The Determinants of Research Competitiveness Among Universities

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The search for a definition of research competitiveness, and the increase in the number of universities committed to a research orientation, are occurring simultaneously. Whether this increase is good or not remains in dispute, as does the question of whether further increases should be promoted through public policies. Statements about the increasing number of competitive universities also raise another issue: Are the correct factors being measured? Can the recent gains in the market share of academic R&D expenditures (to introduce one measure of competitiveness) for a select number of universities, and the toe holds of a larger number of other universities as research-intensive universities withstand a shakeout from structural imbalances between the increased number offering their services as research performers and the projected levels of federal and industrial funds to support the academic R&D enterprise? This issue, too, is problematic.

It is not self-evident that a substantially larger number of institutions would be more competitive if they possessed more of those factors that supposedly contribute to research competitiveness. A broader diffusion of cited factors might increase the relative...
importance of selected, less replicable factors or the ability to weave factors together in a dynamical and innovative manner. It is also questionable whether establishment of a consensus about the factors that help competitiveness is prescriptively useful because such a list would include items such as history, geography, and governance that are not readily manipulable. Other items, such as discretionary funds, may lay beyond the feasible resource bounds of some institutions; attempting to exceed these bounds might risk major harm to other academic missions, such as undergraduate instruction.

The murkiness of the concepts of competition and competitiveness as applied to research universities in many published studies increases the complexity of the above issues. These economic terms appear to be used more for metaphoric than analytic ends.¹

Generally, the subject is analyzed in terms of the factors that “make one university better for science than another,” to quote the title of one recent account (Spector, 1992). Moreover, even as one seeks to define (or achieve) research competitiveness, the commitment of many parties to competition as the central motivation for academic research may be questioned. To some academic leaders, competition, indeed, is a defining and salutary characteristic of American universities. For example, Henry Rosovsky has written that:

American universities exist in the real world, where leaders are challenged and sometimes forced to make room for—even be replaced by—newcomers. For us, the comforts of Oxford, Cambridge, the University of Tokyo, and the University of Paris do not exist. At all times there is a group of universities clawing their way up the ladder and others attempting to protect their position at the top. If one believes in the virtues of competition, as I do, one would stress the benefits of the system. That a large proportion of the world’s leading universities are located in the United States I have already in part attributed to the effect of inter-institutional rivalry (Rosovsky, 1990, p. 226).

This endorsement of market processes is by an economist who was dean of the Faculty of Arts and Sciences at Harvard Uni-

versity; this view is not universally held, however. Ambivalence about the legitimacy of the allocative and distributive functions of competitive mechanisms, exists, especially when the affected parties are not faculty and universities, but elected federal and state government officials.

This questioning approach is a necessary safeguard in relating the findings from the AAAS-conducted focus groups (see chapter 3) to previous research and exegesis on the factors that contribute to research competitiveness. Otherwise, the task is deceptively easy. It is not hard to find scholarly narratives, sage observations based on laboratory and administrative experience, and empirical findings consistent with the themes and specific items highlighted in the focus groups. A general consensus exists as to the factors that comprise research competitiveness.

However, a more critical reading of these studies and of the focus group narratives reveals numerous cracks in a seemingly flawless surface. The proposition frequently found in the focus group sessions and the literature, that “there are no hard and fast answers” to the question of why some institutions have attained (and maintained) preeminent standing (Hoke, 1993), is double-edged. On the one hand, the proposition highlights the openness, flexibility, and possibilities for institutions that aspire to new or improved standing. On the other hand, in a more formal sense it reflects a repeated failure to detect structural relationships amidst lengthy catalogs of putatively important factors.² Just when it seems safe to use the congruence between the focus group sessions and literature findings for prescriptive, planning, or policy purposes, substantive analytical issues surface.

This chapter is organized to examine these analytical issues and to validate the lists of factors offered by the focus group participants. It follows a backward mapping technique; thus, it ends with the list of factors, but begins the next section by first making explicit the economic concepts that suffice the subject of research competitiveness. It then winds its way through the labyrinth of issues relating to units of analysis and units of measurement. This section also presents data in addition to those offered in Geiger’s chapter, “Making the Grade: Institutional Enhancement of Re-
search Competitiveness,” on the distribution of academic R&D expenditures. Beyond reinforcing Geiger’s conclusion, the data establish an empirical context for interpreting propositions about research competitiveness.

The subsequent section is the main part: it distills findings from a review of the literature on the determinants of faculty productivity, institutional standing, and research competitiveness. At least four major research traditions have dealt with the subject of university research competitiveness: (1) higher education; (2) economics of education; (3) sociology of science; and (4) practitioner accounts. The review is a modest sample from among these traditions. The final section offers concluding observations.

The backward mapping has one unintended consequence. By starting with foundation concepts, the paper highlights the numerous conceptual and methodological complexities and confusions of past treatments and current debates. Thus, it begins on a critical note. This critical tone should not be taken to imply that universities cannot alter their competitive position by adding or organizing factors, nor is it a prescriptive statement that they should not attempt to do so. Rather, this critical approach suggests that a more precise understanding of competition is needed to both interpret focus group findings and existing studies and to more explicitly note that truly competitive processes need not produce the outcomes sought by every aspiring university or state.

One final introductory observation: For a treatment of academic research competitiveness to have substantive rather than symbolic meaning, a consensus is needed among the rivals, as well as between the rivals and the sponsors of the awards, about the legitimacy of the criteria used to award prizes, and the fairness of the procedures by which these criteria are applied (Chubin and Hackett, 1990). Thus, it is necessary to assume, at least initially, that all agree that the prizes for which players are competing—awards, research grants, status—should be awarded primarily on merit-based criteria related to the intrinsic quality of the proposed or published research, augmented by ancillary criteria relating to mission relevance and the like. In addition, it is necessary to assume that those making the awards do not consider the distribution of prizes among competitors as an award criterion.

**The Competitive Structure of the Academic R&D System**

**Universities as Firms**

The question of what constitutes research competitiveness subsumes several prior questions. These include (1) determining the competitors and the potential prizes, (2) the functions served by competition, and (3) the context of competition. The economic terminology suffusing this subject makes an economic framework an appropriate organizing device for examining these multiple questions.

