental faculty (S_UGSCH) and .0138 for undergraduate official class section productivity (S_UGOCS) are also modest. Only two variables out of fourteen in both of these regression iterations are significant; thus, we can assume that undergraduate instructional productivity of supplemental faculty is not affected to any significant degree by departmental research spending.

The adjusted R^2 of .0815 for undergraduate student credit hour productivity of teaching assistants (TA_UGSCH) and .1240 for undergraduate official class section productivity (TA_UGOCS) are small, but are larger than the R^2 values for *other* regular and supplemental faculty. In addition, a majority of variables entered into the TA_UGOCS regression are significant at the 95th percentile; however, departmental research expenditures and research spending as a share of departmental budgets are not significant in explaining the variability of undergraduate student credit hours and official class sections taught per teaching assistant. We may surmise that undergraduate instructional productivity of teaching assistants is not affected to any significant degree by departmental research spending.

<u>Research Question 2</u>

2. Are there faculty undergraduate instructional productivity differences among academic fields?

There are significant differences in faculty undergraduate instructional productivity across academic fields for tenure/tenure-track faculty and for teaching assistants. Although some academic field variables are significant for *other* regular and supplemental faculty instructional productivity, the overall R^2 of these latter two regression iterations are small.

Tenure/tenure-track faculty within agriculture sciences, engineering/computer science, fine arts, nursing/pharmacy, and business produce fewer undergraduate student credit hours per instructor than do the social science/humanities reference group. This finding supports Dundar & Lewis's (1995) and Gander's (1995) earlier results that there are underlying undergraduate instructional productivity differences among different academic fields. The two broadly defined academic areas of home economics and physical sciences & math are not significantly different than the social science/ humanities reference group in faculty production of undergraduate student credit hours.

When considering undergraduate official class sections taught per tenure/tenure-track faculty, all academic fields but one (physical sciences & math) are significant. For four of the groups (agriculture, engineering/computer science, home economics, and fine arts), the number of undergraduate class sections taught per tenure/tenure-track faculty member is greater than for the social science/humanities reference group. Faculty in these academic areas taught fewer student credit hours but more undergraduate classes per instructor than did the social science/humanities reference group.

In two of the academic fields (nursing/pharmacy and business), tenure and tenure-track faculty not only produce fewer undergraduate student credit hours but also teach fewer undergraduate class sections per instructor than did the social science/ humanities reference group. These two academic areas show indications of being labor intensive in undergraduate education and having limits on the total number of classes, variety of classes, or enrollment allowed within their programs.

Undergraduate instructional productivity variation in academic fields also appears when examining the results for teaching assistants. Differences in teaching assistant productivity regarding the number of undergraduate class sections taught per assistant are significant in five of the seven academic groupings. Teaching assistants in the areas of home economics, physical sciences & math, and the fine arts teach more undergraduate classes per assistant than do the teaching assistants in the social science/humanities reference group. Teaching assistants in the areas of nursing/pharmacy and business teach relatively fewer undergraduate classes per assistant than do those in the social science/ humanities reference group. Teaching assistant productivity in undergraduate student credit hours taught is also significant and negative in four academic groups: agriculture, engineering & computer sciences, physical sciences & math, and nursing/pharmacy.

<u>Research Question 3</u>

3. Are there differences between public and private institutions in faculty undergraduate instructional productivity?

Institutional status is significant in determining undergraduate instructional productivity per tenure/tenure-track faculty member and per teaching assistant. Tenure/tenure-track faculty members within public universities teach 56.5 more undergraduate student credit hours and almost one-third more undergraduate class sections per instructor than their counter parts in private universities. Since these figures represent undergraduate student credit hours and class sections taught during the Fall semester only, it may be speculated that the undergraduate instructional productivity differences between public and private universities is even greater when considering a full academic year.

The undergraduate instructional productivity differences between public and private university faculty are particularly noteworthy because the regression model controls for instructional expenditures per FTE student, a proxy that often is used as a measure of quality in higher education. Based on these regression results, wherein at least one departmental quality measure is controlled, it appears that tenure/tenure-track faculty at public universities are relatively more productive in undergraduate education than those faculty who teach at private universities, regardless of departmental quality, as measured.

Institutional status also appears to affect the undergraduate instructional productivity of teaching assistants. Teaching assistants at public universities teach almost 1 1/3 more undergraduate classes per assistant and more than 78 additional undergraduate student credit hours than their counterparts at private universities.

Chapter 5 will review this study and discuss the interpretation of the research results. Additionally, policy implications of this research will be examined and additional areas of inquiry for future research efforts will be proffered.

CHAPTER 5

SUMMARY, CONCLUSIONS, POLICY IMPLICATIONS

Summary of Conceptual Framework

The conceptual framework used as the basis for this study was Pfeffer & Salancik's (1978) work on how environments external to an organization constrain the actions of organizations and their sub-units. External interest groups dictate organizational form, mission, goals, and objectives of individual enterprises because the enterprise depends upon these external associations for critical resources (Pfeffer & Salancik, 1978). An organization's ability to acquire and maintain resources is the very foundation of its survival (Pfeffer & Salancik, 1978). Thus, the financial interdependence on various organizations external to an institution's formal structure is a major constraint upon institutional behavior.

Three factors determine the relationship of organizational interdependency among enterprises: 1) the relative magnitude and criticality of a resource to the operation and survival of the organization; 2) the extent to which an interest group controlling the requisite resource has discretion over its apportionment and utilization, and 3) the assortment of alternative resource providers; that is, the range of control by a single organization over the essential resource (Pfeffer & Salancik, 1978).

When the availability of resources and their providers are in a state of transition, the organization receiving the resources becomes an unwilling participant in an insecure environment (Pfeffer & Salancik, 1978). The unsteadiness of the external environment precipitates destabilizing behavior within the internal organizational structure (Pfeffer & Salancik, 1978). In an attempt to regain organizational equilibrium in a period of resource vacillation, organizations are pressured to modify their internal behaviors to counterbalance variation in external resource flows (Pfeffer & Salancik, 1978; Slaughter & Leslie, in press).

