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Identifying Success Factors in Research Fund Competition: A Case Study Involving Three Medical Institutions in Texas

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Identifying Success Factors in Research Fund Competition: A Case Study Involving Three Medical Institutions in Texas

by

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Dedication

I dedicate this work to my family members who have taught me the meaning of hard work and perseverance, and who have supported and inspired me through many challenging endeavors; thank you, Dick, Mom, Dad (1932-1986), Chris, Norm, and Teri.

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Some research institutions are more successful competing for federal research funds. The purpose of this qualitative study was to identify the institutional factors that explain how two groups (more and less competitive institutions) differ in their competitiveness (i.e., their rank in the top 100 research universities as measured by federally financed research and development [R&D] dollars). Two annual National Science Foundation surveys that collect total institutional R&D expenditures and federal obligations data were examined. From these data, three Texas medical institutions were selected for in-depth case studies. Multiple data sources were used and allowed the researcher to explore each institution's research development over time. Institutional factors identified in organizational development literature as key to an institution's effectiveness were investigated. The extended research period (1971 to 2000) covered several institutional presidential terms and allowed the examination of leaders' roles in

the institution's research enterprise. The case studies included interviews with key people with knowledge of the institution's research activities.

Four internal factors that facilitated the research enterprise (culture, people, research capacity, and processes) were found to differentiate the highly competitive medical institutions from the less competitive institution. The more competitive institutions acquired federal research funds because their cultures (i.e., core beliefs and values) placed cutting-edge research as a high priority and promoted a strong passion and commitment to an intellectually-rich research environment. These institutions aligned their human and physical resources (i.e., research capacity) to be more effective in innovative research. Concurrently, this research-supportive culture promoted streamlined processes (i.e., practices, procedures, and policies) that facilitated the research enterprise. The less competitive institution lacked such a culture and, consequently, could not successfully direct its people, capacity, or processes toward research; as a result, this institution was less competitive in acquiring federal research funds.

Based on these findings, many institutions with research capacity who desire high national ranking will not achieve this goal as they lack the four identified critical factors. State and institutional resources should be directed to those institutions with higher probabilities of success whose cultures, people, capacities, and processes support research or are more likely to be developed.

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Chapter 1. Introduction

The federal government has exerted a major influence on American higher education through its initiatives to meet prevailing national goals and priorities (York, 1978). Many of these initiatives have sponsored academic research and expanded research in areas of agriculture, defense, space, energy, medicine, bioterrorism, and homeland security. One example, the 1887 Hatch Act, established support for agricultural research. Later, the 1944 Public Health Service Act expanded the National Institutes of Health (NIH) research support and provided extensive opportunities for universities in medical research (York, 1978). Other initiatives have provided opportunities for expanded basic research, graduate studies, and scientific buildings, equipment, and laboratories (Graham and Diamond, 1997). Thus, universities and colleges have benefited tremendously from the federal government's long-term commitment to research.

Changing national priorities create major shifts in federal agency research and development (R&D) budgets that impact those institutions performing the research. Some institutions are significantly more successful at competing for federal research funds. One hypothesis is that these institutions are better prepared to perform the desired research and, thus, to take advantage of these shifts in federal opportunities for research grants (RAND, 2002). This study aims to identify the institutional factors that explain

the effectiveness of research universities to position themselves for research opportunities. Institutions should know if they are capable of performing such research and of competing successfully for research funding. Presently, which institutions can make the necessary adjustments to benefit from the new Department of Homeland Security and its terrorism research focus? Biological terrorism defense is a current national priority and requires "having highly secure 'biocontainment' laboratories for the safe study of dangerous microbes" (Brainard, 2003). Not every university, however, has the required capabilities or is positioned to capitalize on new funded opportunities (Geiger and Feller, 1995).

Over six hundred institutions of higher education perform research at the $20 million per year level; however, in fiscal year 1999, only 154 major competitors accounted for 91% of the total federal research expenditures (Lombardi *et al*, 2001). The top 100 institutions have for many years received roughly 80% of all federal funds allocated to academic research (Wolfle, 1978; Stahler and Tash, 1992). Some researchers assert that institutions with a research-intensive component such as (1) a medical school, (2) an engineering school, or (3) a land-grant, agricultural school have been the national leaders in obtaining federal research funds (Graham and Diamond, 1997). Many of the thousands of four-year colleges and universities in America possess a research-intensive component. Thus, something other than a research-intensive component must distinguish the more competitive institutions.

Leading competitors have distinguishing features. They have the necessary facilities, libraries, equipment, and other resources to perform and provide quality service

and research (Texas Higher Education Coordinating Board, 1998). Moreover, they have the reputation that attracts the top faculty and students (Kerr, 1994). Another hypothesis is that the leading competitors respond better to their competitive external environments by adapting and aligning their strategies with the prevailing funding sources. This study aims to increase understanding of this highly competitive research environment by identifying those factors which lead to more successful competition for federal research funds.

Leading competitors also appear attentive to federal policy changes that affect their research funding success. These institutions develop the necessary processes and expertise around those strategies that address external challenges such as changing national priorities. A preliminary analysis of the top 100 universities (in federally financed R&D expenditures) confirms the influence of the federal government's changing priorities.

For example, the Department of Defense (DoD) doubled its total academic research budget during the mid-1970s and 1980s resulting in a doubling of federal support for engineering (Geiger, 1993). More recently, the NIH R&D budget doubled between 1998 and 2003. Analyzing three decades of data (1971-2000) reveals that universities performing engineering research have descended in rank whereas those focused on medical research have ascended. Specifically, in 1972 eight institutions with an emphasis on engineering research but with no medical school affiliation were ranked in the top 50; in 2000 seven of these eight institutions descended and three were ranked below 50. In contrast, in 1972 only five health institutions were ranked in the top 100; by

2000 a total of 13 health institutions were ranked in the top 100. Six of these 13 health institutions are located in Texas and Table 1 shows the six institutions' respective federal R&D expenditure rankings over the period of this study's analysis.

Table 1. Federal Research & Development Expenditure Ranking of Six Texas Health Institutions: 1972 and 2000

Institution	Federally financed R&D expenditures	
	1972 rank	2000 rank
Baylor College of Medicine	49	25
U. T. Southwestern Medical Center at Dallas	103	48
U. T. Medical Branch at Galveston	117	90
U. T. Health Science Center at Houston	236	71
U. T. Health Science Center at San Antonio	179	84
U. T. M. D. Anderson Cancer Center	73	67

Sources: National Science Foundation, Survey of R&D Expenditures at Universities and Colleges
Note: Federally financed research and development (R&D) expenditures are all federal funds expended for research and development activities in Science & Engineering. Data available 1972-2000.

In 2000, two of the six aforementioned Texas health institutions, Baylor College of Medicine and U. T. Southwestern Medical Center at Dallas, ranked in the top 50, 25th and 48th respectively. The U. T. M. D. Anderson Cancer Center's ranking rose (67th in 2000 from 73rd in 1972), but remained between 51 and 100. The other three institutions (U. T. Medical Branch at Galveston, U. T. Health Science Center at Houston, and U. T. Health Science Center at San Antonio) climbed into positions 51 to 100 from lower positions in 1972. What enables particular institutions to compete more successfully for

research funds? For example, what enabled Baylor College of Medicine (BCM) and U. T. Southwestern Medical Center at Dallas (UT Southwestern) to be more competitive in terms of their top 50 positions as measured by federally financed R&D expenditures?

STATEMENT OF THE PROBLEM

Many governors, legislators, and higher education leaders believe their constituents would receive significant benefits from having nationally recognized research universities. Thus, they encourage institutions to compete for federal research funds. However, many institutions will not become successful competitors. Consequently, not every university can or should attempt to become a major competitor. It is essential to determine what it takes to be an effective competitor and which aspiring institutions will likely succeed in the national competition for research funding.

Building a research university requires extensive time and resources. Given that most research grants do not cover all research-related costs such as the indirect costs or overhead (e.g., utilities, administrative services (e.g., payroll), and building and equipment maintenance), building research capacity requires a long-term commitment and supplemental funding to support the research mission (Murray, 2002). Competing state needs also create a drain on limited resources (Bracco, 1997). When resources are limited, funding choices are more difficult. Performing research also requires institutions to adapt to their environment. This adaptation requires implementing strategies that respond to shifting national goals and funding sources (Krohn, 1992; Diamond, 2000). Changing economies require that an institution continually engage in self-evaluation,

strategic planning, and actions that may include abandoning the status quo (Tierney, 1999). All of these actions are costly overhead expenses. In addition, emphasizing research can create tensions among constituents who favor teaching over research. Resulting political tensions can adversely influence institutional funding.

Decision makers are then faced with critical questions: Should an institution attempt to become a major competitor for federal research funds? If so, why and how? If the endeavor is itself expensive and the resources are limited, which institutions have the greatest likelihood of being successful?

PURPOSE OF THE STUDY

Universities and colleges benefit from the federal government's long-term commitment to sponsor academic research. Table 2 depicts the expanding national R&D economy, the changes in terms of who is performing the research, as well as the sectors funding the research in years 1972 and 2000. Over this 28-year period, higher education institutions increased their share of the national R&D performance by $28 billion (Payson and Jankowski, 2000). The total R&D expenditures at colleges and universities have increased over the past 40 years (Table 3). Over this period, colleges and universities have expanded their own amount of institutional funded research by almost $6 billion. Table 3 also depicts that all the sectors funding academic research have continued to increase. Still evident is the influence of the federal government, the largest supporter, with an increase of over $17 billion.

Table 2. U.S. Research & Development Expenditures for 1972 and 2000 by Performing Sectors and Funding Sources

	1972	Percentage	2000	Percentage
Performing Sector			(millions of current dollars)	
Industry	19,004	66.1	197,861	74.8
Universities and Colleges	2,757	9.6	30,974	11.7
Federal Government	4,676	16.3	17,469	6.6
All Others	2,303	8.0	18,312	6.9
Total	28,740	100.0	264,616	100.0
Source of Funds			(millions of current dollars)	
Industry	11,715	40.76	183,724	69.43
Universities and Colleges	312	1.09	6,210	2.35
Federal Government	16,039	55.81	66,208	25.02
All Others	674	2.34	8,474	3.20
Total	28,740	100.00	264,616	100.00

Source: National Science Foundation (2002), Division of Science Resources, National Patterns of R&D Resources: 2002 Data Update. Data assembled from Table 1a and 1b. Retrieved August 10, 2003, from http://www.nsf.gov/sbe/srs/nsf03313/pdf/tab1a.pdf and http://www.nsf.gov/sbe/srs/nsf03313/pdf/tab1b.pdf

Table 3. Total Research & Development Expenditures at Colleges and Universities by Funding Sources, 1960 to 2000

Year	Total	Federal Government	State and Local Government	Industry	Institutional Funds	All Other Sources
Millions of Current Dollars						
1960	705	453	90	40	67	55
1970	2,418	1,686	237	66	259	171
1980	6,455	4,335	519	264	920	419
1990	16,936	9,936	1,399	1,166	3,187	1,249
2000	30,154	17,475	2,197	2,310	5,969	2,203
Percentage Distribution						
1960	100	64.3	12.8	5.7	9.5	7.8
1970	100	69.7	9.8	2.7	10.7	7.1
1980	100	67.2	8.0	4.1	14.3	6.5
1990	100	58.7	8.3	6.9	18.8	7.4
2000	100	58.0	7.3	7.7	19.8	7.3

Source: Science & Engineering Indicators–2002. http://www.nsf.gov/sbe/srs/seind02/append/c5/at 05-02.xls Retrieved 10/6/03.

In spite of this academic R&D expansion, little research exists on the strategies used by leading research universities, including how they have aligned their research activities to match funding sources (Keefe, 2003). Less is known about those institutions that capitalized on increased federal funds such as from the NIH research initiatives that have experienced continuous growth since 1965 (Graham and Diamond, 1997). Two federal agencies, the DoD and Health and Human Services (parent agency of NIH), distribute most of the academic R&D funds. The NIH is now the largest single source of academic research funds (Brainard, 2004a).

Academic medical institutions have been significant recipients of NIH research dollars. In 1997, the 125 U.S. medical schools had research awards (all sources) totaling $7.8 billion, of which $5 billion (64%) came from NIH awards (Moy *et al*, 2000). Studying specific recipients of NIH funding can provide a better understanding of how some institutions developed and cultivated a competitive advantage in a changing federal research environment. This study will test the hypothesis that institutional factors explain the difference in research rankings, i.e., highly competitive institutions adapt better and align their institutional strategies with national goals and priorities.

Preliminary data analysis reveals that in annual R&D rankings little movement occurs among the top institutions. The analysis also reveals slight percentage changes in shares among the top 100. The top 100 institutions (in federal R&D expenditures) continue to receive over 80% of the federal research dollars while the top 50 receive 60% (Stahler and Tash, 1992). Thus, upward movement within the rankings requires considerable funding increases. For example, UT Southwestern ranked 48th in terms of

federal R&D expenditures in 2000. To ascend to the 25th position occupied by BCM, UT Southwestern would need an increase in its annual federal research expenditures of $84 million. In like manner, U. T. Medical Branch at Galveston ("UTMB") would require an increase in its annual federal research expenditures of $47.8 million to climb from its 90th position to the 48th slot occupied by UT Southwestern. New and useful information might be gained from studying medical institutions that ascended in rank during the 30-year period of growth in NIH funding. While academic health institutions may have an advantage over nonhealth institutions in the competition for NIH grants and contracts, not every academic health institution has been successful at competing for federal research grants (Brainard, 2004b). This study was conducted to provide new knowledge on organizational characteristics of the highly competitive medical institutions.

RESEARCH QUESTIONS

With most academic R&D funds coming from the federal government, an institution's research competitiveness can be measured by analyzing its ability to secure federal R&D funding. Most federal R&D funds are awarded on the basis of an institution's or individual faculty member's ability to perform the desired research (Moy *et al*, 2000). Thus, many internal and external factors will influence an institution's performance. External factors (e.g., increased federal funding in particular fields of study) are important but they are not the focus of this research. However, in relevant areas, external factors will be briefly discussed. Rather, the focus of this study is to

identify and examine the differences and similarities of key internal organizational factors among three academic health institutions. This study seeks to answer the following research questions:

Research Question 1: To what extent do leading and less competitive institutions of higher education differ in their ability to implement and execute successful research policies and practices?