In a stylized manner, the academic research system may be described as follows: Universities are multiproduct firms that offer a mix of outputs—undergraduate education, graduate education, and research (Cohn, Rhine, and Santos, 1989). They operate in markets characterized by perfectly competitive input markets and (to allow for product differentiation) monopolistically competitive output markets. Universities have considerable latitude, constrained loosely by legal charters, to select their preferred output mix. Thus, they are free to seek (if not to achieve) standing and rank as a research-intensive university—that is, at the industry level, the barriers to becoming a prospective supplier of externally funded research are assumed to be few. In addition to their own internally generated resources, universities compete for externally supplied research inputs by offering differentiated research proposals and complementary goods (e.g., facilities, equipment, reputation). Universities compete for recognition, prestige, and current resources based on the quantity and quality of their outputs which are not easily measured, leading at times to the use of input measures (e.g., R&D expenditures) as a proxy for both. The production function for academic outputs—that is, the relationship between the quantity and quality of inputs and the quantity and quality of outputs—is not well specified. Each of these stylized propositions undergirds statements found in the focus groups and the related literature on
research competitiveness; they constitute the framework for a further examination of unit of analysis.

Concepts and Measures of Competitiveness

Defining the competitors is an immediate issue in discussions of what constitutes research competitiveness among universities. As Teich and Gramp observed in their article on the Focus Group sessions: "When participants were asked for their first impression of what it means to be competitive in research, almost all responded with a question—what is the unit of analysis—individuals, institutions, states, international science?". In fact, the question raised by participants should be broadened to this: Who is competing for what? Until this new question is answered, it is not possible to identify the relevant outputs, much less proceed to further issues of the correct ways to measure these outputs and of estimating of the production processes that link a set of inputs to them.

However, before seeking an answer to this expanded question, two additional basic questions must be answered if the concepts of competition and competitiveness are to have analytical value. First, what functions are served by competition? Second, what is the context of the competition?

George Stigler offers an answer to the first question: "Competition is not a goal; it is a means of organizing activity to achieve a goal" (G. Stigler, 1994, p. 531). Not surprisingly, this answer leads to a further question: What goals are to be achieved? Or, more broadly, what is being competed for? An answer to this second question is offered by Steven Stigler’s differentiation between intellectual competition and competition for financial resources within and between universities. He writes that:

The fundamental competition involving our research universities . . . is the intellectual competition that takes place as . . . faculty seek to maximize an unusual variety of gain or income . . . Individually, faculty will compete for higher salaries and for such amenities as larger offices, but collectively—as departments, as schools or colleges, and as universities—they compete primarily in the currency of ideas . . . What makes the intellectual gain from teaching and research in universities unusual is that it requires competition for its recognition and award: it is only through the competition itself that we can tell when we are successful (S. Stigler, 1994, p. 133).

Steven Stigler, like Rcsovsky, highlights the functional value of competition in science: faculty compete for recognition, prestige, and reputation—all of which are tied to the idea of being first, or among the select few.

The difference between intellectual and financial competition bears emphasis. Intellectual competitiveness is measured by output—prizes, reputation, citations—not by research grants or expenditures per se. To return to George Stigler’s terminology, the competition for financial resources is over means, not ends: In terms of Steven Stigler’s dichotomy, competition over financial resources is important only to the extent that it contributes to intellectual competition.

This distinction goes to the core of how research competitiveness is measured. If, for example, the institution is the unit of analysis, several different scales can be used to establish rankings. These include Carnegie classifications, Association of American Universities (AAU) membership, National Research Council (NRC) rankings of graduate programs, National Science Foundation (NSF) rankings of academic R&D expenditures, and bibliometric rankings of departmental publications and citations, as well as U.S. News and World Reports and other journalistic measures. These measures are related, but not identical. The similarities and differences among the measures are illustrated by Groth, Brown, and Leslie’s construction of what they term a Research Activity Index, a multidimensional measure comprised of R&D expenditures variables, graduate student variables, and library holdings. According to the authors:

Although the R&D expenditures measure has proven successful in reflecting an institution’s ability to raise and expend research money, it may not assess research activity in any broad sense; that is, R&D expenditures may not be an
adequate proxy for other research attributes, such as the number of doctoral degrees awarded by an institution, the research training provided to graduate students, and the library activities associated with research. Also, some research is capital intensive and some is personnel intensive, and the unidimensional R&D expenditure measure makes no allowance for the distinct differences between the two (Groth, Brown, and Leslie, 1992, p. 28).

The authors report a high degree of association between the two measures in institutional rankings, especially among the top group of 25 universities, but note that specific institutions are ranked appreciably higher or lower on one scale than on the other. A similar emphasis on multidimensional measures that group together facets of intellectual and resource competition is found in the scales used in NRC rankings of graduate programs. The NRC's 1982 assessment of the quality of graduate programs in the social and behavioral sciences, for example, contained 18 measures of program quality. Only two items related to R&D expenditures—fraction of faculty holding research grants from selected federal agencies, and total R&D expenditures in selected fields.

To continue the examination of the measures of competition, George Stigler has defined competition as “rivalry between individuals (or groups or nations), and it arises whenever two or more parties strive for something that all cannot obtain” (G. Stigler, 1994, p. 531). This strict use of the term “competition,” however, may not apply to all attributes frequently used to compare research universities with one another. Competition, as conventionally used in discussions of academic standing, has both absolute and relative dimensions. Institutions may become better or worse by some absolute standard; they may also have an improved or worsened standing relative to other institutions. For example, it would be possible for an increased number of institutions to become members of the AAU—an institutional mark of research accomplishments—and for more departments to be ranked as superior or very good in NRC rankings. Unlike “the Lake Wobegon effect,” in which every institution seeks to be above average, it is consistent with both elementary statistics and the behavior of institutions for the average level of capabilities to rise by some measures but for skewed distributions of selected outcomes to still exist.

This absolute-relative dichotomy appears repeatedly in various measures of competition. Rivalry for something that cannot be obtained by all appears vividly in treatments of the distribution of R&D expenditures and in competitions for major facilities (such as between MIT and Florida State University to be the site of the NSF’s National High Magnetic Field Laboratory). It appears, too, in rivalries to be in the top five or top ten rankings, and ranked in periodic polls, scholarly or popular. This emphasis on relative rankings appears less overtly in discussions of intellectual competition. All researchers may not be the first to report specific discoveries, but many may be regarded as capable of conducting high-quality research. Although the number of pages in specific journals is as limited as external research dollars, faculty do not speak of competing with other faculty for space in a journal; by common usage, articles are accepted or rejected based on refereed and editorial judgments of absolute measure of quality.