In the past ten years the financial resources that colleges and universities depend upon have become more uncertain. In response to this precarious external funding environment, universities are undergoing organizational destabilization as described by Pfeffer & Salancik (1978). To regain organizational equilibrium, universities modify their behaviors to align themselves more closely with those external interest groups that have the power to provide necessary resources (Barnett, 1992; Pfeffer & Salancik, 1978; Silva & Slaughter, 1980; Slaughter & Leslie, in press).

The purpose of this study was to examine whether changes in university resource dependence affects faculty instructional productivity in undergraduate education. Do faculty re-allocate their time among undergraduate teaching, research, and service (and therefore adjust their instructional productivity) in response to external demands by various stakeholders in order to seek out, acquire, and maintain sources of external research funding in the form of grants and contracts?

Summary of Method

This study investigated the influence of separately budgeted research expenditures (external resource providers) upon faculty instructional productivity (internal organizational behavior) in undergraduate education. The unit of observation was academic departments in a sample of Research I and II universities in the United States. The analysis examined the relationship between research spending by these departments and the number of undergraduate student credit hours produced per faculty member and the number of class sections taught per faculty member.

Three research questions were proposed and subsequently answered:

1a. Do departments in Research I and II universities with greater research expenditures (on a per faculty member basis and as a percent of total research, teaching, and public service expenditures) produce fewer undergraduate student credit hours and/or fewer undergraduate class sections taught per tenure/tenure-track faculty member?

1b. Do greater research expenditures affect the number of undergraduate student credit hours and class sections taught per *other* regular faculty members, supplemental faculty members, and teaching assistants?

2. Are there faculty undergraduate instructional productivity differences among academic fields?

3. Are there differences between public and private institutions in faculty undergraduate instructional productivity?

To answer these questions, two, ordinary least squares regression equations were utilized:

$$UGSCH = a + b_1T\_FACPER + b_2INST\_FTE + b_3RES\_TFAC + b_4RES\_PER + b_5T\_GRSCH + b_6SVC\_FTET + b_7DV1 + b_8DV^{*}... + e_1 \quad (1)$$

$$UGOCS = A + B_1T\_FACPER + B_2INST\_FTE + B_3RES\_TFAC + B_4RES\_PER + B_5T\_GROCS + B_6SVC\_FTET + B_7DV1 + B_8DV^{*}... + e_2 \quad (2)$$

UGSCH represented the number of undergraduate student credit hours produced per full-time equivalent (FTE) tenure/tenure-track (T-TT) faculty member, and in subsequent analyses, the number of undergraduate student credit hours produced per *other* regular faculty member, supplemental faculty member, and teaching assistant. UGOCS represented the number of undergraduate organized class sections produced per FTE T-TT faculty member, and in following analyses, the number of undergraduate class sections taught per *other* regular faculty member, supplemental faculty member, and teaching assistant. T_FACPER represented the percentage of tenure/tenure-track (T-TT) faculty within a department.

The variable INST_FTE measured the direct instructional expenditures per FTE student by the department and was used as a proxy for the quality of instruction within the department. The variable RES_TFAC measured a segment of Pfeffer & Salancik's (1978) first major factor influencing resource dependency: the relative magnitude of the department's resources (total research expenditures per tenure/tenure-track instructor) in maintaining current levels of departmental operation and sustaining long-term survival. RES_PER measured Pfeffer & Salancik's (1978) criticality of the resource (research expenditures as a percent of total departmental spending in research, instruction, and public service) to the organization's stability. The T_GRSCH and T_GROCS variables were the number of graduate student credit hours and official class sections taught per tenured or tenure-track faculty member.

SVC_FTET measured the separately budgeted public service expenditures per FTE T-TT faculty member. Eight dummy variables were used in the analyses. DV1 measured the effects of institutional status upon undergraduate instructional productivity. DV2-8 measured the effects of separate (grouped) academic fields upon undergraduate instructional productivity; essentially, productivity differences by academic field. The study used standard linear form equations for the analysis. A logarithmic transformation was performed on the data to examine the elasticities of the independent variables in relation to the dependent variable.

The data set for this series of analyses was contained in the 1994 survey results of the National Study of Instructional Costs and Productivity (NSICP), a longitudinal project conducted by the University of Delaware and underwritten by a grant from the Fund for the Improvement of Postsecondary Education (FIPSE). This database contained detailed departmental measures of faculty teaching workloads; research, instructional, and service expenditures; and faculty instructional productivity. The final, selected sample included 27 Research I and II universities (of which four were private institutions), 93 departments, and 955 data points (N = 955).

Conclusions

The adjusted R^2 elicited from the regression model regarding student credit hours and class sections taught per tenure/tenure-track faculty member explains approximately 24 percent of undergraduate instructional productivity variability. The explanatory power of the model can be described as modest. Why is this the case?

As Dundar & Lewis's (1995) research reveals, academic fields of study have differing production functions; that is, how information is produced and transmitted to undergraduate students varies widely among academic disciplines. This variability in undergraduate instructional productivity originates from the history and tradition of the specific academic area. That is, it can be said, to a considerable extent, disciplined-based norms, expectations, and preferences drive departmental production functions. The number and internal uses of tenured and tenure-track faculty, *other* regular faculty, supplemental faculty, and teaching assistants within the discipline; whether lab courses form an integral part of the academic instructional package (such as science fields); and departmental enrollments, the number and variety of courses that may be offered in the academic field, and other field-specific factors impact instructional productivity. These discipline-based and departmentally-formed factors of undergraduate instructional production cannot be fully captured by a single model that, by its very nature, focuses on a select subset of variables to examine undergraduate instructional productivity variation broadly, across disparate departments. That is, the productivity paradigm used in this study and the production function models used in past research cannot contain all the factors that would impact instructional production in higher education because there is no universally agreed upon set of elements (inputs and outputs) that should be included/excluded in such models.

As noted earlier in Chapter 3, in all previous studies, research expenditures (or some other proxy for research productivity) along with instruction have been considered a joint product output in production function analyses. This research did not examine joint productivity of research and instruction, but instead concentrated solely on the specific effects of separately budgeted research expenditures upon undergraduate instructional productivity within departments. Caution, therefore, should be exercised when evaluating the conclusions since the power of the model to describe accurately a faculty member's true undergraduate instructional productivity function is limited by the production paradigms in use within higher education and the data set variables that were available for inclusion in the model.