Research Question 2: Do institutional factors explain the difference in research rankings for more and less competitive higher education institutions as measured by federally financed R&D expenditures?

Research Question 3: What particular factors make a difference in a higher education institution's ability to effectively execute its strategies or more effectively compete successfully for federal research funding than less competitive institutions?

SIGNIFICANCE OF THE STUDY

When national goals change, institutions encounter fluctuating federal agency budgets. Institutions that depend on a particular agency's funds should be concerned with potential changes in national goals and priorities as older initiatives (e.g., agriculture, engineering) could experience fund reductions when new initiatives (e.g., medicine, bioterrorism) become funded. A major decrease in an agency's budget can have negative consequences for these funded institutions. Historically, land-grant

institutions benefited from increasing agriculture support. Later, engineering institutions gained momentum from increased DoD funding. More recently, medical institutions have ascended due to enhanced NIH funding. Researchers argue that these research-intensive components (agricultural, engineering, and medical) are the factors for success in acquiring federal research grants (Graham and Diamond, 1997). However, not all institutions among these given types have grown equally in terms of federal research funding.

Knowing what strategies are associated with institutional advancement during such shifts may provide clues for others to make informed decisions about their capability to become major research competitors. At present, can institutions make the necessary adjustments to benefit from the new Department of Homeland Security and its terrorism research focus? Defending against biological terrorism is a prevailing national priority and includes "having highly secure 'biocontainment' laboratories for the safe study of dangerous microbes" (Brainard, 2003). For decades, only two major government-run biosafety level 4 facilities have existed: the Centers for Disease Control and Prevention in Atlanta and the U.S. Army Medical Research Institute of Infectious Diseases in Ft. Detrick, Maryland (Enserink, 2000). Without government support, these expensive facilities would not likely be built. In spite of an economic downturn, Congress gave NIH $372.5 million (FY 2003) for bioterrorism-related research which included construction grant money for two new Biosafety Level 4 laboratories plus nine other less secure laboratories (Brainard, 2003). Does a particular institution have the expertise and infrastructure to perform this type of research? If not, can an institution

acquire them quickly to take advantage of this new agency's proposed $1 billion R&D budget for 2004 (Brainard and Borrego, 2003)?

DEFINITION OF TERMS

Acronyms have been used throughout this manuscript for ease of communication; this list is provided in Appendix A (p. 135). For purposes of this study, the following terms will have the meanings presented below.

More competitive institutions – those higher education institutions that are positioned 1 to 50 as measured by federally financed R&D expenditures and are referred to as BCM and UT Southwestern.

Less competitive institutions – those higher education institutions that are positioned 51 and below as measured by federally financed R&D expenditures and referred solely to UTMB.

Adaptability – an institution's capacity for internal change in response to external conditions (Denison and Mishra, 1995).

Strategies – concerted plans usually implemented in response to internal and external challenges and opportunities.

Organizational Structure – the arrangement or design of an institution, the departmental (micro) and institutional (macro) levels. Structure is not solely understood by an organizational chart.

Financial Support – private, discretionary, endowment, and other nonfederal fiscal support.

Rewards or Incentives – compensation or enticements (something offered that is desired (e.g., opportunities, recognition, space, awards, or endowed positions).

Politics – the activities of national, state, and local governments or internal organizations concerned with debate and creating and implementing policies; also, interrelationships regarding power, authority, or influence.

People – faculty (key characteristics), students (graduate and postdoctoral), administrative staff, or others (particular leaders, e.g., deans, chairmen).

Processes – institutional practices, procedures, and policies.

Research Capacity – ability to conduct research based upon individual and institutional core competencies and capabilities (e.g., skills, technical expertise) and physical assets (equipment, buildings, land, or unrestricted funds).

LIMITATIONS

This study is limited to one state (Texas) and to one type of higher education institution (academic health) and does not attempt to extrapolate the results beyond Texas or to other institutional types (e.g., major research universities, land grant institutions). The study uses one measure of ranking, federally financed R&D expenditures, to differentiate between more competitive and less competitive research institutions. The organizational factors identified in this study may be unique to the institutions studied. However, the findings should be generalizable to any institutional type that competes for federal research dollars as the results suggest these factors are critical for research

competition. Future studies with other institutional types may be needed to confirm this statement.

Another limitation results from the small number of interviews. Even though faculty or administrators were purposively selected based on their familiarity with the institution's management, organizational structure, and research activities, and their own active involvement with research, their experiences may not capture information available from others not interviewed.

DESIGN OF THE STUDY

To better understand the factors that contribute to an institution's competitive strength, a historical and institutional perspective of what actually transpired within the institution's internal policy and procedures, governance structures, and leadership is needed. In developing this comparative study, the researcher determined that a quantitative study would not provide the rich detail of the institutions' developments as compared with a qualitative approach. Institutional case studies are valuable in comparing institutions and capturing unique distinctions in internal characteristics; accordingly, qualitative research methods were deemed more appropriate for this retrospective, exploratory study to better understand the institutions' research capabilities (Patton, 1990).

To understand how institutions operate, investigators need to analyze institutional development over time. A reputation of expertise and excellence is fundamental to attract top faculty, students, staff, and research support. To build reputation, institutions

must produce cutting-edge ideas, pursue excellence, enhance graduate education, and compete among the best (Association of American Universities, 1947; Selingo, 2002). The case studies seek to identify the organizations' capabilities and competencies, and then examine how specific organizational factors (e.g., structure, people, processes, and strategies) facilitate building reputation and obtaining research grants.

Two federal fund and support surveys assembled by the National Science Foundation (NSF), described in Chapter 3, aided the researcher in identifying Texas academic health institutions ranked in the top 100 as measured by federally financed R&D expenditures. Institutions listed in the top 50 were grouped and defined in this study as the leading or more competitive institutions. The remaining institutions (ranked 51 or lower) were grouped and defined as the less competitive institutions. Institutions from both groups were compared to identify differences and similarities in structure, strategies, and processes that might explain differences in research rankings. It was theorized that comparing these groups would help recognize any particular organizational factors leading to successful competition for federal research funds.

The case studies included interviews to obtain personal knowledge of the institutions' internal developments and of the factors that facilitated successful competition for federal research funds. Face-to-face semi-structured interviews were performed with past and present key university administrators and faculty who worked closely with the day-to-day research operations. Initial open-ended questions regarding success factors allowed spontaneous answers and other semi-structured questions sought answers to specific developmental issues. In addition, other quantitative and qualitative

data were also collected to complete this exploratory study. Quantitative data (e.g., performance indicators) depict an organization's assets (e.g., endowments assets, faculty awards) and indicate how well it performs in selected areas. These indicators do not explain how the institution was able to perform at a particular level but they helped the researcher structure the case studies and subsequent interviews. Using separate data sources helped corroborate and give validity and reliability to the findings.

Texas medical institutions were selected for this study in part because of their accessibility to the researcher, but primarily because Texas had several institutions in the top 50 and several in the second 50 as measured by federally financed R&D expenditures (reference Table 1, p. 4). In addition, Texas is one of few states receiving very large amounts of NIH grant money (Brainard, 2002). Three of the Texas medical institutions were selected for in-depth case studies which would offer the most informative data on the factors that contribute to an institution's ability to compete successfully for research funds. The more competitive group included BCM and UT Southwestern, selected because they were ranked in the top 50 in 2000 and because they are, respectively, a private and public institution. The less competitive institutions included four public institutions from The University of Texas System (UT System). While the Health Science Centers at Houston and San Antonio have progressed further in ranking, UTMB was selected because (1) this institution appears to provide more breadth and depth to study, (2) it is the oldest medical school in Texas and has the longest exposure to research, (3) it ranked lowest of the six in 2000, and (4) it has very recently begun emphasizing research. The U. T. M. D. Anderson Cancer Center is not a medical school

and does not confer M.D. degrees; it was eliminated from consideration because its unique features are not comparable to the others. A brief institutional history of the three medical schools studied is provided in Appendix B (pp. 136-138). These institutions have similar missions (education, research, and patient care) although their origins differ as described in their histories.

STUDY ORGANIZATION

This study is divided into five chapters with the introductory chapter explaining the study's purpose and significance, and presenting the statement of the problem, the research questions, and the design of the study. Chapter 2 reviews the literature for the study's background and theoretical framework. Research methodology is explained in detail in Chapter 3. Chapter 4 presents and analyzes the findings from the three institutional case studies. The summary of the findings, conclusion, and policy implications for Texas' research universities are presented in Chapter 5, along with future research possibilities.

SUMMARY

Providing empirical research on factors that determine the ability of institutions to compete successfully for research funds is significant. It can enhance the awareness of best practices while providing governors, legislators, institutional, and higher education leaders with the requirements for building competitive research institutions. Initiatives that increase the probability of success should be identified so that the capable

institutions can then attempt to acquire research grants, top faculty, and the best students. Conversely, reducing futile efforts of the many institutions unable to be competitive is desirable as over 80% of federal research dollars are awarded to fewer than 100 institutions (Stahler and Tash, 1992; Arnone, 2003). Many institutions can perform research, but few have the reputation of expertise and excellence to obtain large amounts of federal funding. Supporting too many institutions has negative policy implications. Limited resources are ineffective when spread too thin. National rank confers bragging rights; more importantly, it bestows enhanced stature and national recognition that attract the best faculty who actively advance an institution's teaching and research effectiveness (Geiger, 1993). In addition, the state or region benefits from the economic development through the institution's graduates, research, and programs.

Understanding the factors that contribute to competitiveness should help institutional and government leaders make the appropriate decisions regarding an institution's potential for successful national competition for research dollars. The results of this study are intended to provide important strategic information for those institutions capable of performing research that matches prevailing funding sources. From the literature review, eight factors (strategies, organizational structure, processes, people, financial support, rewards or incentives, research capacity, and politics) were identified as influencing research competitiveness. The researcher hypothesizes that differences between more competitive and less competitive research institutions can best be described in terms of internal characteristics. The successful practices identified from the study may confirm or advance existing organizational theories. Understanding the

contributions of others in this field was important in framing this study. The following chapter reviews the literature.

Chapter 2. Literature Review and Conceptual Framework

Higher education has seen an increased emphasis on research and intensified competition for federal research dollars during periods of expanded federal research opportunities. Recent studies, although limited in number, have examined individual, departmental, and institutional attributes as the determinants for research productivity. Faculty competence and quality, leadership, and financial resources have been recognized as important factors (Dundar and Lewis, 1998). Although many institutions possess these attributes, fewer than 100 research institutions are highly competitive and productive in terms of federal research grants awarded. These top 100 institutions generally remain the major competitors as they continue to receive over 80% of all federal R&D obligations directed to colleges and universities (McCoy *et al*, 1982; Stahler and Tash, 1992).

Only a small body of literature has studied the increased emphasis in research and the specific reasons behind an institution's ability to be ranked in the top 100 or the more elite top 50. A convincing explanation is that the more competitive institutions had the autonomy to make the necessary internal adjustments including developing and executing strategies which matched federal research opportunities. Thus, analyzing institutions in the top 100 could be beneficial in understanding how these major competitors are able to respond to external environments such as the federal government's research initiatives.

This chapter reviews the literature related to organizational development. Empirical research is scarce on the determinants of research productivity in higher education and on the internal factors that explain highly competitive institutions' effectiveness in performing research. Few studies have involved in-depth case studies. The current literature and conceptual frameworks deal primarily with for-profit organizations; nonetheless, that body of scholarship may help explain higher education's ability to compete successfully in the highly competitive federal research environment. The aim of this study is to focus attention on an issue that has not been addressed adequately in the literature: *what internal organizational factors determine an institution's top-ranked position in terms of federally financed R&D expenditures?*

A brief discussion follows on the difficulty of comparing and ranking institutions, and in measuring their research productivity. This researcher acknowledges the difficulty is due to classifications, labels, and descriptions of research universities, all of which change. The multiple terminologies, rankings, and descriptions in use today and in the past make historical comparisons and analysis problematic. Comparisons are made even more complex by the diversity of institution type, size, mission, etc.

WHAT TO MEASURE

Although much has been written about rank and classification, most scholarship debates how to define and measure success and status. Consequently, comparing performance and reputation of academic institutions becomes difficult because ranking perspectives are often vague, subjective, and open to debate. Yet, institutions have been

ranked and compared by programs, reputation, and academic mission for decades (Keniston, 1959; Cartter, 1966; Roose and Anderson, 1970; Jones *et al*, 1982; Webster, 1983; Geiger, 1986, 1993; Carnegie Foundation, 2000; Lombardi, 2000; Clarke, 2002; Gater, 2002). These measures (i.e., programs, reputation, academic mission) may be indicative of success in particular areas but are ineffective for the purposes of this study. In addition, none of these studies explored the factors which influenced ranking and performance. One popular magazine, *U.S. News and World Report* (U.S. N&WR), annually ranks America's best colleges and universities. Its methodology has been questioned and many of its rankings are subjective (Clarke, 2002). For example, in determining academic reputation, U.S. N&WR requests administrators, whose knowledge of other institutions may be limited or too biased toward their own institution or where they went to school, to rank other institutions' schools and programs (The Chronicle of Higher Education, 2001; Gater, 2002).

Another example, the Carnegie Foundation, a private higher education policy and research center, has classified higher education institutions since 1973 (Carnegie Foundation, 2000). Although not intended for ranking, the classification is frequently used as such. The classification has changed four times since its inception and a fifth change is imminent. At one point, the Carnegie classification categorized institutions by academic mission (research, doctoral, or medical). The classification of Research I and II institutions took into consideration federal research dollars awarded although the classification for Doctoral I and II institutions did not. Both Research and Doctoral institutions perform research but the Research I group is more research intensive and is

frequently considered the most prestigious (Carnegie Foundation, 2000; Lombardi, 2000).

The data collected in this study was better suited to compare and rank medical research universities but there are implications for other academic institutions competing for federal research support. The data comes from two NSF surveys completed annually for over 30 years (*Research and Development Expenditures at Universities and Colleges* and *Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions*). From these surveys, NSF ranks institutions according to the amount of federally financed R&D expenditures, federal obligations for science and engineering (S&E), and total R&D expenditures. These measures correlate directly with each institution's level of research activity. Furthermore, historical depth is achieved from the many years of reporting with little variation in the reporting methodology. Consequently, the data appear more accurate, objective, and reliable than other methods of ranking research activity.