Three issues are thus conjoined: (1) intellectual versus financial competition, (2) selection of measures appropriate to each form of competition, and (3) appropriateness of absolute versus relative measures to denote standing and status. To summarize: If the goal of competition is to increase the relative share of R&D expenditures among states, then the debate is properly cast solely in terms of research dollars. But if the debate is about academic quality, reputation, or prestige, then absolute metrics are also appropriate.

Given either absolute or relative measures, it is possible for institutions to improve by one measure of competition but not the other. For example, the University of California—Santa Cruz has been cited as an institution that does not appear among the list of top 100 universities in total R&D spending, but ranks first in physical sciences and twelfth in biological sciences when the measure of competitiveness is citations per paper (Hoke, 1993).
The distinction between intellectual competition and resource competition should not be overdrawn, however. Financial resources for research are needed to compete for intellectual recognition (in most, if not all, academic fields). Research dollars are both components of (additive) factor scores by which rankings are made, and intervening variables (or contributing factors) that lead to these scores. (In fact, it will be interesting to test for the relationship between changes in research share by discipline among universities during the 1980s and measures of academic quality in the forthcoming NAS study.) Similarly, recognition or its correlates, prestige and reputation, are the ends of intellectual competition as well as the means of achieving these ends. Prestige translates into research and graduate education. As Massy has observed:

Research is a ‘good’ because it opens the ways for new solutions and opportunities, and the prized, media recognition, and extra income simply reflect its value. Prestige brings the institution comparative advantage in the competitive market for faculty as well as intrinsic pride in accomplishment and recognition . . . Institutions compete for prestige, and over time the quest becomes self-fulfilling and regenerating (Massy, 1994, p. 31).4

Context of Competition

Competition means something different to rivals in the Oklahoma land rush who race for prime plots but have an equally good chance of being better off than before, or to those seeking space in a lifeboat—in other words, it all depends on whether the game being played involves a growing, static, or decreasing pool or value of prizes. The external context affects more than the rhetorical or political tone by which rivals relate to one another; it is also an independent factor in the number of competitors. More formally, the level of competition among firms is not independent of the growth of demand for an industry’s product. The more rapid the growth, the more likely it is that existing firms will seek to expand and that new firms will enter the market (McDonald, 1986). This thesis reflects the experience of the post-World War II American research university system, as an increased number of universities put on a research mantle in part because of the increased availability of federal funds.

However, the current examination of research competitiveness among universities occurs in the context of (1) fiscal stresses on the academic research enterprise; (2) a growing belief that the system is overextended relative to demands for scientific and technological research and that fateful choices need to be made about the enterprise’s aggregate size and distribution; and (3) repeated warnings about the risks of mimetic behavior for aspiring institutions that wish to become research universities (Langenberg, 1992; Rosenzweig, 1992).5 The response from aspiring institutions is that the constraint of their aspirations would represent cartel-like behavior by established institutions seeking to protect their market share.

Here we turn to yet another question: What model of competition is to be used? Comparing institutional rankings at various points in time and deducing the factors that lead to advancement from these positive moves is analogous to the economist’s concept of comparative statistics: Introduce a change and observe a new equilibrium in outcomes. Various cross-sectional studies on costs and productivity differences among universities tend to focus on economies of scale and scope; these studies suggest, but do not require, a conclusion that resources flow to larger, more research-intensive institutions.

A different perspective on models of competition is implicit in judgments that emphasize history, tradition, and culture as the sources of the leading universities’ existing strengths—several of which were specifically established with research missions (e.g., Kerr, 1991). This emphasis on history and culture implies first-mover advantages, by which leaders in one period accumulate advantages over rivals that provide them with the resources and capabilities to maintain their leadership positions in subsequent periods, even against the distinctive knowledge-based advantages of would-be entrants. The effect is most readily seen in areas of research where specialized facilities—high-energy physics or astronomy, for example—contribute to an institution’s ability to
maintain its market share because of being the primary site for the research. Several authors have noted that the post-World War II concentration in academic R&D followed from the concentration of wartime R&D efforts, contributing to the physical and support infrastructures report of the already premier research institutions. Merton’s Mathew Effect also may be at work, both as effect and cause of accumulative advantage. Institutional reputation may also enhance the likelihood that a proposal will be funded.

Abstracting from debates about “old-boy” networks, this outcome is neither surprising nor dysfunctional. It may reflect documented institutional capabilities and commitments to similar projects. It is analogous to relying on brand recognition to provide a measure of quality assurance under conditions of uncertainty. An established university may act as a fast second—seldom in the intellectual vanguard of new lines of scientific inquiry, instead relying on its resources and reputation to maintain its leadership position by bidding away faculty from other institutions who were first to develop a field. Against these advantages of leadership and established strength may be set the weaknesses of rigidities in structures, inflexibilities in reallocating resources, and presumptions of leadership that lead established institutions to remain enmeshed in declining areas, and permit latecomers to leapfrog to preeminence in selected areas.

Schumpeter’s theory of creative destruction offers an alternative perspective wherein which to view these possible scenarios. Research—the search for new knowledge or applications—is a continuous process of creative destruction that constantly redefines the value of existing theories, data, techniques, and equipment. The ability of established institutions to maintain their positions over long periods of time does not imply that they possess the most creative researchers, or distinct quantities or combinations of critical factors at a point in time. Rather, they have internalized the capacities to identify emerging research areas, to attract a continuing flow of resources, and to use these resources in ways that contribute to continued intellectual leadership over time. In describing Harvard University as a competitor, Kerr has made the following observations:

. . . I marveled at how, as the nation’s oldest university, it was the newest in responding the most quickly to out-front developments in the intellectual world; at how careful it was in its national and international search for persons for tenured positions . . . ; and at how determined it was to keep a numerical balance between the younger and older faculty members with a rapid turnover of junior fellows competing for tenure. Harvard will always be at the top (Kerr, 1991, p. 12).