The primary finding of this research is that Pfeffer & Salancik's (1978) conceptual framework (as applied in this study) linking separately budgeted research expenditures (a proxy for external resource provider influence) and faculty undergraduate instructional productivity (a proxy for internal organizational behavior) is not supported, at least for academic departments. The level of departmental research expenditures per instructor (corresponding to Pfeffer & Salancik's [1978] magnitude of influence) and research spending within the department as a share of the total budget (corresponding to Pfeffer & Salancik's [1978] degree of criticality) are not tied significantly to undergraduate student credit hour productivity for tenured and tenure-track faculty. Departmental spending on research and the research share of departmental budgets appear to have little impact on a tenured or tenure-track faculty member's student credit hour production by department. This conclusion was unexpected and did not support the researcher's initial hypothesis regarding the magnitude and criticality of research spending having a significant and negative effect upon faculty undergraduate instructional productivity (as measured by student credit hours).

It should be noted, however, that in framing the resource dependency issue, this research concentrated on faculty instructional productivity effects (within departments) arising from declining state support of higher education (as a share of total funding) and the concomitant rise in grants and contracts (substituting for the loss in state dollars). Thus, this study used research spending as the proxy for Pfeffer & Salancik's (1978) factor of external resource provider control. Recent budget initiatives within some colleges and universities that focus on enrollment-based, departmental funding formulas could have been used as the proxy for the external control agent, with potentially different results.

In any case, other factors not measured in this study, such as faculty training (the preparation that faculty receive at graduate schools regarding the future instructional and research responsibilities of professors when employed by a university), faculty and departmental culture within higher education (group norms, expectations, and preferences for teaching versus research), departmental power and influence (the prestige of the department and how the department fits into the political structure of the university), internal reward structures of departments (who gets promotions, salary raises, and tenure), and other demand driven, specific institutional-level factors may hold greater promise in explaining faculty undergraduate instructional productivity.

The second measure of tenure/tenure-track faculty undergraduate instructional productivity (official class sections taught) and its linkage to research spending and share of expenditures was significant within the model, but the effects were nominal and off-setting. Research spending as a percent of total departmental expenditures (criticality) had a negative effect upon undergraduate class section "productivity." This partially supports the initial hypothesis that as the share of a department's budget devoted to research activities grows, a dampening effect occurs upon the department's production of undergraduate instruction. As faculty devote more and more time to grant-seeking behavior, they allocate less time to undergraduate class sections taught.

Research spending per tenure/tenure-track FTE faculty member (magnitude), however, had a positive, yet moderate effect upon faculty ability to produce undergraduate class sections. As research spending per faculty member rises, the ability of tenured and tenure-track faculty to teach more classes is increased, perhaps because the additional research dollars received by the department through faculty efforts subsidizes departmental overhead expenses, thus freeing up faculty time from administrative support duties that can now be handled (funded) by staff, such as secretaries. The time faculty previously spent on department, college, and university administrative matters can be redistributed, allowing for more class sections to be taught.

Why is undergraduate class section productivity affected by research spending and not undergraduate student credit hour productivity, and why are research expenditures per faculty member (a positive effect on undergraduate class section productivity) counterbalanced by budget share of research spending (a negative effect on undergraduate class section productivity)? Class section productivity is significantly impacted by research expenditures because faculty workload is normally defined by departments as the number of classes taught, not student credit hours generated. Faculty behavior and time allocation are impacted primarily through the number of class sections taught, rather than through the number of students taught. Departments appear to respond to the external pressures of greater research expenditures (grant-seeking behavior) by assigning, on average, slightly fewer sections or classes to be taught; however, student credit hour production is not affected negatively.

Regarding why there is an offsetting effect between research spending as a share of the budget (negative effect) and research spending per faculty member (positive effect) on undergraduate class section productivity, there is an upper limit to faculty's ability to increase undergraduate productivity through class sections taught. Class sections cannot be appended to a faculty member's workload, ad infinitum, without concomitant increases in student enrollments. At some point, student enrollment is bounded. Faculty undergraduate class section productivity improvements through increased research funding are thus bounded by two factors: 1) an upper limit to student enrollments, and 2) faculty grant-seeking behavior that eventually limits the time that can be devoted to teaching more undergraduate class sections.

The productive capacity of *other* regular faculty, supplemental faculty, and teaching assistants in undergraduate education is not determined by the dollar amount or dollar share of research within a department (with one exception as noted in the paragraph following). We would not expect this to be so. Teaching loads of these groups are determined by the circumstantial needs of individual departments, i.e. student enrollments, faculty retirement, faculty sabbaticals, research buyouts, etc., and not by factors captured in the model such as overall research spending, the percent of tenure/tenure-track faculty, instructional spending per student, or the level of graduate instruction.

In the log transformations investigating the elasticities of the variables, however, teaching assistant productivities appeared to respond in a modest (relatively inelastic) and mixed manner to the level and share of research spending. Increases in the level of research expenditures per FTE tenure/tenure-track faculty member had positive effects upon teaching assistant productivity. Increases in research spending as a share of the total departmental budget had negative effects upon teaching assistant productivity. Since these effects only appear in the log model, we may conclude that teaching assistant productivity is not linear in nature.

As research spending increases, at some point departments may use part of these funds to hire teaching assistants. Teaching assistants may be required to teach more students and/or classes because of research buyouts. Through this process the overall productive capacity of teaching assistants may rise. At some point in time, however, the increased productive capacity of teaching assistants is bounded because there is an upper limit to student enrollments within a department, regardless of research spending. As noted earlier, the productive capacity of tenured and tenure-track faculty is reduced when the time allocation to maintain grant funding (as a share of the total budget) interferes with the production of undergraduate class sections. With this additional pressure, departments may turn to hiring even more teaching assistants to help with the instructional load, but saturation is eventually reached when the marginal return from hiring one more teaching assistant fails to increase undergraduate instructional productivity to any significant degree.