The remaining literature review presents studies related to expanded markets and competition. Organizational theories follow as they are particularly important in analyzing what internal institutional factors facilitate effective research productivity. These theories factor in the human and institutional aspects that help explain why some institutions are more effective than others in acquiring federal research grants. Critical elements identified in the literature, e.g., leadership, management, structure, processes, and governance help define a broad concept: an organization's structure or design (Cohen and March, 1974; Keller, 1983; Hardy *et al*, 1984; Karr and Kelley, 1996; Leslie

and Fretwell, 1996; MacTaggart, 1996; Rowley *et al*, 1997; Collins and Porras, 2002; Association for the Study of Higher Education, 2003). Cultural and open systems theories are meaningful to further understand the governance process (Lawrence and Lorsch, 1967; Barney, 1986; Armel, 1997).

FACTORS INFLUENCING RESEARCH PRODUCTIVITY

The literature has compared and ranked institutions to explain the factors that lead to successful research performance. Studies have rated an institution's ability to obtain federal funds by the quality of its graduate programs, faculty, and the number and quality of publications (Stahler and Tash, 1992). Others found that financial resources are a good predictor (Lombardi *et al*, 2002); although this can be misleading. For example, the top national research competitor, Johns Hopkins University, ranks 23rd in endowment assets whereas Harvard University has the richest endowment asset (Pulley, 2003). If financial resources alone were the determinant for research productivity, Harvard University would be ranked higher than its present 6th position in federally financed R&D expenditures, its 8th rank in federal obligations for S&E, or its 23rd position in total R&D expenditures. Hence, financial resources are not the only determinant of research performance; expanded markets and funding sources can be important determinants in explaining research productivity.

Expanded Market and Competition

An institution's rank within the top 100 is an indicator of its ability to compete successfully among research universities. Important information can be learned from these successful competitors by identifying those factors that differentiate them from other universities. More analysis is needed to confirm how these organizations perform cutting-edge research and to identify what specific internal organizational factors correlate with high levels of research activity.

Some studies contend that the top-ranked research universities maintain their positions for several obvious reasons. One, these universities have historical competitive advantages from prior federal research work, and, two, they enjoy the favorable halo effect that causes prevailing perceptions of their continued strength and performance regardless of whether they still exist (Cole and Cole, 1972; Keith and Babchuk, 1998). Geiger (1986, 1993) has focused on these more established prestigious institutions and has found minor variation in positions among the mature top institutions. His findings confirmed an earlier study noting that over time "a small number of academic institutions with a decided research mission conduct the bulk of academically sponsored R&D" (McCoy *et al*, 1982, p. 325-326). Geiger also affirmed that academic research centers and institutes played a major role in conducting and expanding research activity within major research universities (Stahler and Tash, 1994).

Similarly, Ellyson and Krueger (1980) also confirmed that the concentration of research for many years among the top ten research institutions left little room for new

entrants. These institutions received about 20% of federal research funding (NSF, 2002). The concentration is also noted among medical institutions. According to a study of the 125 U. S. medical institutions, Moy *et al* (2000) found the distribution of NIH research awards were concentrated among the top ten. In addition, the annual distribution showed little change among the top ten ranked medical institutions between 1986 and 1997. In these studies, only a few new institutions were able to enter successfully into federal research competition. As an economic side note, market conditions impact academic competition as they did other established leaders in nonacademic markets. In most mature industries (e.g., the banking and automotive industries) where leading businesses produce long-lasting and perceivable achievements, these leading businesses maintain their market share, competitive advantage, and positioning (Galbraith and Lawler, 1998).

More recent studies have observed an increased number of institutions capitalizing on the growth of federal research funding and the benefits of obtaining that research support. The increased availability of federal research funds has changed the distribution of funds among the "established, entrenched, and self-perpetuating network of elite universities" (Falcone, 2001, p. 554). More research universities exist than 50 years ago; this provides federal agencies more alternative choices in meeting their mission-driven goals (Selingo, 2002).

Graham and Diamond (1997) performed a historical analysis of 213 institutions identified by the Carnegie Foundation classification as Research or Doctoral institutions during the years 1945 to 1995. The results showed that 21 public and 11 private research universities challenged and in some cases displaced the historical elites. Graham and

Diamond found that these institutions' success was attributable to "a decentralized, pluralistic, and intensely competitive academic marketplace fueled by [the growth of] federal research dollars" (p. 2). To level the playing field among diverse institutions, the investigators used a per capita full-time instructional faculty measurement to compare federal awards and publication productivity. These measurements (strength of per capita numbers and publication output) can be distorted by different institutional reporting methods and more notably by some classified research projects being prohibited from publishing results. Additionally, publication output does not necessarily predict success in obtaining research funds.

Graham and Diamond (1997) defined four higher education system ingredients that lead to the building of successful research universities: a decentralized college and university system; a widening competitive market for students, faculty, and financial resources; a strong private university sector competing with diverse state systems (i.e., institutional pluralism); "and federal funding characterized by multiple agency sponsorship and peer review competition" (p. 200). More importantly, their findings are consistent with the findings of Geiger (1990) and Falcone (2001) that research opportunities have increased and that some of the historically non-established research universities have developed expertise in unique areas that aligned with funding sources.

ORGANIZATIONAL THEORIES

Prior to 1960, most organizational theories viewed organizations as closed, rational, systems models, i.e., organizations had fixed boundaries independent of

environmental factors (e.g., economic, political), were structured on internal dimensions (institutional goals and tasks), and were fully rational in decisions (Scott, 1981). The closed-systems model presumed that there was one best way of departmentalizing and structuring labor by tasks, and centralizing decisions and authority. Since 1960, researchers have questioned the closed-system models and developed the open-systems models. Open systems theorists recognize the important role environment has on an organization, making its boundaries permeable and its structure and decisions focused on "system survival" rather than efficient "goal attainment" (ibid, p. 409). The open-systems model accounts for institutions having to manage their daily affairs while simultaneously making the necessary changes to improve their capabilities to match an ever-changing environment.

Lawrence and Lorsch (1967) developed the Contingency Theory which focused on organizations as open systems (open to the demands of uncertain environments) that differ structurally in their response to environmental challenges and opportunities (cited in Johns, 1996). These researchers note the best way to organize is contingent on the nature of the environment and of the situational variables (e.g., strategies, resources) available at the time and that those institutions that make the best fit achieve the best adaptation. To summarize, competitive research-intensive institutions adapt to external and internal forces. Adaptation, Dill and Sporn (1995) argued, stresses the need for new forms and structures in the areas of governance, management, and leadership—a rational response to changing environments. Being able to adapt internal organizational features

to external environments is an important part of an institution's success at responding to new research opportunities.

Denison and Mishra (1995) assert that an organization's capacity to change and maintain flexibility is attributable to involvement and adaptability whereas its "capacity to remain stable and predictable over time" is attributable to consistency and mission (p. 216). Detroit Edison, one of the nation's leading utility companies, was one company they studied. The organization had well-defined authority, was controlled mainly by engineers, and experienced turbulence during the 1970s energy crisis. Denison and Mishra found Detroit Edison's internal consistency hindered its ability to adapt or to redefine its underlying mission. The positive aspect of the consistency concept is that it allows integration and coordination, but the negative aspect is that it is the most resistant to change and adaptation. To survive the changing external research environments, institutions must adapt, reallocate resources, restructure, and redesign to accomplish their goals (Tierney, 1999). Economic, cultural, and political pressures will continue to prompt adjustments in policies, procedures, and in ways of raising revenue and controlling spending (Stahler and Tash, 1992).

Open systems theorists find that organizations are like living systems open to the influence of their environments (Armel, 1997). From a systems perspective, organizations have many interrelated parts. Armel argues that performing at higher levels requires change and improvements to the system's arrangements (organizational design) but also "in the way the organization relates to its external environment" (p. 32).

Organizations and their interrelated parts have been described as loosely coupled systems (Weick, 1976). Loosely coupled means weak (or relatively absent) control, influence, coordination, or interaction among events, components, and processes (Pajak and Green, 2003). Research shows how loosely and/or tightly coupled properties (highly interdependent) within organizations serve appropriate purposes (Scott, 1981; Peters and Waterman, 1982; Pajak and Green, 2003). Lawrence and Lorsch (1967) argued that developing differentiated structures allows these interrelated parts (units or departments) to cope with specific environmental concerns with little disturbance to other organizational structures. For example, academic health centers have three missions: teaching (educate health professionals), research (conduct biomedical research), and service (deliver patient care). These different functional activities require different kinds of task organizations (Wilson and McLaughlin, 1984). Patient care and teaching are two activities that require consistency, stability, and standard curriculum and care guidelines that are predictable over time. These two activities would be indicative of well-integrated systems (i.e., tightly coupled) that have little room for discretion, autonomy, and innovation. On the other hand, research activities need loosely-coupled systems to encourage autonomy, creativity, and innovation in response to dynamic environments.

Stahler and Tash (1994) examined the role of academic research units at the fastest growing research universities in the top 150 as measured by federal R&D expenditures in 1983 and in 1990 to determine what effect academic research units had on their universities. Research units (or centers) were structured to allow institutions the flexibility and agility to respond to external research provider interests. Consistent with

Geiger's (1993) findings, Stahler and Tash confirmed the reason for these universities increased research and enhanced reputations was having research units; the units focused research on engineering, physical sciences, and medicine. The results also confirmed Gardiner's earlier work (1985) that research centers at University of California Berkeley, Harvard, Massachusetts Institute of Technology, and Stanford "encouraged interdisciplinary collaboration and increased research productivity and quality" (cited in Stahler and Tash, 1994, p. 549). The primary purpose for these large centers was to perform research and attract external funding. The centers had full-time support staff, the ability to respond in ways that faculty members not associated with centers would not have, and most importantly were "credible to funders in terms of [their] access to resources, appropriate researchers, university administrative support, and consistency with the university's mission and status" (ibid, p. 551).

Scott (1987) went further and described a Strategic Contingency Theory with multiple actors whose differing interests, motives, and powers provide opportunities for alliances (cited in Dill and Sporn, 1995). In responding to external funding sources, institutions perceived as coalitions have had to move from performing independent, basic research to interdisciplinary, mission-driven research involving many players, different institutions and campuses. This was necessary to build the alliances to accomplish the goals of the funding agency. Whether developing differentiated structures or building coalitions, institutions are making deliberate choices to adapt and change in response to expanded research opportunities and increased competition.

Institutional Factors

Institutional dimensions have been linked to organizations effectively producing research and responding to their external environments. Ellyson and Krueger (1980) randomly selected 60 research universities from the top 200 in terms of federal research funding to identify what institutional characteristics predicted their increased federal funds. Their quantitative study collected data for 38 public and 22 private institutions for fiscal year 1975. The public institutions' predictor was internal research funds; for private institutions, it was the awarding of doctoral degrees; both internal reasons. The study's statistical data did not provide enough richness or in-depth information to explain cause-and-effect relationships.

Krohn (1992), Stahler and Tash (1992), and Diamond (2000) also identified institutional factors new competitors developed to increase their research capacity within particular research environments. Krohn (1992) analyzed 106 institutions over a 12-year period (1974 to 1986) and found 29 advancing research universities whose research market percentage and engineering capabilities increased during expanded opportunities funded by DoD, industry, and by the institutions themselves. Krohn's analyses of Georgia Institute of Technology, Rensselaer Polytechnic Institute, and Virginia Polytechnic Institute and State University identified five successful actions (two initiating and three sustaining strategies) that facilitated their advancement:

- Developing a research mission,
- Building the faculty,
- Accommodating the mission,

- Securing funding, and
- Conducting research in expanding fields.

Stahler and Tash (1992) conducted an exploratory study to examine the role of institutional factors for the rapid research funding growth during the 1980s. Their work evaluated 30 institutions ranked in the top 150 in 1990 and compared their rank to that of 1983 according to total R&D expenditures. The most important factors identified were:

- Research support by top academic administrators through policies,
- Expanded facilities and new equipment, and
- New faculty hire packages in selected fields.

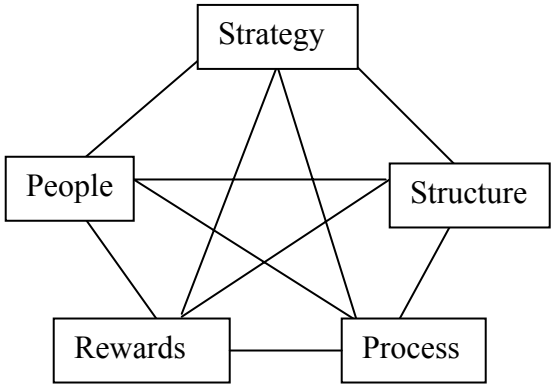
In a small quantitative study, Diamond (2000) identified the factors attributable to the research success of the University of California-Santa Barbara, Brandeis University, and Emory University as "…successful

- Exploitation of geographical advantages,
- Dedication to a research mission,
- Acquisition of a critical number of talented research faculty,
- Research agenda that matched federal funding priorities, and
- Appropriate research infrastructure" (p. 434).

Altogether, these studies showed institutions adapting and making decisions to support research missions that responded to their external environments.

Galbraith (1977, 2000) has studied organizations for decades; he developed the Star Model (Figure 1) to depict five key elements of an organization's design, i.e., how an organization is formed: strategy, structure, processes, rewards, and people.