Ambivalence Toward Competition

Ambivalence permeates discussions of research competitiveness among universities, at least for external R&D funding. As Steven Stigler has noted, whereas competition is seen as promoting socially desirable outcomes in economic markets, sports, and nature, in higher education it “fosters complaints of duplication, cries for support, pleas for exemption from laws against collusion, and attempts to restrict new entries” (S. Stigler, 1994, p. 131).

The normative and political concerns underlying attention to competitiveness for financial resources are clear. The pattern of concentration of federal expenditures for academic research in a relatively small number of states and institutions is well known. Based on average expenditures for the two-year period FY 1989–90, five states accounted for 38 percent and ten states accounted for 55 percent of federal R&D expenditures, while 17 jurisdictions (16 states plus Puerto Rico and the District of Columbia) accounted for 10 percent. In 1991, the top ten institutions accounted for 19.7 percent; the top 50, 59.4 percent; and the top 100, 82.5 percent of total federal R&D expenditures (National Science Foundation, Science and Engineering Indicators—1993, Table 54). This pattern of concentration has been a long-standing matter of concern to Congress and many state government officials (Murphy, 1969). The issue has intensified following recent emphasis on research-intensive universities as engines of regional economic growth (Feller, 1990; Luger and Goldstein, 1991; Malecki, 1991).
Determinants of Research Competitiveness

Irwin Feller

The normative and political tensions surrounding the subject of research competitiveness are illustrated by latent tension within the objectives of NSF’s EPSCoR program. Competitiveness is built into the program’s title, Experimental Program to Stimulate Competitive Research. Competitiveness to participants in EPSCoR has meant both (1) systemic improvements in faculty and institutional capacities to win a merit-reviewed award from NSF (or from other federal agencies)—an outcome consistent with absolute, but not necessarily relative, increases in R&D expenditures—and (2) an increase in relative share of R&D expenditures by institution and state. From the former perspective, targeting funds to selected institutions and states via sheltered competitions that emphasize the scientific merit of research proposals is seen as a means of increasing quantities of relevant inputs and engendering systemic change. And from this perspective, EPSCoR is an equal opportunity, not an equal outcomes, program.

Competition, however, involves exit as well as entry. As attested to by the history of American agriculture—with its high rates of return to R&D and shrinkage in the number of production units—competition is a treadmill that can increase in speed and steepness over time. Increased efforts to acquire the right factors or combination of factors by universities with low shares of academic R&D expenditures may be necessary just to maintain these shares in the face of actions by dominant institutions and new entrants.

Most significantly, competitiveness among institutions is not identical to competitiveness among states. For example, what if San Jose State University develops a stronger research capability, as it has done? At whose expense do such gains occur? More institutions are ranked between 100 and 200 in federal R&D expenditures in non-EPSCoR states. It is not difficult to envision a scenario in which not only do lower-ranked institutions gain relative share at the expense of higher ranked institutions, but non-EPSCoR states concurrently gain shares relative to EPSCoR states.

Finally, consider this scenario. What if the institutions ranked between 100 and 200 (plus institutions above 200 who aspire to be among the top 200) in R&D expenditures come to possess most of the factors listed below, and then find that relative shares, at least between broad groupings—say between the top 100 and the rest, or among states—do not change significantly? Would the outcome be politically acceptable? The likely answer is no. As suggested by the Office of Technology Assessment, “No matter how fair the competitive process, the outcomes may still be seen as ‘unfair’” (U. S. Congress, OTA, 1991, p. 9).

Explicit national objectives for the broad distribution of research capabilities coexist with national objectives to allocate R&D resources towards their most productive (creative) performers of institutions. NSF enabling legislation states that:

...it shall be one of the objectives of the Foundation to strengthen research and education in the sciences... throughout the United States, and to avoid undue concentration of such research and education (National Science Foundation, Statutory Authority, Section 3[e]).

In *Federally Funded Research: Decisions for a Decade*, OTA has argued that in setting priorities for research,

...the principal criteria for selection, scientific merit and mission relevance, are in practice coarse filters. Concerns for developing human resources and building regional and institutional capacity must also be considered; these criteria strengthen future research capability (pp. 11-13).

These statements reflect overtly distributive goals that can be used to alter outcomes generated by competitive processes.

Increased Research Competitiveness and Market Share

Two simple indicators suggest the onset of increased research competitiveness among universities. First, the number of institutions defined as research-intensive has grown steadily, according to reports and studies issued over the past 35 years. The increase is readily computed: the President’s Science Advisory Committee [*Seaborg Report* (1960)] called for doubling the number of research universities from between 15 and 20 in 1960 to 30 and 40 in 1983; Rosenzweig and Turlington pointed to "perhaps fifty to
seventy-five in all” research universities (1982, p. 2); the President’s Council of Advisors on Science and Technology, in its 1992 report *Renewing the Promise: Research-Intensive Universities and the Nation*, included 175 universities within this category. Allowing for the judgmental and political considerations that influence these counts, the pattern over the past 30 years has been striking: a doubling every decade!

Second, the distribution of academic R&D expenditures has become increasingly dispersed, at least among the major recipients. Geiger has reported a steady decrease in the share of federal R&D obligations received by the top 10 institutions dating back to the 1950s (Geiger, 1990). Employing a larger number of universities in the denominator, the NSF’s Division of Policy Research and Analysis dates the onset of dispersion to the 1960s, with the “increased demand for graduate education and the shifting of Federal R&D priorities from defense and atomic energy to medical and general sciences” (National Science Foundation, 1989, p. 94).

More recently, Geiger and I have described the 1980s as a decade in which all but a few of the country’s 200 leading research universities had absolute increases in R&D expenditures, but in which relative shares became more equal (Geiger and Feller, 1995). The most noticeable change occurred in the top 10 institutions; their relative share fell from 20.2 percent to 17.9 percent of the total over this period. Over the full set of 200 universities, the aggregate losses in the top groups of 10 and 50 universities were offset by gains among the universities ranked 61 to 100. The aggregate share of the next 100 universities increased from 13.2 percent to 14.6 percent of the total, but slightly more institutions (53) lost rather than gained share.