When considering the elasticity of tenure/tenure-track faculty undergraduate instructional productivity, as the percent of tenured and tenure-track faculty within a department rises, undergraduate instructional productivity of these faculty also rises. There appears to be a synergism among this faculty group as its numbers grow within a department (as a percent of total faculty). This synergism may result from several factors: faculty members may work more collaboratively with one another on research projects thus freeing up time devoted to undergraduate instruction; faculty may join in team-teaching efforts for more efficient instructional delivery; faculty members may share technological improvements in course delivery (development of computer-assisted instructional packages, simulations, evaluation procedures, etc.); or perhaps with the rise in tenured/tenure-track departmental slots, there is an opportunity for increased departmental instructional support, thus freeing faculty time for undergraduate instructional responsibilities. In any case, the increased productivity that may result from increased numbers of tenured and tenure-track faculty is ultimately bounded because of finite student enrollment.

It should also be noted that these productivity gains must be viewed from a per faculty line concept and not measured by departmental dollars spent per student credit hour. As an example, suppose a department hires a faculty member with a salary of $50,000 per year. The faculty member teaches 1,000 student credit hours (SCH) per academic year. Alternately, suppose the same department hires four teaching assistants for the same amount of money and to cover the same number of SCH. The faculty member produces 1,000 SCH; each teaching assistant only produces 250 SCH. From this standpoint, the faculty member is more productive; however, dollars spent per SCH remain the same. In this example, there is no efficiency gain by hiring a tenure-track faculty member if one measures productivity efficiency by dollars spent per SCH. The point here is that one must be careful in reaching policy conclusions regarding how instructional resources are best employed: causality is again in question; results may reflect actions regarding how resources presently are deployed.

The institutional quality of a department, as measured by the instructional expenditures per FTE student within the department, directly affects the number of undergraduate student credit hours and class sections taught per tenured and tenure-track faculty member. Increased instructional spending on students reduces faculty undergraduate productivity. From an economic viewpoint, one might expect that as more money is spent for something you would get more of it. In higher education, as more money is spent on instruction, smaller classes and fewer sections offered results; that is, the teaching load of a tenured faculty member (or those on the tenure track) is effectively reduced when ample resources are available to spend on instruction (hiring more faculty members). Fewer classes with smaller enrollments translate into higher undergraduate quality, as historically defined.

A cautionary note is advised here. Quality is measured in this study by instructional expenditures per FTE student. As defined, it is impossible to simultaneously raise quality (raise spending on instruction) and increase productivity (more student credit hours or class sections taught) in this model. Why? Because the definition of quality used in this research is linked to increased spending per student. But more money spent per student directly correlates negatively with productivity. As more money is spent on instruction, either in the form of increased faculty salaries or increased number of faculty members hired, faculty instructional productivity will either remain the same or fall. In effect, we have a tautology situation between quality and productivity because how one is measured (or defined) is the direct result of how one measures (or defines) the other. Quality may rise with productivity in higher education, but quality must be measured (defined) differently from instructional expenditures per FTE student to accurately measure the change.

This monetary impact of educational spending on undergraduate instructional productivity is further illustrated when examining teaching assistant productivity. As the instructional spending per student in the department rises, undergraduate instructional productivity per teaching assistant declines. As more instructional money is made available to the department, apparently those funds are allocated to hiring full-time faculty, as opposed to using teaching assistants to carry the undergraduate instructional load. This reinforces another dimension of departmental quality: percent of faculty within a department who are tenured or on the tenure track.

The variables that have the greatest impact upon tenured and tenure-track faculty undergraduate instructional productivity are the number of graduate student credit hours/class sections taught per faculty member (a negative, joint production effect), the percent of tenured and tenure-track faculty within a department (a positive effect), and instructional expenditures per FTE student (a negative effect). Thus, it is not work in research (departmental research spending and share of spending) that determines a faculty member's undergraduate instructional productivity, but rather <u>other</u> instructional work. Put another way, departments with large graduate course offerings are unlikely to have large undergraduate offerings.

There are several limitations to the proper interpretation of the findings in the above paragraph concerning the negative joint production impact of graduate instructional productivity upon undergraduate instructional productivity. A rise in research spending would tend to increase the number of graduate hours and class sections taught because the bulk of any "spillover" (Philpott, 1994, p. 33) in research spending usually falls on graduate education. This "income effect" (dollars spent on research) upon graduate instructional productivity is not fully captured in the research model because graduate student credit hours and class sections taught were modeled as independent variables (inputs); they were not measured as dependent variables (outputs).

A rise in research dollar spending (income) in a department would most naturally fund additional students in the graduate programs of that department. In effect, the increased departmental income gives rise to gains in graduate productivity separate from any absolute changes in undergraduate productivity; that is, undergraduate productivity may appear to decline relative to graduate productivity because graduate productivity has increased relative to the baseline production of undergraduate instruction. The two productivity functions (graduate and undergraduate) may be unrelated because additional research dollars (income) may have differential impacts upon graduate and undergraduate student enrollment. Increased departmental activity in some private grants and contracts may be said to correlate with increased graduate instructional productivity and a perceived, relative decline in undergraduate instructional productivity, but causality should not be inferred.

Based on the results of the regression model, it may be concluded that faculty undergraduate instructional productivity varies widely across most academic fields for tenure/tenure-track faculty and for teaching assistants. As was noted earlier in this section, this variability probably derives from the history and tradition of production functions in the separate academic fields. For example, the production function of a fine arts department (such as music) tends toward offering many class sections with small enrollments; sometimes music classes will contain only one or two students. This has been the case historically because of the nature of most fine arts programs: individualized attention and instruction, and a wide variety of concentrations (for example, cello or trumpet in music; water color painting or sculpture in art). In addition, it may be that some academic areas (such as agriculture sciences, engineering, computer science, and business) teach less than the social science/humanities norm because of market-based factors, while others may teach more. Faculty in these fields often demand higher salaries, increased research opportunities, and less teaching duties than others. In some, the low explained variances in this study no doubt are accounted for, in considerable measure, by variations in production functions across departments.