Figure 1. The Star Model



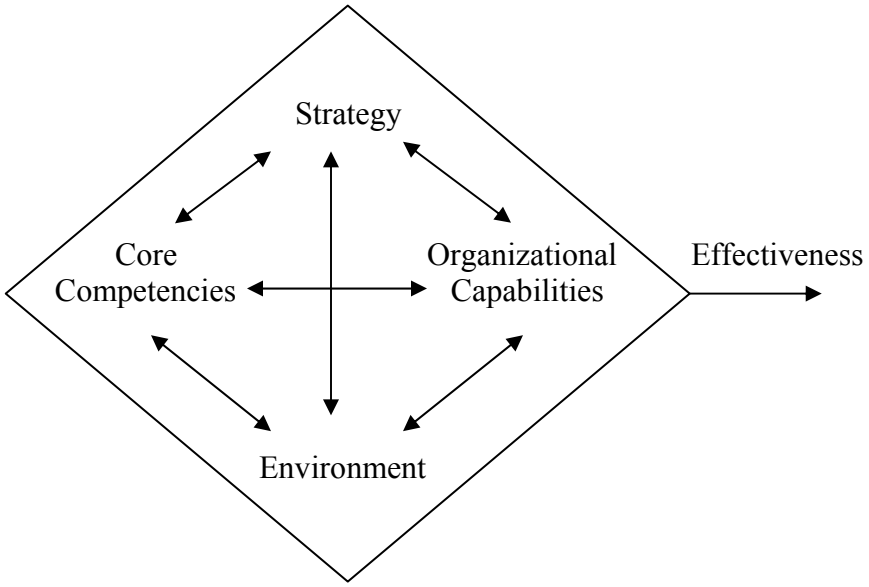
Source: Galbraith (2000), p. 10.

As Galbraith (2000) maintained, "Different strategies require different configurations of structure, processes, rewards, and people practices" (p. 10). In his Star Model, each element appears equally important. Schuster *et al* (1994) confirmed the importance that people have on developing and implementing processes, strategies, and structures that move an organization towards its goals (cited in Kezar and Eckel, 2004). To be successful, a research institution must to flexible and must develop research areas that are funded by external sources. As Buck (1971) and others have asserted, "The most important property of an organization is responsiveness," i.e., the ability to change because of shifting environments (p. 168).

More recent organizational designs focus on core competencies and capabilities as determinants of effective, competitive organizations (Mohrman *et al*, 1998). Galbraith and Lawler (1998) constructed the Diamond Model (Figure 2) which identifies four

elements (strategy, core competencies, organizational capabilities, and environment) that when aligned create effective organizations. In this model, Galbraith and Lawler stress the importance strategy plays in responding to the environment in which the organization operates. To design, develop, and implement the effective organization, they argued, the business strategy must match the environment. Once the strategy has been defined, the core competencies and organizational capabilities must be identified and developed to match the strategy.

Figure 2. The Diamond Model



Source: Galbraith and Lawler (1998), p. 6.

For example, if an institution chooses a strategy to respond to a federal research initiative, then the institution must identify that it has, or can develop, the core competencies and organizational capabilities to match the federal research initiative.

Otherwise, the institution will not be effective in its strategy. Core competencies are attributable to individual and institutional skills and technical expertise, i.e., "an organization's technical knowledge and its intellectual capital" (ibid, p. 6). An identifiable area of research expertise is a core competency; examples include "miniaturization at Sony…or logistics at Wal Mart" (Finegold, 1998, p. 239). Competencies can give an institution its competitive advantage. This model highlights the importance of people to performance and linking "individual competencies…to desired organizational capabilities" (ibid). The importance of individual competencies was also noted by Fitz-enz (1993) who commented that high performance "is the result of vision, aspirations, and skills of individuals" (cited in Doerfel and Ruben, 2002, p. 10).

In both models (Star and Diamond), a good fit between the elements is required to develop a more competitive institution; therefore, when one element in the model changes, other elements must change to ensure effectiveness. For example, any federal agency R&D budget that changes dramatically creates a volatile *environment* for those supported institutions. A defined *strategy* must address the current environment which could see an increase in defense research and concurrently a decrease in biomedical research. The four elements (*people, structure, process, rewards*) must align with the organization's strategy or the organization will not be effective. These four elements create the *organizational capabilities* and *core competencies*. Galbraith and Lawler (1998) argued that competitive institutions are successful because these institutions intentionally design a competitive advantage that distinguishes them from others.

Institutional factors seem to predict the effectiveness of an institution in its ability to successfully compete for federal research support. As a side note, the NIH R&D budget for biomedical research has seen uninterrupted growth since 1965. Such expansionary periods would appear to benefit all NIH recipients. However, Graham and Diamond (1997) identified several public institutions without medical schools (i.e., the University of Illinois and the University of Texas at Austin) that experienced a decrease in their NIH support. Whether these specific institutions were unable to obtain a good fit between the elements and adapt and capitalize on this funding growth is worthy of specific research but is not in this study's scope.

Governance

According to Kennedy (1993), governance is "the organizational context that directs how choices are made, and who makes them" (p. 127). In understanding governance, scholars have focused on "the line of authority, roles, procedures, and bodies responsible for decision making" (Kezar and Eckel, 2004, p. 375). Academic institutions must respond, make decisions, and act through various multi-level bodies (i.e., state boards, board of trustees, administration, faculty senates, and student government), with each body having its own different role. Kezar and Eckel (2004) emphasized the importance of governance in higher education as a crucial internal process of policymaking and macro-level decision making. Institutions make choices when establishing policies, setting resource priorities, selecting the next program or research initiative, and negotiating for space and facilities.

Scholars have tried to understand governance for over 40 years. The early focus was on centralized decision making at small, similar campuses with low-stake constituents (trustees, administration, and faculty). Some argued that shared governance hindered an institution's flexibility and agility. Others (Berdahl, 1991; Birnbaum, 1991) have argued that the overlap of authority and roles (dual systems) helped streamline the governance process and accommodate different faculty and administrator perspectives (Kezar and Eckel, 2004). Less scholarship on governance has been reported of late and this may be due to the complexity of current academic structures, the role governance plays at each campus, or with its historical role within institutions. The current focus is on decentralized decision making at big, complex, multi-layered, campuses with many high-stake constituents (ibid).

Weick (1976) developed the concept of coupled systems (loose or tight) and maintained that higher education institutions that balanced decentralized and centralized authority and governance structures were able to adapt and respond to the environment. Weick argued as did Mintzberg (1979) and Birnbaum (1988) that loose coupling allows decentralized decision-making structures (i.e., professional bureaucracies or faculty) their needed autonomy, allowing for innovation and flexibility. However, these structures were slower and their processes less efficient. Kerr (1963) and others argued that these multi-layered structures facilitate an institution's ability to be flexible and to act quickly since the separate parts can function "with little effect on the whole" (cited in Kezar and Eckel, 2004, p. 376). Mallon (2004) further asserts that "suburbs" of the university (i.e., research centers and institutes) have changed the traditional governance to a more

disjointed governance; through these "adaptive units [the university is able] to stay in tune with its environment and to be more responsive to external pressures without having to change, or even engage, its core" (p. 70).

Organizational Culture

An organization's culture is expressed in its beliefs, core values, assumptions, and symbols which are widely shared and understood by its members. This expression is often thought of as the organization's personality (Association for the Study of Higher Education, 2003). Peters and Waterman (1982), Barney (1986), Denison and Mishra (1995), and Juechter *et al*, (1998) have examined the relationship of culture to an organization's effectiveness and whether culture influences governance. Many of these same scholars have argued that a unique culture which encourages creativity, adaptability, high levels of involvement and participation, risk taking, and innovation provides research institutions their sustainable competitive advantage.

Many interrelated organizational parts drive performance. For example, most management concepts are embedded within an organization's culture. Some management practices aim to make operations more efficient and have endured whereas other concepts have not had such success (Keller, 1983; Hardy *et al*, 1984; Gumport, 1993; Karr and Kelley, 1996; Leslie and Fretwell, 1996; MacTaggart, 1996; Massy, 1996; Myers, 1996; and Rowley *et al*, 1997). Management restructures processes to balance an organization's mission to its resources, to improve programs, service delivery and quality, and to save costs (Kaiser, 1992). Two enduring concepts, total quality

management and reengineering, address specific areas of improvement. Total quality management (TQM) attempts to achieve continuous quality improvement in an organization's products and services, whereas reengineering seeks to radically redesign an organization's processes (Johns, 1996). Open systems theorists maintain that these management practices are attempts to better align an organization's internal structure to its environment in hopes of increasing its survival against competition (Scott, 1981).

Many of these management practices address symbolic, short-term solutions but have not addressed comprehensive, proactive management strategies (Cohen and March, 1974; Keller, 1983). Research shows, however, that it is not so much the specific practice behind an organization's success as it is the emphasis the organization places on the underlying "quality" philosophy. In other words, it is not any one specific practice such as TQM but the commitment to the philosophy; the organization learns how to do it, how to do it right, and how to be the best (Doerfel and Ruben, 2002). These tightly held beliefs or core values become well-integrated within the organization for consistency, stability, and predictability over time (Denison and Mishra, 1995). In being proactive, management acts and takes the initiative with rigid central directives (tight properties) but allows for decentralized structures (loose properties) that can anticipate and plan responses to events rather than having to react spontaneously. Frequently, an institution's culture determines and impacts management's overall, long-term effectiveness.

Behaviors (i.e., policies, processes, management, restructuring practices, strategic planning, and resource allocation) are embedded within an institution's culture (Alpert, 1985; Kaiser, 1992; Gumport, 1993; and Myers, 1996). Dundar and Lewis (1998) found

involvement and participation (cultural traits) linked to an organization's effectiveness. Often, faculty members work independently; this autonomy gives them a strong sense of ownership and responsibility that has prevailed in the academic culture for decades. Denison and Mishra (1995) examined four cultural traits (Table 4)—involvement, consistency, adaptability, and mission—and found these characteristics "useful predictors of performance and effectiveness" (p. 204). Involvement and consistency focus on the internal integration whereas adaptability and mission focus on external adaptation (or orientation). The positive aspect of consistency is that it allows integration and coordination, but the negative aspect of consistency is that it is the most resistant to change and adaptation. Integrating two companies with strong cultures often is very difficult as each company wants to retain its own core values, beliefs, and behaviors.

Table 4. Theoretical Model of Culture Traits

	Change, Flexibility, Growth	Stability & Direction
External Orientation (adaptation)	Adaptability	Mission
Internal Integration	Involvement	Consistency

Source: Denison and Mishra (1995), p. 216.

Are the cultures of leading organizations unique? Collins and Porras (2002) examined 18 long-standing, outstanding for-profit service and industrial companies and compared each to one of their top competitors. In their six-year research project, Collins and Porras identified two key concepts behind visionary companies: (1) preserve the organization's core values and purpose (primary reason for being) and (2) stimulate progress (new ideas and innovation) to ensure a competitive advantage over others. These companies were long-term successes because they were built on a solid foundation (core values and purpose) and then ensured the foundation was preserved. To ensure their longevity and vitality, the companies had to make certain they were strategically aligned to encourage progress. People were important for progress, but are only part of the success. People tend to come and go. In doing so, they leave their mark on a company. It is the combined strength of these two concepts and peoples' added contributions that make companies successful for long periods of time. Collins and Porras used the terms "architect" and "clock builder" for effective leaders, terms analogous to building and creating effective organizations. Their motto would be "Design it (i.e., the organization) built to last."

Collins and Porras' concepts suggest that long-term management strategies shape the cultures that transcend any leaders who may have created and influenced them. Being strategically aligned to encourage progress for a research institution means having a culture that establishes and nurtures its people, commits to and provides a vibrant, growing research organization, remains attentive to new growth areas, and ensures its people have the best research-oriented colleagues.

SUMMARY

These theories and concepts collectively provide the principal framework for this study. Though little has been written about institutional factors that facilitate leading research universities' national rank, such factors are presented more as the causes for success. Particular factors (strategies, organizational structure, processes, people, financial support, rewards or incentives, research capacity, and politics) were mentioned in the literature review as the most identified topics or subject areas in organizational theory (Ellyson and Krueger, 1980; Geiger, 1986, 1993; Kotter and Heskett, 1992; Stahler and Tash, 1992; Galbraith, 1977, 2000; Graham and Diamond, 1997; Dunbar and Lewis, 1998; Galbraith and Lawler, 1998; Diamond, 2000; Falcone, 2001; Lombardi *et al*, 2002). The list is not exhaustive. Yet, these organizational factors along with any other factors that emerged during the interview phase of the study helped establish what occurred and what management features facilitated successful research competition at the three case study institutions analyzed. This study tested the hypothesis that institutional factors explain the difference in research rankings between two groups, more and less competitive institutions. The institutional research performance was based on rank in federally financed R&D expenditures in 2000 which measured research activity in dollars. The following chapter explains the research methodology (the methods and approaches) developed to examine the role institutional factors play in explaining the success of top-ranked research institutions.

Chapter 3. Research Methodology

As more institutions want to know if they are capable of successfully competing in the national research market, the attributes of success must be understood. This study was designed to identify factors that distinguish the more competitive institutions from the less competitive as defined by their rank in federally financed R&D expenditures. To perform the necessary research, methodologies must be identified, justified, and verified.

METHOD SELECTION

The literature comparing institutional research performance and identifying the factors associated with such performance is heavily weighted on quantitative issues that focus on financial assets, expenditures, and federal funds dispersion. Quantitative and qualitative research methods differ, with each having its own benefits and limitations. Quantitative research involves controlling the variables studied so as to measure and identify cause-and-effect relationships (Morgan and Smircich, 1980; Denzin and Lincoln, 2000). In contrast, qualitative research involves an interpretive, naturalistic approach that aids understanding and gives more depth and meaning to phenomena or events (Patton, 1990). This study documents institutional development over time and presents an in-depth analysis of how institutions are able to compete nationally. Qualitative approaches were determined to be more appropriate and were therefore used. Extensive statistical data were created to provide summaries and generalizations regarding trends with

endowment funds, faculty awards, total research expenditures, and other performance indicators and to determine whether any specific indicators played a role in institutional achievements.

Qualitative Research

Qualitative research has been criticized for its lack of scientific rigor but praised for its ability to capture and generate a wealth of rich and detailed information (Patton, 1990; Mays and Pope, 1995). Qualitative research as Patton (1990) and others have pointed out refers to collecting, organizing, and analyzing text, or non-numerical data. This study aimed to bring understanding to the internal factors that distinguish nationally competitive research institutions, defined as those in the top 50 in federally financed R&D expenditures, from the less competitively ranked in positions 51 or lower. A theoretical orientation within qualitative research is a systems perspective and systems theory (Patton, 1990). This framework focuses on systems and "viewing things as whole entities" (ibid, p. 78). This systems study presents a holistic portrayal of three Texas medical institutions and raises the question: How and why does an institution as a whole achieve the research levels that it does?