Patterns of loss of share in the top 50, gains by the next 50, and turnover with little net gain for the next 100 universities, raise new questions about the context within which research competitiveness is discussed. What part of the distribution does one concentrate on in identifying the factors that contribute to competitiveness—the top 10, 50, or 100? The conditions for success are drawn largely from the characteristics of leading institutions or from those that have made recent rapid advances. This procedure involves considerable selection bias. Lists of factors refer only to success, or the removal of barriers. Many questions arise. How do we handle institutions that have these factors, or have added them to improve their relative position but do not advance, or indeed lose, share? How do we identify the missing elements within these institutions that aborted the relationship between a factor (input) and output? Moreover, what type of relationship between a factor and competitiveness are we referring to? Is it dichotomous? An institution either has or does not have a factor. Is it linear? Is it curvilinear, characterized by both a critical minimum threshold and diminishing marginal product? What factors are characterized by which function and form? What is the context within which universities or states define their relevant set of competitors or peers?

Although Geiger and I have emphasized the growing dispersion of R&D expenditures at the upper end of the distribution, a quite different perspective emerges when the focus is on institutions in these top cohorts. Even though their shares of R&D expenditures have fallen over time, the specific institutions that comprise the leading research universities have remained relatively unchanged for long periods. Kerr has observed that amidst the natural, eternal, and increased intensity of universities to be better, “Few institutions, however, improve their positions very dramatically in the course of this race, or decline dramatically, over short periods of time” (1991, p. 10). According to Kerr, when universities make rapid moves, these tend to be discontinuous and made possible by rapid shifts in the total level or composition of external funding environment, which is not a foreseeable condition in the immediate future.

**A Review of the Factors that Contribute to Research Competitiveness**

**A List of Factors**

The easiest aspect of the task is to identify the list of factors from the published literature that are held to contribute to research competitiveness. The list is long and does not differ appreciably
from that offered by the focus groups. It includes "tangible" and "intangible" items. Some of the factors included are: (1) facilities, modern instrumentation, staff to run and maintain equipment, and the willingness of administrators to provide resources for investigators; (2) flexible administrative practices to foster timely responses; (3) a good support staff, including secretaries and contract administrators; (4) an active capital development office; (5) discretionary resources to fill in the gaps left by funding agencies; (6) high caliber students (to run equipment and bring faculty up to date on newest techniques); (7) access to administrators; (8) support from department heads for junior faculty in getting them exposure, and protection of junior faculty from extraneous activities; (9) creation of an intellectual climate; (10) support and collaboration with colleagues, including cooperation in the use of facilities; and (11) lighter and/or reduced teaching loads (Spector, 1992). Several studies also have pointed to the importance of unit productivity as a factor in shaping individual productivity (Braxton, 1983).

Tasch and Stahler's survey of university research administrators whose institutional share of federal R&D had either risen or fallen markedly from 1983 to 1990 provides a supplementary list. The following were cited as contributing factors by respondents: (1) deans and department heads setting research as a high priority; (2) the hiring of new faculty with a commitment to research (coupled with strong initial research support space, facilities, and equipment); (3) the presence of cross-disciplinary research institutes that facilitate researchers' ability to get around bureaucratic procedures and decision-making systems to secure resources; and (4) decisions to focus on growth areas, such as health sciences and engineering. Conversely, the absence of these factors was seen as the reason for slower-than-average growth and declining shares.14

Competitiveness also means housecleaning—replacing "deadwood" administrators who do not share research mission, and raising standards for promotion and tenure. Increased pressure to obtain grants is another factor. "Perhaps the most powerful way the university can encourage grant-getting is by considering a scientist's funding record in decisions about raises, promotion, and tenure. At some universities faculty are evaluated, in part, by the dollar volume of research they perform in a given year" (Hackett, 1990, p. 258). Size also enhances research competitiveness. Jordan, Meador, and Walters' study of 2,058 Ph.D.-granting departments in 23 academic disciplines indicates that per capita publications increased up to a point with department size, and were higher in private than in public institutions (Jordan, Meador, and Walters, 1989; see also Golden and Carstensen, 1992; Meador, Walters, and Jordan, 1992). The capital-intensive nature of modern research likewise leads to the existence of economies of scale and of scope in the conduct of research—and even more so in the production of supportive services, like libraries and administrative services (de Groot, McMahon, and Volkwein, 1991). Thus, a university needs either a critically minimum number of faculty pursuing work in a specific area, or a number of faculty/research groups across fields of research who can benefit from similar equipment to form a coalition of interests within the university. Such a group can piece together the pools of funds from the university, college, and department to maintain the equipment. Benchmarking data in selected disciplines suggest that research dollars are a curvilinear function of the number of faculty in related fields.

An important element is highlighted in the focus groups and recent statements by university officials: the capabilities of universities to provide matching funds/cost-sharing in competitions for federal, state, and industrial R&D awards (Vest, 1994). These requirements have spread among federal agencies. Approximately 80 percent of university administrators have noted increases in these requirements since 1990 (Feller, in progress). The requirements appear to be having their greatest impact on faculty's unending need for upgraded equipment to perform state-of-the-art research. NIH and NSF surveys conducted in the 1980s indicate that state-of-the-art instruments become obsolete every three to five years, down from seven to ten years in the 1970s (U.S. Congress, OTA, 1991, p. 180). Relatedly, OTA reported from interviews conducted in 1990 with researchers at the University of
Michigan and Stanford University that “instrumentation was becoming obsolete at a faster rate”; “most research fields were becoming increasingly dependent on advances in research equipment”; and that “support personnel are required in increasing numbers to operate equipment” (U. S. Congress, OTA, 1991, p. 181).

The nature of the new competitive environment associated with matching fund requirements is highlighted by Yale University’s provision of a $1.3 million matching contribution to receive $480,000 from NSF to acquire a high-field nuclear resonance spectrometer for polymer, catalysis, and biological studies. Universities competing with Yale for faculty and students and seeking to increase their match from 30 to 50 percent now find themselves confronted with an even higher standard to match: a ratio of 2.5 to 1.