Tenured and tenure-track faculty within agriculture sciences, engineering & computer science, fine arts, nursing/pharmacy, and business produce fewer undergraduate student credit hours per instructor than do those faculty within the social science/humanities reference group (social science, English, communications, education, and philosophy). This conclusion is supported and broadened concerning class sections taught, where all academic fields (except for one) were significantly different from the reference group regarding undergraduate instructional productivity. This research result supports Dundar & Lewis's (1995) and Gander's (1995) findings regarding the underlying variability in undergraduate instructional productivity across academic fields.

It is important to note that the grouping of academic fields for this study, although based on Dundar & Lewis's (1995) and Gander's (1995) research, was still somewhat arbitrary. This is especially true regarding the social science/humanities baseline group. Approximately one-half of the academic fields in this group cannot strictly be considered a normal part of social sciences or humanities. They were included in the social sciences/humanities reference group because they were more closely related to that academic area than to any of the other groups. Grouping into broad academic areas was necessary because individual academic departments (history, for example) did not contain enough data points to make meaningful inferences from the data (the maximum number of data points per individual academic department is 27; the number of Research I and II universities sampled in this research).

The major result of the above limitation regarding the heterogeneous grouping of academic fields into broader academic areas is that it may have reduced the measured (observed) effects of resource dependency within the model. For example, a $60,000 research grant given to an education department may have a significant effect upon organizational behavior, while the same $60,000 might have a relatively small effect if awarded to a physics department. Because both of these departments are included in larger academic groupings, the potential resource dependency effects of the grant is subsumed within the variability or "noise" of the other academic fields. Potentially significant, within field variation is not captured by the current model.

Variability in undergraduate instructional productivity among tenure/tenure-track faculty and teaching assistants is demonstrated when institutional status of the university (private vs. public) is considered. Faculty members and teaching assistants within public universities teach more undergraduate student credit hours and class sections per instructor than do their counter parts in private universities. These differences in instructional productivity hold up even when considering the academic quality of departments (quality, as measured by the proxy of instructional expenditures per FTE student, was controlled in the regression model). We may conjecture that because of public taxpayer oversight of higher education, faculty at public universities are required to be relatively more productive in undergraduate education than faculty at private universities, even when departmental quality is considered.

Finally, the amount of money that is expended on public service by departments per faculty member has no apparent relationship to undergraduate instructional productivity, as defined and measured in this study. A faculty member's public service to the department is a separate and unrelated act divorced from the production of undergraduate instruction. Public service, however, was narrowly defined in this study. The NSICP reported only those funds "separately budgeted specifically for public service and expended for activities established primarily to provide non-instructional services beneficial to groups external to the institution, (such as) cooperative extension and community outreach projects" (NSICP, 1994, no page number listed). Public service conducted by faculty within a higher education institution (such as service on committees, etc.) was not reflected in these externally expended funds. Their is some evidence that the amount of time faculty devote to internally generated public service is limited by the time spent on research, instruction, and leisure (Becker, 1975; 1979). Since there is some indication that faculty instructional and research workload is actually rising (Allen, 1996), public service may have declined in real terms; further, total time worked also may have expanded (Leslie, Rhoades, & Oaxaca, 1997).

Application and Policy Implications

The practical application of this research within higher education and the policy implications that flow from this study may be outlined in terms of potential effects upon faculty, university administrators, legislators, and students/parents.

Faculty and Department Heads

Faculty who teach at major research universities have been accused in the past of neglecting undergraduate education. Although there is some evidence that faculty within these institutions are conducting more research and teaching less, the number of contact hours with students has actually been rising (Allen, 1996). Further, there is no evidence to suggest that those faculty members who are most effective in conducting research are not effective teachers (Feldman, 1987).

Faculty who spend significant amounts of time on research and related grants & contracts do so without significant impacts upon undergraduate instructional productivity. In short, university departments with active research agendas do not neglect undergraduate education. In fact, as the results of this study indicate, there is no apparent relation between the dollar amount of research that is being conducted by department faculty and faculty ability to produce undergraduate education. Faculty within departments that have high research expenditure allocations (and thus we may infer active research agendas) teach just as many undergraduate student credit hours and class sections as those departments without active research programs. Apparently, research is an "add on"; the instructional mission is satisfied first, then research may be attended to.

On the other hand, department heads may wish to evaluate more closely the mix of graduate and undergraduate degree programs and course offerings. It may be argued that the amount of time that faculty may allocate to instruction is fixed. As graduate instructional responsibilities rise, the ability of faculty to devote time to undergraduate instruction falls. However, a causal relationship may not be suggested. It may be that department missions are targeted at one or the other: graduate or undergraduate education. For example, law schools may not teach undergraduates, but this is because legal education is not undergraduate education. On the other hand, some departments may be allocating insufficient resources to the undergraduate mission while teaching more graduate students than sound policy would dictate. Fewer undergraduate student credit hours and class sections generated per faculty member appear to be at least partially related to increased teaching responsibilities in graduate education. More attention should be given to the appropriate mix of graduate and undergraduate programs and course offerings by faculty and their department chairs and whether sufficient resources are being allocated to undergraduate education.

Faculty in those departments that produce fewer undergraduate student credit hours and teach fewer class sections per instructor than the norm may be artificially limited in productivity gains by the history and tradition of their degree programs and course offerings. Fine Arts departments, for example, with their emphasis on small classes, diverse degree offerings, and individualized student attention, may need to re-evaluate their modes of instruction, given the present era of scarce resources. In the current era, many colleges and universities are reevaluating what programs to maintain. More and more, institutions of higher education are beginning to contrast enrollment-generated revenues with instructional costs per student when evaluating whether a department is central to the university's core mission (Schmidt, 1997). With this in mind, faculty and department chairs must be cognizant of low enrollments and low numbers of degrees granted in their programs and the potential long-range effects these low numbers may have upon program continuation.

Other Administrators

For mid-level administrators (deans) and those above (provosts, academic V.P.s, presidents, and chancellors), there may be a need in the academic world to do a better job informing legislators and the public about the real benefits of having tenured faculty on staff (Clark, 1987; Kerr, 1963). Greater numbers of tenured and tenure-track faculty within the university yield gains in undergraduate instructional efficiency (when measured by "lines" and not dollars per student credit hour). On average, large numbers of tenured faculty are not a "drain" on institutional resources or "deadwood" as pundits often decry but rather offer synergistic university empowerment in the delivery of undergraduate education.