STUDY DESIGN

An institutional analysis involves organizing data by specific institutions to provide the most information-rich cases. The NSF Division of Science Resources Studies assembles data annually through two surveys: (1) *Research and Development*

Expenditures at Universities and Colleges and (2) *Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions*. These data were the primary source used to rank institutions and to distinguish the major competitors for federal funding from others. The first survey provides the data for two tables that are published in an annual report entitled *Academic Research and Development Expenditures*. These two tables rank universities and colleges by (1) *federally financed R&D expenditures* and (2) *total R&D expenditures*; both are reported by institutions. Expenditures are the funds disbursed during the institution's fiscal year (FY). Twenty eight years (1972-2000) of survey data were accessible to the researcher. The detailed statistical tables for the FY 2000 report and previous years' reports can be viewed on the NSF Web site: http://www.nsf.gov/sbe/srs/nsf02308/start.htm.

The second survey (reported annually by NSF under the same title as the survey) provides the ranking data on federal *obligations* for S&E as reported from 18 federal agencies (FY 2000 is provided in Appendix C, pp. 139-142). Obligations represent placed orders, awarded contracts, received services, and placed transactions during the federal fiscal year regardless of when funds were appropriated or spent, or when payments were received. The researcher was able to access 29 years (1971-2000) from this source. Most of this study focuses on a 25 year period (1975-2000) and reports most quantitative data in 5-year increments for simplicity; yet a longer period (1971 to 2000) of federal support data and other data was collected and examined to explain any anomalies. The federal survey data and subsequent reports were also accessed through NSF's sponsored Web Computer-Aided Science Policy Analysis and Research

(WebCASPAR) database system

(http://caspar.nsf.gov/includes/checkJavascriptAbility2.jsp).

Unit of Analysis

This study focused on competitive institutions with an emphasis on federally supported medical research. Purposeful sampling is a qualitative research strategy that allows for selecting the appropriate unit of analysis (Patton, 1990). The selected units are those from which the most can be learned about central issues important to the study, i.e., selecting information-rich cases for in-depth analysis. One purposeful sampling strategy is homogenous sampling. Homogeneous samples allow the researcher to select a similar sample (whether people, programs, or institutions) with similar backgrounds and experiences (ibid). The homogeneous sample facilitates comparing institutions with comparable characteristics for the purposes of determining how organizational factors facilitated their competition for federal research funds. Instead of random sampling, a systematic, non-probability sampling identifies specific institutional groups which possess the same characteristics relevant to the phenomena being studied (Mays and Pope, 1995). After the expenditure and obligation data on the 100 top ranked institutions in 2000 were examined, six Texas medical institutions stood out for further analysis. Table 5 lists the six institutions with their respective rankings according to the NSF annual survey data.

Table 5. The Rank of the Six Texas Medical Institutions' Federal Research & Development Expenditures and Obligations for Science & Engineering, and Total Research & Development Expenditures

Institution	Federally financed R&D expenditures		Federal obligations for S&E		Total R&D expenditures	
Year	1972	2000	1971	2000	1972	2000
Baylor College of Medicine	49	25	51	24	65	24
U. T. Southwestern Medical Center at Dallas	103	48	68	47	116	52
UTMB	117	90	124	89	119	98
U. T. Health Science Center at Houston	236	71	80	71	274	87
U. T. Health Science Center at San Antonio	179	84	165	79	185	95
U. T. M. D. Anderson Cancer Center	73	67	323	66	77	56

Sources: National Science Foundation, Survey of Federal S&E Support to Universities, Colleges, and Nonprofit Institutions and Survey of R&D Expenditures at Universities and Colleges

Notes: Federally financed research and development (R&D) expenditures: all federal funds expended for research and development activities in S&E. Data available 1972-2000. Federal obligations for Science and Engineering (S&E): actual obligations made during the designated fiscal year regardless of when funds were authorized for, received by, or spent by a recipient. Excluded are loans, agency support of Federal employee training and development, and indirect support of funds allocated to state agencies even though such funds are destined for use by an academic institution. Data available 1971-2000. Total R&D expenditures: all funds expended (federal, state & local, industry, institutional, and other sources) for R&D in S&E. Data available 1972-2000.

In this study, the characteristic was highly competitive institutions as defined by federally financed R&D expenditures rank. It was necessary to eliminate M. D. Anderson from the study because it does not confer the M.D. degree nor is its structure or mission similar to the other five institutions. Three institutions (BCM, UT Southwestern, and UTMB) were intentionally selected for in-depth case studies. Several reasons justified the selection and review of these particular medical institutions. First, they have ascended because of NIH funding. Second, two of these institutions (BCM and UT Southwestern) rank in the top 50 in federal R&D expenditures and are, respectively,

private and public institutions. They were classified in this study as the more competitive institutions in 2000, being ranked 25th and 48th, respectively. Additionally, these two institutions have different governance structures which can be examined as well.

The three remaining institutions were classified in this study as less competitive institutions. All three are public institutions and have the same UT System Board of Regents governance structure. With such similar characteristics, only one was selected for a comprehensive, in-depth case study. While the Health Science Centers at Houston and San Antonio were ranked higher, UTMB was selected because it appeared that more could be learned from this one institution. UTMB is the oldest Texas medical institution, has the longest research exposure, yet ranked the lowest not only in federally financed R&D expenditures but also federal obligations for S&E and total R&D expenditures.

Case Studies

Case studies are valuable qualitative, descriptive research methods used to capture similarities and differences over a particular time period (Patton, 1990; Mays and Pope, 1995). Patton, Yin (1981) and others agree the case study "is a systematic research tool" that facilitates collecting, organizing, and analyzing data (p. 58). Case studies help examine, understand, and present detailed information about an institution's development over time, where the focus is how and why organizations succeed (Keen and Packwood, 1995). The studies were constructed from multiple sources which included extensive quantitative data, interviews, and historical institutional data.

The researcher wanted to determine what internal organizational factors correlate with the ability of two groups, leading and less competitive institutions, to compete nationally. This objective set the stage for selecting the units of analyses and the participants to be interviewed, and in determining what data were collected, coded, and then analyzed (Glaser and Strauss, 1967). Factors that had been identified in the literature review were used to structure the case studies, but there was no mindset that these factors should be the only focus. Emerging characteristics or patterns were identified to explain what distinguished one institution from another. Each institutional case study included all the information collected from documentary data and interviews.

Data Collection

Historical documents (origins, research reports, journal articles, and other related publications and print media covering higher education, academic health centers, and the specific institutions) were collected for each institution to aid the analysis of research development over time. This data was examined to validate or refute the study's quantitative and qualitative findings.

A quantitative data source was used that provided some aspects of performance: the annual report from The University of Florida Lombardi Program on Measuring University Performance entitled *The Top American Research Universities* (Lombardi *et al*, 2002). This report enumerates nine quantifiable performance indicators for ranking universities:

- total research expenditures,

- federal research expenditures,
- endowment assets,
- annual giving,
- faculty members in the National Academies,
- faculty awards,
- doctoral degrees,
- postdoctoral appointees, and
- entering freshman Scholastic Aptitude Test (SAT) scores.*

*The Medical College Admission Test (MCAT) scores (more germane to the study) were preferred.

These quantifiable indicators depict only organizational attributes and were used as boundaries to collect data for the three case institutions in this study. The researcher used the Lombardi indicators to observe, for example, whether faculty awards or MCAT scores increased over the research period and whether any of these performance measurements played any role in an institution's achievements; if so, why and how?

Several other data sources were valuable in examining each institution's research development. The primary NSF surveys and reports mentioned previously (see Study Design, p. 45) were used to identify the top 100 institutions for federal funding and were also used to collect quantitative data on the three Texas medical institutions selected for in-depth case studies (see Appendix D, pp. 143-144). The NIH Office of Extramural Research provides information on its Web site about NIH extramural research (http://grants1.nih.gov/grants/award/awardtr.htm#c). The *Current NIH Trends Award Data* site provides the research support and ranking to medical schools from 1970 to 2000. Another resource was an annual institutional profile report co-sponsored by the

Association of American Medical Colleges and the American Medical Association (http://www.aamc.org/data/msps/start.htm). The Medical School Profile System is a database and reporting system that the Liaison Committee on Medical Education assembles data through two medical school questionnaires. These questionnaires request institutional information about revenues and expenditures, student financial aid, and operational characteristics of the educational program and allow medical schools to be compared in 36 measures and facilitated the quantitative comparisons in this study (Wilson and McLaughlin, 1984).

Interviews

Interviews are another qualitative method that allows differing views to be captured (Keen and Packwood, 1995). From the literature review and the data collection phase, eight institutional factors were identified and set the parameters for the researcher to prepare an interview guide. While the list below is not exhaustive, it encompasses eight of the most identified topics or subject areas in organizational theory (Kotter and Heskett, 1992; Stahler and Tash, 1992; Galbraith, 1977, 2000; Dunbar and Lewis, 1998; Galbraith and Lawler, 1998; Diamond, 2000; Falcone, 2001):

1. Strategies (concerted plans to achieve goals)
2. Organizational Structure (micro and macro)
3. Processes (institutional practices, procedures, policies)
4. People (Faculty [key characteristics], Students [graduate and postdoctoral], Others [particular leaders])
5. Financial Support (private, discretionary, endowment, other)
6. Rewards or Incentives (compensation or enticements)

7. Research Capacity (awards and expenditures)
8. Politics (governmental or internal organizational activities concerned with debate and creating and implementing policies, or, interrelationships regarding power or influence)

Analyzing these factors helped uncover what occurred at each institution and what management features facilitated successful competition.

An interview guide provides an outline of the questions or issues to be explored thus ensuring the same material is covered with a number of people (Patton, 1990). The draft interview guide was developed and structured according to the eight subject areas identified in the literature review. The questions and issues were developed based upon the purpose of the study, the literature, and the researcher's knowledge and experience in higher education. To check the guide's reliability and extent to which it would cover the issues, the researcher presented the guide to two top academic administrators, each very knowledgeable about the research enterprise, with one having extensive research university experience and the other having extensive health center experience. These two experts were asked to assess the eight factors and to provide perspective in what factors correlate with variations in levels of research funding. The interview outline was modified accordingly from their critiques. The final interview guide is included in Appendix E (pp. 145-146).

The interviews were meant to bring meaning to each factor and to identify other factors that might emerge. Each institution attempts to recruit distinguished faculty, though what matters is how the institution acquires and retains them. Once the quantitative data and other documents were collected and examined, the researcher

attempted to uncover any underlying institutional factors (e.g., strategies) that appeared to explain successful competition for federal research dollars. The study's final stage was conducting individual interviews to seek additional information and to validate data previously collected. The interview portion of the study included identifying the organizations' capabilities and competencies, and then examining how specific organizational elements (e.g., structure, people and processes) benefited the organizations. Conducting multiple interviews and using multiple data sources enabled the researcher to protect against biases while enhancing the reliability of findings (Mays and Pope, 1995).

In this study, interviews with key administrators and faculty who worked closely with the research operations helped capture their perspectives of how each institution developed its research capacity and competence over time. With the help of two prominent Texas academic healthcare administrators (both very knowledgeable of the federal research environment and with extensive academic health center careers), the researcher was able to identify and contact key administrators and faculty at each institution. The administrators and faculty had insight into the research issues as well as access to and understanding or familiarity of the institutional policies and practices in place during the period studied. Responses were likely to differ somewhat because of the differing positions and responsibilities of the faculty and administrators.

Nine interviewees, three at each institution, were contacted. Eight persons agreed to be interviewed; the list is provided in Appendix F (p. 147). One person did not agree to an interview because he felt his experience with the research operations and

institutional policies and practices had been limited. Eight interviews were conducted. Of the eight, seven were in person at the campuses and one was through electronic mail with a subsequent informal, personal contact that clarified the interviewee's responses. The interviews began in March 2004 and were completed by June 2004. Most interviews took one hour.

Patton (1990) and Pedhazur and Schmelkin (1991) have found that mixing the interview structure with open-ended questions, some fixed responses, and a few unstructured items increases the salience and relevance of the entire interview. The open-ended questions allowed the interviewees to express their own personal perceptions (Patton, 1990). Those perceptions were documented and then examined for patterns that contributed to the institutions' achievements. Other semi-structured questions sought specific developmental issues, i.e., Did particular governance structures facilitate prompt reactions to new opportunities (creating new biotechnology or nanotechnology programs) whether in response to shifting federal research priorities or other market-driven needs? Were any specific strategies concerning revenue sources, governance structures, leadership, and infrastructures implemented? Interviews were tape recorded and transcribed, and interviewees were assured anonymity.

The interviews helped identify factors that contributed significantly to competitive differences. In addition, they gave meaning to the factors that were derived during the data-collection phase. The interviews also provided understanding to the internal workings of each institution, the political atmosphere, the role and impact of governance, the role, direction, and issues of leadership, and, specifically, whether

particular leaders, policies and practices, or governance structures were distinguishing factors.

Data and Interview Analyses

The data were organized to test the hypothesis that institutional factors explain the difference in research rankings and to answer the following research questions:

Research Question 1: To what extent do leading and less competitive institutions of higher education differ in their ability to implement and execute successful research policies and practices?

Research Question 2: Do institutional factors explain the difference in research rankings for more and less competitive higher education institutions as measured by federally financed R&D expenditures?

Research Question 3: What particular factors make a difference in a higher education institution's ability to effectively execute its strategies or more effectively compete successfully for federal research funding than less competitive institutions?

Institutional operations were the unit of analysis so most findings, including the interviewee responses, were arranged by the eight internal organizational factors. Most of the quantitative data were organized chronologically for each institution and

constructed into tables to compare developments. Classifying the collected data in this manner facilitated the analysis of patterns and similarities across institutions.

Patton (1990) describes content analysis as the process of analyzing text to identify key concepts, patterns, similarities, and differences in the data. This systematic analysis was accomplished by repetitive review of the transcripts to highlight the most frequently cited or key responses and to identify possible relationships. The researcher searched for strategies such as whether an institution took advantage of an underrepresented geographic area that created opportunities (Brainard, 2002). Many scholars argue that it is the availability of institutional funding that allows research competition; though others would argue there is more to research competition than having institutional funds or possessing great faculty (Lombardi *et al*, 2002; Selingo, 2002). Lastly, the findings were examined to determine if existing organizational theories could explain the developments.