The published literature, like the focus group study, also devotes considerable attention to institutional strategies for attaining and maintaining research standards. That no university can excel or lead in every field is a commonplace observation, as is the need for universities to be strategic in defining their competitive strengths. Just what this proposition adds to the above discussion is unclear. After all, it does not follow that as each institution seeks to be strategic, the level of competition for external awards lessens. In practice, most institutions appear to be terminating those programs that receive little external R&D and redeploying resources to more research-intensive units. This pattern may increase the threshold level of capabilities to be competitive, but may not necessarily alter relative positions. Selection bias also enters here. The case histories of successful strategic planning are well known (Stanford University and the University of Arizona come immediately to mind); reports of strategic initiatives that failed are less publicized. How many universities have underutilized biotechnology centers?

The importance of the factors listed above is also described in studies that detail the baneful consequences of their absence. The major impediments to funded research activities cited in these studies include (1) lack of procedural information, (2) lack of information about funding sources, and (3) lack of a clearly defined system of rewards for those who obtain external funding. These, combined with the tensions felt by faculty in their dual obligations as teachers and researchers, all cumulate in the view that the process of seeking external grants is too risky (Daniel and Gallagher, 1990).

Other barriers to research competitiveness cited in various studies—typically based on experiences at universities with low levels of R&D expenditures—include (1) heavy teaching loads, (2) insufficient knowledge of funding sources and proposal writing techniques, (3) lack of contact with colleagues in other disciplinary areas who may be instrumental in grant procurement, and (4) concern that funding-driven research may result in watered down scholarship. Another set of inhibiting factors relates to political constraints and interferences. Kerr describes Colorado, Hawaii, and Texas as great research universities that “could have been even better if state politics had been less of a historical handicap” (Kerr, 1991, p. 12). Similarly, state politics are seen by Kerr as dampening the achievements of other public research universities—such as the Universities of Wisconsin, North Carolina—Chapel Hill, and Nebraska—Lincoln—as faculty members at these state “flagship” universities become “unhappy and fearful” when surrounded administratively by less research-oriented campuses intent on homogenization” (Kerr, 1991, p. 12).

The Limitations of Factor Lists

Seldom considered in lists of essential factors are the negative aspects of the pressures to enhance a university’s research competitiveness. Trade-offs between research and teaching are rarely examined, although concerns about the excessive drive toward research orientation and the snares of mimetic behavior are increasingly evident—if not extensively in the literature cited here, then in more general statements about the condition of the contemporary American university and in state legislative endeavors to require faculty to devote increased time to teaching (Boyer, 1990; Philadelphia Inquirer, February 14, 1995).

The underlying mode of analysis by which these lists are generated also requires scrutiny. Many published studies are qualitative accounts based on assessments by participants analogous to those provided in the focus groups, or historical accounts of the
rise of specific institutions or clusters of institutions from which emerge a list of important factors. The more empirical studies are, for the most part, based on surveys of respondent assessments. Most studies lack any formal structural relationships, including controls or intervening or confounding variables. Indeed, as noted above, the literature on the factors that contribute to research performance seldom directly uses the term “competition”.

Similarly, compiling lists of factors does not provide a means of weighting or aggregating items. The lack of structural models rules out tests of significance. Furthermore, the more that institutions have come to resemble one another, the less apparent is the source of existing differentials in performance. Once selected factors cease to exist as discriminants, greater weight may accrue to remaining factors or to new factors. For example, if convergence occurs in institutional policies, research infrastructures, and commitments toward a research orientation, competitiveness might essentially be reduced to the differential performance of faculty at different institutions. The question then arises: What factors contribute to this differential? The answer, as suggested by Creswell’s 1985 survey of the relevant literature, is not promising:

Despite at least 90 studies since 1940 . . . , the measures of research performance are vague and poorly understood. Researchers do not clearly identify explanations for high research performance. The specific correlates of high performance are fraught with measurement problems, unclear causality, and unspecified predictive power (Creswell, 1985, p. iii).

One manifest source of variation in performance, given wide diffusion effects of factors close up, is context. Context means that: the impact of a factor or cluster of factors on individual faculty or institutional performance is highly contingent on the presence or absence of other factors within the university, the external environment, and, less obviously, the actions of other universities. The role of context in shaping the significance of factors is noted in the focus groups, but seldom appears in published studies. Ascher’s observations in another setting describe the contingent relation-

ships that constrain the employment of factors lists as a precursor to action:

the . . . approach is sensitive to the broad social matrix in which policies are formulated and applied. It thus emphasizes context (many aspects are relevant), and how these many aspects fit together (relevant factors are connected in complex ways that cannot be straightforwardly aggregated via statistical summation). Rather than being static, or regarding decision as a single-moment event, it is sensitive to dynamic processes, including policymaking itself (Ascher, 1986, p. 383).

As an example of this sensitivity, consider the fit between the observation that faculty should be able to pursue their research projects in the ways they see fit in order to be productive scholars, and current administrative tools of strategic planning and benchmarking. Robert Rosenzweig has written that the accomplishments of the American university have been based on “the independence conferred on faculty to pursue their own interests” (Rosenzweig, 1994, p. 300), as opposed to having to fit themselves into larger enterprises, the purpose of which has been defined elsewhere.

The larger enterprise in question, however, may be the college or university whose academic officials issue strong messages to faculty—that convey threats of sanctions related to promotion, tenure, or salary increases—about selecting research topics to appear in a specific set of journals in order to enhance institutional reputation. University officials also may simultaneously prod faculty to secure external awards that may involve mission-oriented studies, but then they ignore publications in applied or interdisciplinary journals that are the major outlets for such research. Moreover, the emphasis on securing external research grants, according to Roland Schmitt, has further weakened links between academic research and education, particularly undergraduate education. In addition, Schmitt argues that:

The pursuit of research has become an entrepreneurial activity pursued by individuals who happen to reside in universities while the educational function has remained
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an institutional responsibility. Thus the federal government now largely 'procures' research from the faculty and staff of universities without a clear policy of linkage to either education or utility (Schmitt, 1992, p. 257).

Thus, strategic planning and associated administrative pressures to maximize publications in selected journals may provide short-term spurs but may detract from longer-term institutional stability and competitive success. Along these lines, consider this description provided by Stuart Leslie of the underlying lessons behind Terman's strategy for building top-notch academic programs:

Do not waste time with the undergraduate programs, Terman advised, for they never pay big dividends no matter what kind of resources are devoted to them. Instead, he said, put the effort into the graduate programs, where national reputations are forged. Do not deviate from the guiding principles of the 'mainstream' theory and the 'steeple' concept. There was no point in creating excellent programs in fields no one cares about, Terman believed. Stay in the mainstream and make the programs count. Far better to build superb programs in a few crucial fields than to try for comprehensive coverage and end up doing lots of things well but not with distinction (Leslie, 1993, p. 45).