This synergy spills over to the amount of undergraduate instructional production conducted by teaching assistants. As the percent of tenured and tenure-track faculty rises, there is less reliance upon teaching assistants to teach undergraduate students. Administrators seeking to convince legislators and the general public that their students are being taught by qualified faculty should detail the beneficial effects of increasing the number of long-term, dedicated, efficient, tenured faculty on university staff.

Legislators

Many of the implications and policy applications raised in the above section apply equally to legislators' concerns about the conduct of undergraduate education at major state-supported research universities. In addition, educational quality and productivity gains within publicly supported higher education institutions should be considered by legislative bodies. For legislators, the most relevant finding of this research is that despite persistent, ongoing declines in state funding for higher education (as a share of a university budget), departments in colleges and universities have not experienced accompanying declines in undergraduate productivity. State support, as a share of university funding, is falling while the number of student credit hours and courses taught by tenured and tenure-track faculty continue to rise.

Legislators often debate whether to divert students to private institutions of higher learning for undergraduate education. The strategy of off-loading surplus in-state undergraduate students and feeding them into those private universities that exhibit under-capacity is often encouraged by legislators seeking to limit the cost of enrollment growth in public institutions (Carnegie Commission, 1973; Herzlinger & Jones, 1981; Layzell & Lyddon, 1990; Singer, 1972).

Expansion of tenured and tenure-track faculty (with their ability to teach more students and classes per instructor than other faculty groups) in combination with increased utilization of current facilities (more night classes, weekend programs, summer schools) may be a more efficient and effective way to handle growing enrollments while maintaining quality standards. As this study indicates, faculty undergraduate productivity within public research universities is superior to private university productivity functions, when quality is controlled. Thus, those who allocate the resources towards undergraduate education should consider expansion of tenured faculty slots within state research universities as a valid alternative to state-mandated enrollment caps or publicly funded financial support schemes for private universities. Expansion of tenured faculty slots should be considered even though the research results contained here are at mean productivity levels. De Groot et al. (1991) found that economies of scale are present at public universities at and beyond mean output levels.

Students/Parents

Large, state-supported research universities enroll the majority of college-aged students seeking a four-year degree (Allen, 1996; NCES, 1995). The amount of research that is conducted by these universities and the perceived high use of teaching assistants in undergraduate instruction is the basis of many students' (and therefore parents' as well) complaints about the condition of higher education in America (Association of American Colleges, 1985; Boyer, 1987; Clark, 1987; Jacobson, 1992; Kerr, 1963; Massy & Wilger, 1992; Study Group on Conditions of Excellence in American Higher Education, 1984).

Massy & Wilger (1992) and Massy & Zemsky (1994) theorize on one aspect of these student/parent stakeholder perceptions: the expansion of research preeminence in the American university through the process they called the "academic ratchet." In the academic ratchet, there is a gradual change in the research and teaching mix (favoring research) at colleges and universities because of shifts in faculty norms of research and grant seeking behavior (Massy & Wilger, 1992; Massy & Zemsky, 1994). But as this study suggests, the academic ratchet does not favor one faculty activity over another (research over teaching; teaching over public service, etc.). Neither does the study indicate that teaching assistants are more productive or that they perform the bulk of undergraduate instruction. Rather, the level of faculty research endeavors (as measured by dollars spent on research) and undergraduate instructional productivity (whether by tenured faculty or teaching assistants) do not appear to directly influence one another.

If an academic ratchet does exist, it is probably a general principle that raises the workload and time commitment of all faculty towards research and undergraduate instruction on a near-equal basis. This proposition is partially supported by the author's recent work on an NSF supported research project involving undergraduate education (Leslie, Rhoades, & Oaxaca, 1997). In interviews with science, math, and engineering faculty at a major research university in the midwest, this author found strong qualitative evidence that undergraduate education is not being neglected. Instead, with the increased commitment to undergraduate education and an expansive research agenda, time devoted to public service by faculty is being reduced as well as available leisure time (Leslie, Rhoades, & Oaxaca, 1997).

Students who attend major research universities may perceive little faculty focus on undergraduate education because of large classes and the tendency of some students to get lost in the shuffle. Parents should realize that large classes at state colleges, although perhaps undesirable, are a natural consequence of faculty instructional productivity under resource constraints. Parents and students should petition state legislators for relief from college overcrowding through the hiring of more tenure-track faculty, not place the blame on publicly supported faculty who are more productive than their private university counterparts.

The real issue for parents and students appears to be how large classes impact quality in the undergraduate experience. Increasing class size, say from a large lecture class of 100 students to 150 students, would seem to have little impact on the overall quality of instruction. In other classes, however, where student enrollment jumps from 15 students to 25, changes in the quality of instruction may be significant. This study examined student credit hours and class sections taught in relation to research expenditures and academic fields. Overall patterns of whether more student credit hours are being taught in fewer class sections (that is, larger but fewer classes) and the impact this may have on the quality of instruction could be determined more easily through a time series study, not the cross-sectional approach used in this research.

Recommendations for Future Research

Production functions in higher education consist of a series of complex interactions that are difficult to interpret given that inputs and outputs often swap position in the production equation based on their current definitions and how the research is being conducted. Why such complexity?

> The fact (is) that the technologies of instruction, research, and public service are poorly understood, and the tools for estimating the requisite functional forms and coefficients are woefully inadequate to the task. ...The very nature of the interactions between teaching and research is difficult to express in mathematical terms...(and) in the absence of any uniform, exogenously provided set of prices for the inputs and outputs of higher education, there is simply no way to escape the multidimensional character of the production function and all of the specification and estimation problems that it entails. (Hopkins, 1986, p. 4-5).

This study suffers from the same problems as outlined by Hopkins and others regarding production functions and measures of productivity within higher education. In addition, the cross-sectional approach of the research does not capture production function variability through time. The relative explanatory power of the model is thus confined by the constraints imposed by the innate complexities of joint production within higher education and by the limitations of the data set and model.