Interviews present difficulties, because people tend to have their own biases (assumptions, values, and attitudes) that are expressed and those biases may be inconsistent with other data collected (Patton, 1990). The researcher integrated and compared multiple sources (often referred to as triangulation) to minimize the bias effect and to enhance the validation and credibility processes. Denzin (1978) defined triangulation as "the combination of methodologies in the study of the same phenomenon" (cited in Jick, 1979). Keen and Packwood (1995) described the strategy as supporting all data items from at least another source and another data collection method. Historical institutional documents (origins, research reports, journal articles, and other

related publications and print media covering higher education, academic health centers, and the specific institutions) were examined to validate or refute the study's findings (Glaser, 1978). By using multiple data sources and collection methods, the researcher was able to minimize data problems such as inconsistencies in published data with that collected through other databases (NSF and NIH Web sites) and changes in reporting methods. Occasionally, funds are duplicated or left unreported so examining multiple reports enabled the researcher to eliminate inconsistencies or to explain why figures for specific periods differ among reports.

SUMMARY

This study used a qualitative research design combined with quantitative data (statistical) to complete in-depth, case studies on three Texas medical institutions. The studies entailed collecting historical data (financial, journal articles, other related publications, and performance indicators) from multiple sources and databases. The final stage of the study included conducting personal interviews to generate evidence to answer the research questions. Nine key administrators and faculty members, three from each institution, were identified and contacted for interviews; eight agreed to be interviewed. All the data collected were organized by eight substantive factors (strategies, organizational structure, processes, people, financial support, rewards or incentives, research capacity, and politics) identified during the literature review and data-collection phase that could impact research performance (Dunbar and Lewis, 1998; Galbraith, 2000). The data were analyzed for each institutional case study and then

cross-case analyzed to identify any patterns that contributed to the institutions' achievements. The results are described in the following chapter.

Chapter 4. Case Analyses and Findings

Qualitative methods were used to identify factors influencing research competition in three medical institutions located in Texas. Some quantitative (statistical) data were also employed to substantiate the findings of the internal organizational factors that facilitated successful competition for federal research dollars. To understand how these institutions operate, this study analyzed each institution's development over time. In-depth case studies were used to discover what highly competitive research institutions do that might explain their accomplishments. Institutions were identified and selected from two federal fund expenditure and support surveys collected annually for over 30 years by the Division of Science Resources Studies at NSF. From these surveys (*Research and Development Expenditures at Universities and Colleges* and *Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions*), NSF ranks institutions according to the amount of federally financed R&D expenditures, federal obligations for S&E, and total R&D expenditures.

Institutions were selected from the top 100 as measured by federally financed R&D expenditures for FY 2000. The top 100 institutions have for many years received about 80% of all federal funds allocated to academic research (Wolfle, 1978; Stahler and Tash, 1992). Of that 80%, the concentration is in the top 50 institutions (i.e., the top 50 expend roughly 57% of all federal funds) rather than the bottom 50 institutions (spending

23% of all federal funds). Because of this concentrated level of research activity, the top 100 institutions were divided into two groups. The first group included those institutions ranked in the top 50 as measured by federally financed R&D expenditures and defined hereinafter as the *leading* or *more competitive* institutions. The second group included those institutions ranked 51 or lower, defined hereinafter as the *less competitive* institutions. Institutions in each group were compared to identify differences and similarities in structures, strategies, and processes that might explain differences in research rankings. In addition to being in the top 100, institutions were selected based on two other conditions: (1) institutions had to be similar (i.e., medical schools) and (2) they had to be located in a single state. During a one-year study, data was compiled from interviews and documents to examine three medical institutions in Texas, two in the more competitive group (BCM and UT Southwestern) and one in the less competitive group (UTMB).

The institutional case studies were structured around eight factors identified in the literature that could potentially impact research competition (Ellyson and Krueger, 1980; Geiger, 1986, 1993; Kotter and Heskett, 1992; Stahler and Tash, 1992; Galbraith, 1977, 2000; Graham and Diamond, 1997; Dunbar and Lewis, 1998; Galbraith and Lawler, 1998; Diamond, 2000; Falcone, 2001; Lombardi *et al*, 2002):

1. Strategies (concerted plans to achieve goals)
2. Organizational Structure (micro and macro)
3. Processes (institutional practices, procedures, policies)
4. People (Faculty [key characteristics], Students [graduate and postdoctoral], Others [particular leaders])
5. Financial Support (private, discretionary, endowment, other)

6. Rewards or Incentives (compensation or enticements)
7. Research Capacity (awards and expenditures)
8. Politics (governmental or internal organizational activities concerned with debate and creating and implementing policies, or, interrelationships regarding power or influence)

While the list may not be exhaustive, it encompasses eight of the most identified topics or subject areas in organizational theory as revealed through the literature review (Dunbar and Lewis, 1998; Galbraith; 2000).

The goal of the in-depth case studies was to provide knowledge of the internal workings of each institution, particularly related to the internal factors that facilitated successful competition for federal research dollars. The studies required collecting and analyzing historical data including institutional documents (financial reports, journal articles, and other related publications) and performance indicators (e.g., total R&D expenditures and faculty awards). Nine performance indicators were identified in an annual report (entitled *The Top American Research Universities*) developed by The University of Florida Lombardi Program on Measuring University Performance (Lombardi *et al*, 2002). The indicators describe how a research university performs in each area, but they do not explain how the university was able to achieve that particular level. Structuring the data collection around the performance indicators and using qualitative analysis helped the researcher determine how and why each institution was able to perform at a particular research level.

Interview data were also part of the case studies. Eight interviews were conducted with key university administrators and faculty members familiar with the

institutions' day-to-day operations and research activities over time. Open-ended questions allowed spontaneity and for any other factors to emerge that might not have been considered by the researcher during the data collection phase and analysis prior to the interviews. The personal perceptions of individual interviewees from the three case study institutions were examined for factors and patterns that contributed to the institutions' development into nationally ranked research institutions. For ease of presenting the findings, the interview analysis will be discussed first, followed by the quantitative data analysis.

INTERVIEW ANALYSIS

The influence of institutional factors on an organization's ranking was examined during the interviews. During the cross-case analyses, differences and similarities between the more and less competitive institutions were identified. The results from the interviews indicate that of the eight factors identified from the literature search, three particular factors (people, processes, and research capacity) were important to facilitate successful competition for federal research dollars. An additional (ninth) factor, culture, was also identified as the most important factor to ensure the institution's success in adapting and aligning its strategies with the prevailing national research goals.

Four Significant Factors

Among the two groups (i.e., more and less competitive institutions), there were four key differentiating factors found in their ability to commit to and perform cutting-

edge research: people, processes, research capacity, and culture. During the interview analysis phase of this study, these four factors were repeatedly identified in the two highly competitive institutions (BCM and UT Southwestern, ranked in the top 50) and infrequently identified in the less competitive institution (UTMB, ranked in position 51-100) as critical to the institution's success in competing for federal research funds. These four critical factors influenced the more competitive institutions' success and effectiveness at pursuing and supporting research activities; the findings are described below.

People

People who possessed particular characteristics were found to be the primary drivers in ensuring that all other factors facilitated the research mission. These individuals were competent scientists and/or visionary leaders who had the desire, determination, and dedication to ensure that the research mission succeeded. At the more competitive institutions, effective leaders (administrators, deans, chairmen, and faculty) were found to be the force behind most major advances. The concepts and visions of these individuals were transformed into strategies that guided the institution's research mission. The institutions' missions then focused on and maintained cutting-edge research and on growing an invigorating research environment. Leaders, such as Drs. DeBakey (President, BCM) and Seldin (Chairman, Department of Internal Medicine, UT Southwestern), made significant strides for their own departments, but, more importantly, their philosophies (or guiding principles) of academic and research excellence permeated

the institutions' atmospheres. Many leaders still speak in open admiration of both men and their accomplishments for their respective institutions. When asked about the brusque somewhat controversial Dr. Seldin, President Wildenthal (UT Southwestern) acknowledged, "as long as you're committed to excellence, you won't have any conflicts with [him]" (Kling, 1996).

Interviewees reported that these leaders ensured that their governing boards and legislative representatives were enlightened and appreciated the importance research had for educational and institutional stature, and the value of investing in research. These leaders in turn recruited and retained more research-ambitious people with high performance standards (faculty and administrative levels). It was also noted by the interviewees that top quality departmental chairmen needed to possess two qualities: a heightened taste for excellence and extraordinary unselfishness. Incorporating such beliefs encourages research progress while tolerating behaviors of selfishness (i.e., a chairman concerned more for his own research rather than the entire department) was believed to stifle research growth. Interviews revealed that the more competitive institutions had great chairmen and leaders who possessed these qualities considered hard to find. In addition, most of the chairmen were active researchers themselves, an attribute that also promoted research growth among faculty. Furthermore, having a significant number of national and international leaders at one institution had a positive ripple effect (Wildenthal, 1996). These leaders attract competitive grants, distinguished faculty and rising stars, and better students (ibid). This synergy maintains momentum and allows the cycle to be repeated. The four active Nobel laureates at UT Southwestern

have produced substantial results in this regard. In a follow-up question to the importance and role of particular people, the researcher asked, "Can four Nobel laureates sustain UT Southwestern?" The respondent commented:

> *No, absolutely not. But what four Nobel laureates can do [is enhance our research]…Our research expenditures were about $35 million a year [1985] and they're now $300 million a year [2004]. [Having four Nobel laureates] allows you to recruit…outstanding [people] not only…in their labs but [who] want to be in the environment that that fosters, having that kind of potential interaction.*

From the cross-case analysis, it is clear that the more competitive institutions had a large number of prominent people with the passion, ambition, and reputation for excellence.

Processes

Processes at the more competitive institutions created and maintained an effective structural form and continually streamlined administrative processes to facilitate research. The processes and infrastructures were described as being flexible and not constrained by rules. The institutions were described as encouraging collaboration, sharing of resources, and performing multidisciplinary work among colleagues. Most important was the description that the institution at all levels confirmed and maintained its commitment to research as noted by the resources and support given to research.

The administration was described as continually encouraging improvements in processes, infrastructures, and communications to ensure that administrative matters were not obstacles to preclude the university from accomplishing its research goals. The

administration was described as a service provider to the research enterprise. As described in one interview:

> *You have to have departmental administrators that support the department. Those [administrative offices] can easily turn into regulatory adversarial programs and your grants and contracts sponsored research people can be adversarial with the faculty. That is a kiss of death. It's…critically important that all…who have any contact with the research enterprise understand that their job is to support the enterprise and not to impede it.*

Another interviewee noted:

> *Very important is to foster as open a process and as flexible as possible processes to facilitate interactions between the various elements of the institution and especially within the research community…You have to have supportive systems and we have gradually grown a…substantial supportive system.*

In the more competitive institutions, the administration's primary role was to create, facilitate, and unify organizational structures (administrative, research and academic units) in their service to each other. In describing processes, several interviewees viewed their organizations' design as an:

> *Incredibly streamlined administrative structure…[the processes are] very, very streamlined and that hasn't changed in 20 years.*

Going further, this same interviewee added:

> *We really do work hard to try and to streamline things and make these processes work better. If they don't work well, they just slow things down. They frustrate people.*

A second interviewee described it another way:

> *There are lots of ways a repressive financial organization can stifle research…put rigid constraints on grants so that people are not allowed to spend in the next year of a grant so they have two months on nothing and then they lose their staff. We don't let it happen.*

In summary, the more competitive institutions' accounting, purchasing, and human resources processes were streamlined and aligned to support research.

A repeated management process identified in the interviews was the practice of nurturing young investigators and helping the recruits become distinguished faculty. Whether providing limited seed money or employing faculty mentors, the more competitive institutions nurtured young investigators and gave them opportunities to display their capabilities. It was described by one interviewee as:

> *[Baylor College of Medicine] is in the position of providing investment funds to establish people.*

This management practice was also illustrated through processes which reduced teaching and administrative burdens so new recruits had time to establish themselves.

Similarities at the more competitive institutions were also noted in the decisions made (i.e., governance processes) to continually facilitate the research enterprise. This

was observed by departments continually servicing and working to simplify and expedite the processing time for the research activities including the reviews for research proposals with human participants. One interviewee stated:

> *The Institutional Review Boards…accumulate a lot of paperwork but in fact…are a very important thing and this place has gotten pretty good at managing them.*

The processes at the more competitive institutions encouraged and maintained high standards, both in performance and in recruiting the best faculty, students, and staff. High standards included having strong qualifications and impressive records both in writing and receiving grants, and in conducting million dollar research projects.

At the more competitive institutions, the administrations were decentralized which shifted decisions from the top down to the department chairmen and faculty. This autonomy facilitated the department's ability to accomplish goals. Departmental chairs were allowed to shape policy and to implement initiatives to develop various programs essential to the institution's success (e.g., enhance the basic or clinical sciences when an area was weak). Such actions were not dictated by central administration but came from the departments advocating the research. Upper administration supported the departments essential to the institution's success and ensured that a good program or person progressed.

In contrast, the less competitive institution often struggled to streamline its processes. One interviewee spoke of the need to update its outdated, inadequate, and incompatible systems. Because of antiquated processes, the institution was often unable to obtain essential data to aid the decision-making processes. For example, UTMB's

accounting software did not match grants management software so that awarded grants were not set up accurately. In this case, the faculty could not get access to contract money to hire people or to buy equipment because no one had the information to set up accounts. In addition, the administrative and research infrastructures had breakdowns in communicating and working together. One interviewee described the breakdown with a sports analogy:

> *Service organizations may be doing some of the grunt work; they may be doing the blocking and the tackling. But if you don't have that [infrastructure] effectively there, then your fastest running backs are going to go nowhere.*

In other words, the processes were not integrated to best serve the institution and its research progress was slowed.

Research Capacity

Research capacity was a key factor in the more competitive institutions' abilities to successfully respond and adapt their research activities to federal funding sources. The ability to perform research (research capacity) is based on both individual and institutional capabilities and core competencies. There were several ingredients to research capacity. The first ingredient included those specific people described earlier in the People section (see p. 64). The role people play in the more competitive institutions' abilities to perform research was noted in several interviews:

One of the big things that happened…in the early '70s was we made this commitment to molecular biology and that was largely driven by Don Seldin [Chairman, Department of Internal Medicine].