These tensions, conflicts, and trade-offs between aspirations for institutional advancement as a research university and the conduct of research reflect the need to reconcile administrators' penchant for controlling inputs in order to shape outputs, with the idiosyncratic production of research.

Production Function Issues

The task of relating inputs to research output is formidable, if not forbidding. According to Hopkins:

... it is apparent that our ability to identify and measure the outputs of research is even more limited than in the area of instruction. Undoubtedly, this will remain an elu-
sive problem, especially where the results of basic, as opposed to applied, research are concerned (Hopkins, 1990, p. 30).

Hopkins also points to the absence of "any evidence (either theoretically or empirically based) concerning the production function for university research alone" (1990, p. 25).

A focus on the production function highlights several other technical and policy issues as well. The production process for research is highly stochastic: The relationship between inputs and output is "uncertain in definition of the problem to be investigated; uncertain in duration and cost to achieve results; and uncertain in the implications of the results both for the structure of knowledge in the discipline and for the practical uses to which the new insights may eventually contribute" (Balderson, 1996, p. 35).

Researchers themselves may not know how flexible their production processes are—that is, the extent to which a choice among alternative techniques may provide an effective alternative route. Researchers may systemically overstate their resource requirements, many of which are costs to the sponsors and forms of expense preferences to researchers. Again, according to Hopkins ["... even if we were successful in fitting such a model to real data, there would be no guarantee that the result would represent the efficient frontier of production possibilities"] Hopkins, 1990, p. 26.

Set against these caveats is the increased commitment of an increased number of universities to a research mission and improved status as a research university. Geiger and I interpreted the increased dispersion of academic R&D expenditures within the top 100 universities as reflecting the existence of the "social capacity" of institutions to perform research, and their abilities to capitalize on an increased level of federal funding for academic R&D. Presumably, more institutions will develop this capability over time. Many of the institutional and organizational variables identified in the literature as required for success in securing external R&D awards can be found at institutions that currently rank in the 80th and 90th percentiles. Interviews that I conducted recently at such universities clearly indicate the presence of factors cited as critical
in the lists above: (1) an institutional commitment towards research; (2) expectations that faculty will seek external grants; (3) liberal research support and indirect cost recovery policies and strategies; and (4) street-smart contract officers. In fact, these institutions have increased their total external grants and contracts, but not their relative shares.

**CONCLUSION**

Research competitiveness can be defined and readily—if selectively—measured, but the state of the art offers few structural relationships. The list of factors is so extensive, interdependent, and contingent on external influences that it offers limited guidance to university faculty and administrators confronting resource allocation decisions. It also does not greatly aid the members of federal agency panels who are asked to review research infrastructure competitions. Competition does not simply involve the quantity of selected factors, but also the specialized nature of these factors, the ways in which they are combined, and their astute or serendipitous allocation of resources to strategic fields of research—often well before major external funding is available. First-mover and accumulative advantages exist, but so too may rigidities caused by long-established successes. Several of the factors that contribute to competitiveness—geography, governance, and state resource base—are beyond the capabilities of universities to change without massive compensating increases in other factors.

New opportunities for institutional advancement do exist. Sapolsky has argued that:

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The current institutional elite in science came to prominence with the initiation of the federal government’s patronage of university research, a patronage that was largely founded upon and then long sustained by the Cold War’s persuasive national security rationale for the support of science. As the rationale fades in its ability to elicit, so too do the prospects of at least some major institutions . . . the democratization of science seems likely to lie ahead (Sapolsky, 1994, p. 161).
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Kerr likewise has pointed to the expected turnover in faculty over the next 20 years as providing universities with opportunities to recruit faculty astutely and aggressively, and thus, for those institutions that do this better, to make major moves.

In some ways, competition in a research university resembles Woody Allen’s shark—if it doesn’t move forward, it dies. Referring to the competitive drives of the top 100 institutional performers of research, Gunport has noted that:

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This is the modern research imperative, the vehicle whereby universities protect if not advance their institutional mobility, for the institution which is not steadily advancing is certainly falling behind (Gunport, 1993, p. 249).
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Any review of competitive influences also highlights the possibilities of improving a predefined set of existing cohorts to improve its relative position, as well as the discontinuities that exist among groups. Change and improvement are obviously possible; the critical factors appear to be vision, commitment to excellence, and patience. Surges in funds also clearly help to compress the period of development and to make leapfrogging possible (*New York Times*, March 24, 1995).

Finally, for those who believe the published literature provides little short-term solace or guidance, there is always a longer term perspective to consider. Despite Kerr’s panegyric, Harvard University has not always been the institution he extols. In referring to the tradition followed by his and other New England families of sending their sons to Harvard, Henry Adams describes the Harvard of the 1850s as follows:

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. . . although none of them, as far as known has ever done any good there, or thought the better of it . . . Any other education would have required a serious effort, but no one took Harvard College seriously . . . It taught little, and that little ill, but it left the mind open, free from bias, ignorant of facts, but docile. The graduate had few strong prejudices.
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He knew little, but his mind remained supple, ready to receive knowledge (Adams, 1931, pp. 54-55).

**ENDNOTES**

1. “Though a few authors briefly mention `competition’ among universities . . . none has analyzed this competitive process or made serious estimates of relevant parameters” (Rothschild and White, 1993, pp. 11-12).

2. If this characterization seems too stark, it closely mirrors critiques of efforts to improve the performance of elementary and secondary education. According to Hanushek, “In the past, the main focus of educational policy and related research has been the development of a specific blueprint for ‘successful’ schools, a blueprint that could be applied with little modification from one school to the next. Yet, despite extensive research, we are currently quite far from an adequate understanding of either the underlying determinants of scholastic performance or the characteristics of school decision-making” [1981, p. 37; see also Spencer and Wiley (1981) and Hanushek’s response for a precursor of the debate about factors that affect research competitiveness].