The results of the research are useful as a starting point in the examination and interpretation of the complex relationship between research and instruction in higher education. Future studies should examine how power, culture, and internal rewards influence faculty time allocations in the academic world; how allocations of time among research, instruction, and service change over time; how faculty undergraduate instructional productivity relates to and is integrated within the extremely complex issue of joint production in higher education; how "production" is defined and operationalized at colleges and universities; and how measures of quality influence production technology within institutions of higher learning.

What is taught, how it is taught, and how the teaching will benefit society as a whole will always dominate the political landscape of undergraduate education in America. There is no question that teaching and research are inextricably tied to one another in our current university system. The benefit of research to the instruction of undergraduate students is an ongoing debate for all stakeholders, a debate that will flow into the next millennium and will offer countless opportunities for study by those within and without our system of higher education.

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

TABLE 1

DESCRIPTIVE STATISTICS

Variable	Mean	Standard Dev	Minimum	Maximum	N
T_UGSCH	182.19	104.55	0	781	729
T_UGOCS	1.78	1.05	0	8.1	729
T_GRSCH	33.09	29.68	0	225	729
T_GROCS	0.64	0.48	0	5	729
R_UGSCH	243.8	350.85	0	3416	729
R_UGOCS	2.25	3.12	0	40	729
S_UGSCH	193.42	346.24	0	2740	729
S_UGOCS	2.2	5.26	0	116.7	729
TA_UGSCH	142.05	233.71	0	1841	729
TA_UGOCS	2.4	2.89	0	30.2	729
T_FACPER	69.42	16.39	12.6	100	729
INST_FTE	6365.85	7437.14	727	168001	729
RES_TFAC	66270.32	118078.3	1	1123556	729
RES_PER	23.8	22.92	0	95.72	729
SVC_FTET	6414.71	21542.27	0	250834	729

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 2

Dependent Variable: T_UGSCH

Multiple Regression

Multiple R = .4991 sig. of R = .0000
Multiple R Square = .2491
Adjusted R square = .2344

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	1982558.8908	141611.3493	16.920	.0000
Residual	714	5975739.1092	8369.3825		

Equation: T_UGSCH = 179.5522 + (-.5296 T_GRSCH) + (.3542 T_FACPER)
+ (-.003055 INST_FTE) + (.00006858 RES_TFAC)
+ (-.3816 RES_PER) + (-.00003039 SVC_FTET) + (56.2053 *DV_1)
+ (-69.1225 DV_2) + (-74.2632 DV_3) + (3.6836 DV_4)
+ (-3.0683 DV_5) + (-61.5246 DV_6) + (-82.7959 DV_7)
+ (-37.9826 DV_8)

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 3

Dependent Variable: T_UGOCS

Multiple Regression

Multiple R = .4693 sig. of R = .0000
Multiple R Square = .2203
Adjusted R square = .2050

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	176.0147	12.5725	14.408	.0000
Residual	714	623.0209	.8726		

Equation: T_UGOCS = 1.3976 + (-.2728 T_GROCS) + (.005224 T_FACPER)
+ (-.00002178 INST_FTE) + (.000001358 RES_TFAC)
+ (-.008322 RES_PER) + (.000003750 SVC_FTET) + (.2426 *DV_1)
+ (.7137 DV_2) + (.2425 DV_3) + (.8520 DV_4)
+ (.008178 DV_5) + (1.2038 DV_6) + (-.4393 DV_7)
+ (-.2054 DV_8)

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 4

Dependent Variable: R_UGSCH

Multiple Regression

Multiple R = .3040 sig. of R = .0000
Multiple R Square = .0924
Adjusted R square = .0746

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	8282974.1523	591641.0109	5.194	.0000
Residual	714	81328856.3936	113905.9613		

Equation: R_UGSCH = 124.5347 + (-.3474 T_GRSCH) + (1.7627 T_FACPER)
+ (-.004999 INST_FTE) + (-.00002808 RES_TFAC)
+ (-.9737 RES_PER) + (-.00007895 SVC_FTET) + (76.6736 *DV_1)
+ (-91.7317 DV_2) + (-64.9953 DV_3) + (25.3801 DV_4)
+ (155.8826 DV_5) + (-147.3089 DV_6) + (-157.3420 DV_7)
+ (39.4008 DV_8)

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 5

Dependent Variable: R_UGOCS

Multiple Regression

Multiple R = .1920 sig. of R = .0191
Multiple R Square = .0369
Adjusted R square = .0180

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	261.6297	18.6878	1.951	.0191
Residual	714	6837.6299	9.5765		

Equation: R_UGOCS = 2.4691 + (-.3614 T_GROCS) + (.0005936 T_FACPER)
+ (-.00004752 INST_FTE) + (6.4774E-7 RES_TFAC)
+ (-.01429 RES_PER) + (.000006202 SVC_FTET) + (.2362 DV_1)
+ (1.1406 DV_2) + (.3305 DV_3) + (1.0870 DV_4)
+ (.6897 DV_5) + (.04370 DV_6) + (-.8241 DV_7)
+ (.1750 DV_8)

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 6

Dependent Variable: S_UGSCH

Multiple Regression

Multiple R = .2201 sig. of R = .0011
Multiple R Square = .0485
Adjusted R square = .0298

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	4229229.5405	302087.8243	2.597	.0011
Residual	714	83046032.3306	116310.9697		

Equation: S_UGSCH = 165.0531 + (-.2827 T_GRSCH) + (1.2835 T_FACPER)
+ (-.002519 INST_FTE) + (.0001133 RES_TFAC)
+ (-.9686 RES_PER) + (-.0008612 SVC_FTET) + (33.8181 DV_1)
+ (-183.9034 DV_2) + (-98.4693 DV_3) + (-29.0037 DV_4)
+ (28.4206 DV_5) + (-94.7144 DV_6) + (-121.5404 DV_7)
+ (-48.0714 DV_8)

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 7

Dependent Variable: S_UGOCS

Multiple Regression

Multiple R = .1415 sig. of R = .4085
Multiple R Square = .0200
Adjusted R square = .0008