Another interviewee said:

A great chair or a great leader…can make all the difference in the world.

The second ingredient in research capacity was physical assets (i.e., equipment, buildings, land, or unrestricted funds). The institution cannot take advantage of expanded research opportunities if the proper people and physical assets do not exist. Research capacity can provide an institution with a competitive advantage others may not have. Noted in one interview:

Baylor College of Medicine…had an extraordinarily strong genetics department… strengths…in the creation of transgenic mice…and…in the discovery of human disease genes. [The] limiting thing to doing that research was how much it cost to keep a mouse in a cage a day. [BCM built] a large mouse facility [that reduced experiment costs] and for…four or five years, [BCM] had the lowest…or the second lowest per diem rate of any institution in the country. [Researchers were able to] do five times the experiments at Baylor than anywhere else.

Loss of research capacity can create problems in several ways. One problem is in the loss of departing faculty. If an institution takes no action to increase research capacity, then that decision may result in dissatisfied faculty members (who are unable to

pursue additional research projects) leaving. The institution loses the research capacity of the departing faculty.

The other problem is the loss of potential research. If there is no available research capacity (due to individual or institutional limitations), then the institution misses opportunities to pursue additional projects. UT Southwestern, for example, grew significantly during the early 1970s, and by the mid-to-late 1980s, the institution had reached full capacity; there was no additional laboratory space to expand. Were it not for gifted additional land that came available in the late '80s, UT Southwestern would have missed opportunities for expanding NIH funds. Simultaneously to the land donation, the administration committed to a 20-year building program to double the research square footage. UT Southwestern sustained its growth with additional faculty and more programs for those new buildings. Concerning that potential lost opportunity an interviewee noted:

> *We had wonderful science, terrific faculty, and no place to grow. So if NIH would have started the doubling in '88 or early '90s, [we] would have missed it [and] been behind the eight ball to…compete for it.*

This researcher examined whether research capacity can influence an institution's ability to change directions in a timely manner when a funding federal agency (e.g., NIH) changes its focus and direction of research activities. An example of agency change is the existing five-year NIH research plan (known as the NIH Roadmap for Medical Research): initiatives to improve future medical research in clinical studies, high-risk research, and molecular libraries (Morrissey, 2003). None of the institutions in this study

ever reached a research capacity point where they could not respond to new research opportunities. However, interviewee responses indicated that if research capacity had been maximized (i.e., no further ability to perform additional research), each institution would have encouraged more faculty interaction both within and outside the institutions to pursue those additional research opportunities.

Lastly, the more competitive institutions created a research capacity that attracts and retains human and financial resources. As described by one interviewee:

> *If you come [here], not only are you going to…work in…great first-rate laboratories…you're also going to be doing the cutting-edge [research] that we know is going to get funded.*

Culture

Interviewees at the more competitive institutions (BCM and UT Southwestern) attributed their success to a culture that continually encouraged and promoted cutting-edge research. The more competitive institutions had a greater enthusiasm and determination for an intellectually stimulating research environment. Organizational culture is difficult to quantify, but culture is evidenced through strong shared beliefs in the institution's purpose among its members. At BCM and UT Southwestern, the administrators and faculty repeatedly spoke of the drive and passion for academic excellence and cutting-edge research. This description revealed an intellectually-rich culture that promoted and stimulated research. It was noted by one interviewee that:

> *Good people will choose [an institution] based upon the intellectual environment.*

Cutting-edge research was described as the standard and served to encourage high standards and enhanced production at all levels. These more competitive institutions were described as responsive to their external environments, including seeking opportunities that may at times appear risky. This was described by one interviewee as:

> *Institutions are supposed to be reactive…But not very many go out…and do something forward thinking.*

The same interviewee noted that, concerning the external environment:

> *This is where the flexibility of the institution is paramount and that is where this institution really counts. Its asset has actually been its freewheeling way.*

Noted in another interview response:

> *You have to develop a kind of institution which…inspires the local community and possibly the state, if it is a state school…So [winning] a Nobel Prize [because of quality academic achievement gets]…people excited and you get a lot of money. And if you establish outstanding performances…you tend to attract support,…other people, and you develop a momentum.*

This culture transcended any individual leader who may have participated in its creation. An incident that took place at BCM in 1996 illustrates a consequence of not having an ideal environment. A large number of BCM's better research faculty left because they did not see a continued commitment to invigorate particular programs. The institution lost 20% of its research grants. As one interviewee described:

> *You never lose the worst faculty; you always lose the best faculty.*

Changes were then made to reinvigorate the research growth with a new building, and BCM increased its research to $260 million from $95 million. BCM felt its research would have been at $350 million without the faculty loss; the loss slowed progress.

In contrast, the less competitive research institution did not have a strong and passionate research culture, nor did it undertake risky ventures. For decades, UTMB has been the state's major medical school that educated and trained Texas' next generation of physician practitioners. The institution had the extensive tasks of providing indigent care for most of the state's counties and for those incarcerated in the Texas Department of Correctional Facilities in addition to owning and managing its teaching hospitals. These tasks have taken attention, time, and resources away from any desire to be a national research competitor.

Distinctions of the Remaining Factors

The results from the interview analysis phase of this study indicate the remaining five factors (financial support, strategies, organizational structure, rewards or incentives, and politics) had less of an effect than the other four factors previously discussed. While important, these five factors were not, to those interviewed, as critical in facilitating successful competition for research dollars. The key findings related to these remaining factors are presented here along with specific differences noted between the more competitive and the less competitive institutions.

Financial Support

This researcher wanted to ascertain what role other financial resources (private, discretionary, endowment, and nonfederal fiscal support) played in acquiring federal research funds. Regarding financial support, all interviewees emphasized that having funds available (whether private or unrestricted endowment) was vital, especially when federal or other grant solicitations required matching funds. Discretionary funds were effectively used as seed money that enabled the institutions to further develop their research operations (e.g., develop new talent, provide expensive equipment that could not be purchased on grants, or grant cost-sharing). Respondents at the more competitive institutions revealed that these institutions saw other financial sources as the means of enhancing the research enterprise. These institutions did not see their role as funding research but rather conducting research. The federal government was their primary source of research support. Said another way:

> *[Baylor College of Medicine] is not in the position of funding research. The NIH is.*

When not seeking federal funds, these institutions sought selective funding from sources (private foundations) with the most rigorous review mechanisms. Winning those private awards conveyed to the research community their programs' quality. This attitude about competition confirmed the high standards of research excellence and the institutions' desires to be recognized based on performing excellent science.

Money and facilities are necessary components of a great institution; however, the more competitive institutions did not perceive these two components as everlasting or associated with first-rate work. Some institutions delay actions to achieve goals because they feel significant resources must be in place first. That was not the case for UT Southwestern, founded in 1943 as a small wartime medical school and housed in abandoned barracks. With modest beginnings, the administrators did not wait for financial support before something was accomplished; rather, they developed conditions that attracted resources. UT Southwestern ensured that the factors for academic excellence (i.e., people, processes, capacity, and a culture committed to enrich the research enterprise) were in place to attract research resources. A respondent's comments:

> *If the ingredients are there for academic excellence very often that will attract resources which weren't there to begin with. So, it is not always the case that resources are necessary before anything is done…They [resources] may be provided, but they also may be attracted.*

Respondents' attitudes at the more competitive institutions about financial support encouraged them to focus on performing good science and cutting-edge research; the benefits (additional research grants, financial and other support, recognition, talent, and other resources) would follow. Thus, UT Southwestern's success in attracting resources has, in part, been enhanced by, among other factors, its four active Nobel laureates.

BCM has also benefited from its innovative research in the human genome area that enabled the institution to turn a modest $3 million research investment into a

nationally recognized Human Genome Sequencing Center whose current year funding is $60 million.

Respondents at the less competitive institution revealed that this institution saw other financial sources as the means of maintaining its overall missions rather than to pursue cutting-edge research. State and private funds were UTMB's primary sources of support. When the state budget gets cut, other public medical institutions endure the same cut for the medical school portion. Unlike the other institutions, UTMB gets hit in other areas—its hospital, and indigent and prison care—all funded by the state. UTMB operated with the attitude that its financial needs would always be met. When those needs were not met, a new reality developed. One UTMB respondent said:

> *Yes…[we're] public…but we cannot expect public support to be sustained at that level and that's a reality*.

In addition, UTMB's private (often restricted) funds directed its mission. For example, UTMB's Development Board promoted the school to the community in efforts to raise money. For many years, UTMB's Development Board focus was on education, student scholarships, practitioners being developed, clinical care, teaching, and disadvantaged populations being served. Only in recent years has the Board promoted research.

Strategies

Strategies are proposed plans to achieve objectives and were used by the more competitive and less competitive institutions. Flexibility had to exist within any strategy to allow for alignment and adjustments within the internal organization as the institution

responded to changing internal and external dynamics. During the interviews, strategies were mentioned more often at the more competitive institution. For instance, strategies (e.g., making a commitment, obtaining consensus, and placing concerted effort into research) established and implemented processes (policies, practices, and procedures) that supported and allowed research to flourish. A crucial and beneficial strategy for UT Southwestern in the early 1970s was its commitment to the study of molecular biology, an area where most NIH money would later be directed. This placed UT Southwestern ahead of most schools in the country. When interviewees were asked if these "at-the-right-place, at-the-right-time" situations were fortuitous, most responded that they were not. As noted in one interview:

> *It was [having faculty and chairmen that] could clearly see that science was moving in that direction…it's partly having people who were sensitive to what was happening…at NIH…And then [the department] started building a nucleus [of expertise in molecular biology].*

In other words, UT Southwestern's success in molecular biology was credited to two other factors: people and the governance process. Particular individuals were sensitive to the external environment and, then, decisions were made to act. Success was not by a stroke of luck.

At UT Southwestern, the Department of Medicine also had a strategy that developed relatively inexpensive human resources (medical students) with little or no long-term commitments. In the 1970s, competitive salary funds were scarce. Consequently, the department's strategy was to discover and nurture outstanding

students, arrange for positions in prestigious training programs, and hope their loyalty would later lead them back as faculty of a developing institution striving for national prominence. Importantly, some of these young physicians did their research fellowships at the federal agencies that were funding academic research, including the NIH. In those situations, these young physicians were strategically placed to observe the direction that science was heading. For example, Drs. Joseph Goldstein and Daniel Foster both left UT Southwestern to do their research fellowships at NIH, returned to UT Southwestern, and became distinguished. Dr. Goldstein served as a clinical associate at the National Heart Institute (1968-70) and as a Special NIH Fellow in Medical Genetics (1970-72); in 1985, he shared the Nobel Prize with another UT Southwestern colleague (Dr. Michael Brown) for their discovery of the basic mechanism of cholesterol metabolism. While at NIH, Dr. Foster chaired the Metabolism Study section, was a member of the National Institute of Diabetes & Digestive & Kidney Diseases Advisory Council, and served two terms on the Board of Scientific Counselors of the Clinical Center. Having been close to and involved with NIH research programs, these two men were attentive to the NIH funding and the direction programs were heading. Following their return to UT Southwestern, they helped the medicine department plan accordingly. Many of these medical scientists later became distinguished, as has their institution—direct results of a deliberate institutional strategy related to the development of research talent potential.

Organizational Structure

The institutions in this study, as with most large organizations, are complex bureaucracies with many layers. Most interviewees concurred that an organizational structure is influenced by governance processes (decisions) and strategies (committing resources such as facilities, land, money, and people to research). However, the more competitive institutions developed and maintained an institutional and departmental infrastructure where research thrived, thus providing a structural advantage over the less competitive institution. These institutions continually simplified their structures so that the bureaucracy was not a hindrance to the research enterprise. This point was reiterated in one interviewee's comments on his institution's bureaucracy:

> *We don't have all the hierarchy of say [others that would require you] to have to go through all these layers to get something done.*

This institution's structure allowed departments to share resources, to communicate with ease, and to exchange ideas and information. As noted by one interviewee:

> *This school was totally designed with the idea of integration. Every building is internally linked…the departments are specially linked in such a way to foster research…that also fosters that whole collegial sharing, using resources jointly.*

Interviewees at the more competitive institutions noted some constraints with organizational structures, but overall, the structures strived to be effective. As one respondent noted:

Here you've got layers of people of an academic and political mindset. The [organizational structure] is really quite restrictive…I'd characterize what this institution has done in our area as phenomenal by institutional standards.

Also expressed was the autonomy given chairmen to operate their departments.

Any organizational structure whether administrative, research, or academic can influence research activities. An example of this influence was seen at BCM when the Board of Trustees, President, and administration made the decision to support the human genome sequencing project with funds and space. Allocating resources, especially an entire floor, had consequences for other areas within the university in that the committed resources were not available for other purposes.

Organizational structures at the three institutions were essentially similar for administration, research, and academia (human resources, accounting, purchasing, contracts and grants, facilities and planning, office of research, provost office, and departments). After decades of growth, the more competitive institutions possessed streamlined administrative structures that continued to facilitate the research enterprise.

In contrast, the less competitive institution was described by a structure which restricted the capability for research and the competition for research grants. According to interviewee provided information, during Dr. Thomas James' presidency at UTMB (1987-1997), a research fund was established, using clinical income and monies from the Sealy Smith Foundation. With that resource, UTMB began to enhance its research enterprise. UTMB recruited top quality, clinical department chairs, funded centers of excellence, and established a research endowment. However, it was said that Dr. James

took a laissez-faire approach concerning the school's administration and left non-research oriented people to implement that task. These people did not appreciate the importance of research for the entire institution. This structure was an obstacle for the research-oriented faculty and slowed UTMB's progress to enhance its research enterprise despite the enhanced research commitment and funding. The organizational structure at UTMB (a bureaucracy with many layers and top-down control) was found to be an obstacle (Wilson and McLaughlin, 1984). One interviewee mentioned the structural failures:

> *Organizational structure needs to take into account…[that] there is no sense of a partitioning between the infrastructure and the purposeful work of the institution…scholars should feel that the service organizations are their partners…I don't think UTMB has achieved this yet.*

Rewards or Incentives

For the most part, the responses were the same regarding the role rewards or incentives play in organizational development and effectiveness as it relates to the research enterprise; they were similarly available to each institution. However, the data identified rewards and incentives as mostly externalities (or the spillover effects) for scientists and institutions for producing good science and research. Many scientists acquire their rewards and incentives primarily from external honors, prizes, awards, and from the prestige that validates their prominent research. The institutions' spillover effects come in the form of prestige, return on their research investments, philanthropy and technology transfers which all help to attract the best resources (faculty, students,

staff, and competitive funds). Institutional awards that are given to faculty members (i.e., endowed chairs) communicate to the general academic and research communities the caliber of their faculty. Overall, the responses revealed that rewards or incentives were important in attracting ambitious or distinguished faculty who seek opportunities and in retaining good people.