3. “On every side, the scientist is reminded that it is his role to advance knowledge and his happiest fulfillment of that role is to advance knowledge greatly. That is only to say, of course, that in the institution of science originality is at a premium. Recognition for originality becomes socially validated testimony that one has successfully lived up to the most exacting requirement of one’s role as a scientist” (Merton, 1957, pp. 29-30).

4. Massey also notes that, “While there is nothing wrong with prestige-building per se, an expanding body of opinion holds that the process has gone too far and that many of higher education’s ills can be attributed to this fact. Unbridled competition for prestige—at least as traditionally defined in terms of research—leads to mission creep, as evidenced by the drive of many institutions to become ‘universities’” (Massey, 1994, pp. 31-32).

5. The level of competition as measured by the identity of competitors and distribution of relative shares may be self-correcting. If a shakeout among research universities is caused by institutions’ inability to secure sufficient external funds for financing their current research enterprises, it may involve turnover among smaller institutions or the exit of recent entrants as research performers.

6. According to the NSF, support provided to universities for defense and atomic energy research during World War II “did not cause a noticeable shift in distribution curve because most Federal funds went to universities which had established distinguished reputations in physical sciences prior to World War II” (NSF, 1989, p. 94). In contrast, Vannevar Bush notes that Office of Scientific Research and Development awards went to 150 universities, but provides no data on relative shares (Bush, 1946, p. 111).

7. Bentley and Blackburn offer an aggregate test of the accumulative advantage hypothesis across Carnegie classifications (1990). They employ the following variables as measures of a university’s research performance: (1) percentage of faculty holding a Ph.D.; (2) percentage of faculty primarily interested in research; (3) number of self-reported professional writings within the last two years; (4) number of books and monographs published over a faculty member’s career; and (5) percentage of faculty receiving any externally sponsored grant support within the past year. By these measures, all five Carnegie institution types increased their research-intensiveness between 1969 and 1988, but Research II and Doctoral-granting I institutions enhanced their position relative to Research I universities. The authors note, however, that the study’s level of aggregation may be too broad to test for accumulative advantage and that tracking “subgroups of institutions by other criteria such as publication outlets or levels of grant support may be more appropriate” (Bentley and Blackburn, 1990, p. 345; see also Geiger and Feller, 1995).

8. Debackere and Rappa’s recent study of faculty mobility among universities reflects these propositions: “Institutional stratification within the scientific community raises an interesting question with respect to scientists who enter a field early. It may very
well be that the relative stature of a university has some relevance in the pioneering behavior of its faculty and students, what might be called the ‘backwater hypothesis.’ On the one hand, prestigious research universities may have the resources that would enable those scientists who are inclined to take chances more readily to explore new fields . . . Unable to convince their mainstream colleagues, some scientists may seek haven at lesser known institutions in order to pursue their unconventional research” (Debackere and Rappa, 1995, pp. 138-139).

9. There is also a normative, almost elegiac, quality to the subject of research competitiveness that reflects concern about the atrophying skills of academic researchers who do not practice their trade. Drew writes of forgotten scientists, young Ph.D.s who, because of the imbalance of supply and demand for new positions in prestigious institutions, scratch for jobs at most less prestigious institutions than at Yale or Berkeley, where they might have gone, and adds: “And the research skills are decaying . . . The increasing employment of highly skilled, highly trained, potentially productive young researchers at second- and third-tier universities has dramatically changed the academic landscape” (1985, p. 2).

10. As noted in Federally Funded Research: Decisions for a Decade, “Given the extraordinary strength of the U.S. research system and the character of scientific research, there will always be more opportunities than can be funded, more researchers competing than can be sustained, and more institutions seeking to expand than the prime sponsor—the Federal Government—can fund. The objective, then, is to ensure that the best research continues to be funded, that a full portfolio of research is maintained, and that there is a sufficient research work force of the highest caliber to do the job” (U.S. Congress OTA, 1991, p.6).

11. A more current, if shorter term, picture of patterns of stability and mobility is provided by other data from Geiger’s and my study. In addition to inquiring into the share received by the first 10 institutions, and so on, we studied the number of institutions that received 20, 40, and so on, percent of academic R&D expenditures, and the identity of the universities in each quintile.

For example, nine universities received 20 percent of total federal R&D expenditures in 1989-90. Of these nine, six were in the group that received 20 percent of these funds in 1979-80; three were from the quintile that received between 21 to 40 percent of federal R&D funds. The three universities that fell from this class moved down one quintile. The overall picture is a mixture of stability and change; approximately one-half of the members of the second, third, and fourth quintiles remained in their class over the decade, while each of these quintiles was entered and exited by institutions that either moved up or down one quintile. The greatest stability was in the bottom quintile, the largest group (n=115). Most institutions in that quintile in 1989-90 were in that quintile in 1979-80.

12. Kerr’s observation is consistent with a finding made by Geiger and me that the institutions making rapid gains in shares of R&D expenditures during the 1980s tended to be those that had invested in biomedical research and medical schools and were thus able to capitalize on the larger increases in federal funding for life sciences relative to other research fields in this period. Moreover, according to our interpretation, one reason for the declining share of leading research universities was the explicit decision by several of them not to allow growth to occur at a rate made possible by the availability of external research support.

13. Commenting on the early histories of the sociology departments at Columbia University and the University of Chicago, Wallace observes, “. . . in universities, as elsewhere, there is no substitute for generosity of spirit and a keen eye for talent in the older generation which has to choose its successors” (1992, p. 512; see also Spector, 1992).

14. Dorris and Fairweather caution against excessive belief in the potency of interdisciplinary organized research units (ORUs) to alter an institution’s performance: “Although formal research structures influence faculty behavior, the findings of this study indicate that what matters most to professors in research universities are the values and norms of their academic discipline, and their standing in the profession writ large. The belief that structure (as represented by ORUs) is the dominant influence on faculty
members is mistaken. The effect of any mechanism of organizing faculty research depends on how well the structure matches with the values and norms of faculty culture. The effect of organizational structure for a particular campus also depends on local circumstances, the environment, and the goals of the institution” (Dorriess and Fairweather, 1992, pp. 15-16).

15. The difficulty with lists of barriers from low-ranked R&D performers is that the same impediments may be found at leading research universities. The process of educating faculty and administrators about sources, procedures, and tactics for securing external funding at research-intensive universities is never-ending.

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