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	403.6474	28.8320	1.042	.4085
Residual	714	19751.0354	27.6625		

Equation: S_UGOCS = 1.9473 + (-.1275 T_GROCS) + (-.004019 T_FACPER)
+ (-.00002605 INST_FTE) + (-.000001560 RES_TFAC)
+ (-.007374 RES_PER) + (-.000003199 SVC_FTET)
+ (.7303 DV_1) + (.05888 DV_2) + (.5047 DV_3)
+ (.4474 DV_4) + (1.4806 DV_5) + (1.0682 DV_6)
+ (-.6150 DV_7) + (-.2862 DV_8)

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 8

Dependent Variable: TA_UGSCH

Multiple Regression

Multiple R = .3465 sig. of R = .0000
Multiple R Square = .1201
Adjusted R square = .1028

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	4775303.6011	341093.1144	6.961	.0000
Residual	714	34987947.7185	49002.7279		

Equation: TA_UGSCH = 146.2848 + (.4082 T_GRSCH) + (.4057 T_FACPER)
+ (-.003405 INST_FTE) + (-.00002778 RES_TFAC)
+ (-.5087 RES_PER) + (-.0004529 SVC_FTET) + (68.0631 DV_1)
+ (-123.7261 DV_2) + (-146.7841 DV_3) + (-35.7832 DV_4)
+ (-87.8388 DV_5) + (-68.2282 DV_6) + (-105.5645 DV_7)
+ (-43.6194 DV_8)

APPENDIX A

Faculty Undergraduate Instructional Productivity, Non-zero Research Funding

(Continued)

TABLE 9

Dependent Variable: TA_UGOCS

Multiple Regression

Multiple R = .3756 sig. of R = .0000
Multiple R Square = .1411
Adjusted R square = .1242

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	856.0988	61.1499	8.376	.0000
Residual	714	5212.8895	7.3010		

Equation: TA_UGOCS = 2.3730 + (.2366 T_GROCS) + (-.01159 T_FACPER)
+ (-.00004160 INST_FTE) + (-.000001623 RES_TFAC)
+ (-.01308 RES_PER) + (-.000003988 SVC_FTET)
+ (1.1929 DV_1) + (.3313 DV_2) + (-.1217 DV_3)
+ (1.3292 DV_4) + (1.7519 DV_5) + (.4654 DV_6)
+ (-1.2077 DV_7) + (-.5791 DV_8)

APPENDIX B

Other Regular and Supplemental Faculty Undergraduate Instructional Productivity

Log Transformation

TABLE 1

Dependent Variable: R_UGSCH

Multiple Regression

Multiple R = .3611 sig. of R = .0000
Multiple R Square = .1304
Adjusted R square = .1174

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	831.4034	59.3860	10.066	.0000
Residual	940	5545.8418	5.8998		

Equation: R_UGSCH = 17.5643 + (.04774 T_GRSCH) + (-.5759 T_FACPER)
+ (-1.2894 INST_FTE) + (.05161 RES_TFAC) + (-.3152 RES_PER)
+ (.06294 SVC_FTET) + (-.7148 DV_1) + (-.5389 DV_2)
+ (.5157 DV_3) + (.4695 DV_4) + (.8831 DV_5)
+ (-.008700 DV_6) + (-.7833 DV_7) + (.8406 DV_8)

APPENDIX B

Other Regular and Supplemental Faculty Undergraduate Instructional Productivity

Log Transformation

(Continued)

TABLE 2

Dependent Variable: R_UGOCS

Multiple Regression

Multiple R = .3141 sig. of R = .0000
Multiple R Square = .0986
Adjusted R square = .0852

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	47.9306	3.4236	7.348	.0000
Residual	940	437.9796	.4659		

Equation: R_UGOCS = 4.2874 + (-.09681 T_GROCS) + (-.08159 T_FACPER)
+ (-.3417 INST_FTE) + (.01369 RES_TFAC) + (-.09322 RES_PER)
+ (.01980 SVC_FTET) + (-.1844 DV_1) + (.1321 DV_2)
+ (.2576 DV_3) + (.2323 DV_4) + (.2306 DV_5)
+ (.1571 DV_6) + (-.1787 DV_7) + (.1858 DV_8)

APPENDIX B

Other Regular and Supplemental Faculty Undergraduate Instructional Productivity

Log Transformation

(Continued)

TABLE 3

Dependent Variable: S_UGSCH

Multiple Regression

Multiple R = .2057 sig. of R = .0002
Multiple R Square = .0423
Adjusted R square = .0281

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	305.0119	21.7866	2.968	.0002
Residual	940	6901.2147	7.3417		

Equation: S_UGSCH = 4.2659 + (.08558 T_GRSCH) + (-.3798 T_FACPER)
+ (.05526 INST_FTE) + (.08775 RES_TFAC) + (-.3205 RES_PER)
+ (-.02778 SVC_FTET) + (.01418 DV_1) + (-1.2239 DV_2)
+ (-.6728 DV_3) + (.03971 DV_4) + (-.4366 DV_5)
+ (.4121 DV_6) + (-.1607 DV_7) + (-.5976 DV_8)

APPENDIX B

Other Regular and Supplemental Faculty Undergraduate Instructional Productivity

Log Transformation

(Continued)

TABLE 4

Dependent Variable: S_UGOCS

Multiple Regression

Multiple R = .2228 sig. of R = .0000
Multiple R Square = .0496
Adjusted R square = .0355

Analysis of Variance

Source	DF	Sum of Sq.	Mean Sq.	F Ratio	F Prob.
Regression	14	31.6264	2.2590	3.507	.0000
Residual	940	605.5710	.6442		

Equation: S_UGOCS = .7634 + (.09523 T_GROCS) + (.008373 T_FACPER)
+ (-.009584 INST_FTE) + (.02390 RES_TFAC)
+ (-.1222 RES_PER) + (-.005858 SVC_FTET) + (.1134 DV_1)
+ (-.1562 DV_2) + (-.02943 DV_3) + (.1889 DV_4)
+ (.09502 DV_5) + (.3190 DV_6) + (.002912 DV_7)
+ (-.1757 DV_8)

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