However, one contrast in the responses should be noted. The faculty felt rewards and incentives were useful, but overemphasized. This seems to confirm that faculty members are more inspired by their work and potential benefits. As one faculty member noted:

Good scientists will go where the research opportunities are.

Consistently, the interviewees noted that rewards and incentives were more important for retention than for recruitment. As noted by an administrator at a more competitive institution:

Most often faculty will trade opportunity and research for salary.

Interestingly, these responses confirm that faculty members go to places where they can do their research. However, interviews at UTMB revealed that recruitment and retention were negatively affected because of the school's location in Galveston. Located on the Texas Gulf Coast, Galveston is not a large metropolitan city or a leading cultural or professional center such as Boston, Chicago, New York, or Philadelphia (Kerr, 1994). Noted recurrently in their interview responses was:

We did lose some [recruits] that wouldn't come to Galveston…it was a little off the beaten path. Some people don't think it's very attractive.

As noted, beauty has not been one of Galveston's assets. In addition, the city has not had an enduring cultural establishment (music, opera, or the arts) or a major airport. Being located one hour from Houston, a city that does possess many attractive assets, ameliorates some of UTMB's recruitment burdens, but it does not change the perception of Galveston.

Most people want opportunities for whatever reason. More importantly, an incentive may be important to attract ambitious or distinguished faculty. The researcher also noted that all the interviewees came to their institutions because of opportunities (to do research, start and run a program, or grow and enhance a department). Their goals were facilitated when the appropriate culture, research capacity, and processes were in place.

Politics

Lastly, internal and external politics touched all the institutions. Institutions will have no control over some politics; others they will. Politics impacts resources and can require institutions to reallocate, restructure, adapt, and redesign. Some political decisions can be favorable (e.g., deciding to double the NIH budget or continuing to fund academic research). Other decisions can be unfavorable such as when a national initiative shifts agency funds to other types of research and influences institutional research programs. For example, the current national homeland defense initiative has

created some institutional adjustments. The core research may be the same, but successful research faculty members are realigning their research activities to match the federal funding sources (Keefe, 2003).

Understanding the political environment helps an institution respond. The more competitive institutions treated the internal and external politics as a business element that must be managed. These institutions' responses suggested they had learned to take more initiative to act rather than reacting as evidenced at the less competitive institution. As a public entity, UTMB noted that compared to a private institution it had to deal with more roadblocks (regulations, i.e., rules and requirements) in terms of construction. Interestingly, interviewees at the more competitive public counterpart, UT Southwestern, did not present politics as a roadblock and appeared to have learned to manage, tolerate, and act on the political decisions influencing its operations. Changes in state politics and within the UT System Board of Regents in the early 1970's shifted the political influence from UTMB to UT Southwestern. This did not happen unexpectedly, but as noted:

It [played] a major role and it hurt Galveston and helped us [UT Southwestern].

State politics have been less of a concern for BCM; the institution receives little state funding relative to its entire budget (0.8%). Local politics with hospital boards and districts can also impact all the institutions' research missions, since most medical research and clinical training occurs in the hospitals.

QUANTITATIVE DATA ANALYSIS

During the cross-case, quantitative data analysis phase of this study, differences were found in two areas (financial support and people) at the less competitive institution. For the first half of their existences, UTMB and BCM were the only two Texas medical institutions. There was no other in-state competition. Both institutions had ample financial resources and were nationally ranked for the quality of their medical education. UTMB chose not to pursue research aggressively but had resources to support a strong research mission as evidenced in the data collected in Table 6. In 1975, total R&D expenditures for UTMB were larger than those for UT Southwestern. Although less established at the time, UT Southwestern quickly surpassed UTMB and continues to hold its lead.

Many reasons may explain UTMB's lack of research intensity during this study including the time and expense associated with owning and managing hospitals, and providing indigent and incarcerated care (Burns, 2003). While providing indigent care is not unique for academic health institutions, UTMB has carried a heavier burden than its public counterpart in this study. In 1997, indigent health care for UTMB totaled $183.6 million whereas UT Southwestern's total was $230,000 (The University of Texas System, 1998). At one point, hospitals were "cash cows," bringing in ample revenue to cover operations plus subsidizing research or other activities. In the last decade, this has not been the case as managed care has reduced revenue for medical care (Wilson and McLaughlin, 1994; Thier and Keohane, 1998). Now, available resources are most often

Table 6. Cross-Case Comparisons of Federal and Total Research & Development Expenditures, Federal Obligations, and National Institutes of Health Support: 1975 to 2000

	BCM	% Chg	UT Southwestern	% Chg	UTMB	% Chg
Federal R&D expenditures (2000)	193,249,000	105%	109,165,000	38%	61,357,000	85%
Federal R&D expenditures (1995)	94,197,000	24%	78,892,000	44%	33,204,000	53%
Federal R&D expenditures (1990)	75,793,000	82%	54,965,000	61%	21,693,000	56%
Federal R&D expenditures (1985)	41,749,000	34%	34,087,000	63%	13,876,000	34%
Federal R&D expenditures (1980)	31,211,000	72%	20,871,000	203%	10,387,000	78%
Federal R&D expenditures (1975)	18,118,000		6,898,000		5,841,000	
Total R&D expenditures (2000)	334,175,000	76%	189,216,000	51%	97,896,000	35%
Total R&D expenditures (1995)	190,375,000	23%	125,301,000	46%	72,569,000	79%
Total R&D expenditures (1990)	155,122,000	145%	85,919,000	84%	40,610,000	82%
Total R&D expenditures (1985)	63,197,000	67%	46,671,000	76%	22,273,000	39%
Total R&D expenditures (1980)	37,908,000	93%	26,586,000	215%	16,041,000	76%
Total R&D expenditures (1975)	19,643,000		8,436,000		9,099,000	
Federal Obligations (2000)	197,295,000	116%	126,389,000	60%	66,512,000	70%
Federal Obligations (1995)	91,209,000	20%	78,776,000	44%	39,014,000	80%
Federal Obligations (1990)	76,110,000	58%	54,616,000	35%	21,652,000	21%
Federal Obligations (1985)	48,321,000	45%	40,443,000	64%	17,846,000	44%
Federal Obligations (1980)	33,279,000	64%	24,734,000	96%	12,368,000	85%
Federal Obligations (1975)	20,273,000		12,648,000		6,680,000	
NIH Support (2000)	169,294,000	105%	121,426,000	63%	60,308,000	98%
NIH Support (1995)	82,779,000	25%	74,636,000	42%	30,415,000	50%
NIH Support (1990)	66,000,000	59%	52,730,000	36%	20,332,000	28%
NIH Support (1985)	41,559,000	44%	38,882,000	61%	15,885,000	49%
NIH Support (1980)	28,786,000	62%	24,201,000	97%	10,658,000	75%
NIH Support (1975)	17,817,000		12,288,000		6,081,000	

Sources: NSF/DSRS, Survey of R&D Expenditures at Universities & Colleges; Survey of Federal S&E Support to Universities, Colleges, and Nonprofit Institutions and Survey of R&D Expenditures at Universities and Colleges; NIH Support to U.S. Medical Schools, FY's 1970-2000 total [total amount and number of grants awarded (research, training, fellowships, R&E contracts, and other activities)].

needed to sustain the institution's day-to-day clinical operations with no surplus remaining for research. Ample government (state and local) funds once existed for indigent and incarcerated care. Today, that is not the case. Government funds for indigent and incarcerated care do not generate a surplus to support scholarly activity (Thier and Keohane, 1998).

The cross-case analysis of total R&D expenditures by fund sources is provided in Appendix G (p. 148) and confirms UTMB's lower research activity level. UTMB had a larger total R&D expenditure in 1975 than UT Southwestern. Despite a comfortable and long existence that has included many decades of support from state and private funds, UTMB failed to keep pace with BCM and UT Southwestern in terms of research as evidenced in the data in Table 6 (p. 88). One explanation is UTMB's broad base of activities with resources too disbursed to be effective in one area such as research.

A characteristic not found at the less competitive institution was the aggressive use of its faculty in discovering and acquiring research support. The less competitive institution's data revealed a less aggressive research faculty with less NIH grant activity and awarded grants than at the more competitive institutions (Table 7). Faculty members are critical to the organization through teaching, delivering patient care, and performing research. Generally, faculty at the more competitive institutions understand the research arena better and know what opportunities exist as they write the grants to obtain funding.

Differences were evidenced also in the performance indicators (total and federal research expenditures [noted in Table 6], endowment assets, annual giving, faculty

Table 7. National Institutes of Health Support to the Three Texas Medical Institutions Examined: 1975 to 2000

Year	1975	1980	1985	1990	1995	% change	2000
Institution						from	
						1975	
BCM							
Total Support	17,817,000	28,786,000	41,559,000	66,000,000	82,779,000	850%	169,294,000
Rank	17	16	18	15	17	24%	13
Total # of grants awarded	160	234	269	318	329	193%	469
Total 25 yr increase							151,477,000
UT Southwestern							
Total Support	12,288,000	24,201,000	38,882,000	52,730,000	74,636,000	888%	121,426,000
Rank	26	20	20	25	22	23%	20
Total # of grants awarded	173	213	240	255	290	102%	350
Total 25 yr increase							109,138,000
UTMB							
Total Support	6,081,000	10,658,000	15,885,000	20,332,000	30,415,000	892%	60,308,000
Rank	44	43	49	53	50	-5%	46
Total # of grants awarded	89	128	130	145	156	131%	206
Total 25 yr increase							54,227,000

(Amounts are rounded in thousands of dollars)

Source: NIH Support to U.S. Medical Schools, FY's 1970-2000 total. Total number of grants awarded (research, training, fellowships, R&E contracts, and other activities), accessed 2/9/04: http://grants1.nih.gov/grants/award/trends/medsup7000.txt.

members in the academies, faculty awards, doctoral degrees, and postdoctoral appointees [noted in Appendix H, pp. 149-150]). Not all the data for these performance indicators were accessible to this researcher, but what data were available (particular years for all three institutions) were provided. The more competitive institutions not only spoke of recruiting well-developed research faculty and staff to help create environments that

allowed research to flourish, but they also adhered to this research commitment as illustrated in some of the indicators presented in Appendix H (pp. 149-150). For example, the more competitive institutions led in faculty honors. Being selected into the American and National Academies of Sciences (private organizations of scientists and engineers that advance science and its uses) is one of the highest honors accorded a scientist or engineer and illustrates something about the quality of researchers recruited. Over a 25-year period, the more competitive institutions (BCM and UT Southwestern) had 14 and 33 faculty members, respectively, selected into the academies. The less competitive institution had only two faculty members selected over the same period.

Faculty awards were another performance indicator that showed distinct differences between the two groups of institutions. Faculty awards included several prominent grant and fellowship programs (i.e., Fulbright American Scholars, Howard Hughes Medical Institute Investigators, NIH MERIT and Outstanding Young Investigator, Pew Scholars in Biomedicine, and Woodrow Wilson Fellows). The two years this data could be accessed (1999 and 2000), BCM and UT Southwestern led with 28 and 47 faculty awards, respectively, yet UTMB only received two such faculty awards for the same period.

Several other quantitative measures were collected in the cross-case comparisons (see Appendix H, pp. 149-150). Institution size was measured by the total number of faculty to determine the number of faculty available for research. UTMB's focus on patient care and teaching has consistently been at the expense of its research enterprise. The ratio of students to faculty is intended to communicate departmental workload. In

2000, UTMB (the less competitive institution) had the greater load (2.165). Of the two more competitive institutions, BCM had the lightest load (0.70) and UT Southwestern was in the middle (1.35). Comparing the earliest year for the data (1970-71), the placements remained the same, UTMB (1.80), BCM (.091), and UT Southwestern (1.58). Fewer UTMB faculty members were available for research. These quantitative results corroborate several findings from the interviews about the more competitive institutions. Competitive research institutions are more research focused and they have in place certain processes that lighten the faculty teaching loads so that research time is available.

SUMMARY

Cutting-edge research and first-rate laboratories help attract research dollars. However, if an institution does not create and maintain the ideal research climate where bright scientists want to work, little can be done to recruit or retain them. Recurrent in the interviews at the more competitive institutions was the importance that institutional climate or culture plays in research effectiveness. Nonfederal funds were important, but the funds did not make the difference between the more and less competitive institutions studied in this situation. Financial resources were not a distinguishing factor in an institution's ability to successfully compete for federal research funds. The more competitive institutions did not sense their role as funding research but rather as performing research, and their attitudes about financial support encouraged them to focus on performing good science and cutting-edge research. Excellence followed in the form of additional research grants, increased financial and other support, recognition, and

talent. The more competitive institutions perceived money and facilities as necessary components of a great institution, but not endless or associated with first-rate work. Culture made the difference in researchers performing cutting-edge research and promoting an intellectually-rich environment where they wanted to stay.

A consequence of not having an ideal research environment is the possibility that distinguished or potentially prominent faculty members leave. That loss can harm the institution in several ways. One, the institution is set back due to lost research effort. Second, the loss can hinder recruitment efforts because potential recruits know that others have left and wonder whether they should now come on board. The perception that an institution may not have the ideal research atmosphere may impede recruitment. The third point is that the faculty members who leave are often the best. These losses are costly to the institution in terms of research capacity. A setback or two can be manageable, but an institution with perpetual setbacks will not be highly competitive.

The more competitive research institutions in this study created more stimulating intellectual cultures by hiring quality research-oriented faculty and chairmen, and giving them the autonomy to perform their work. These institutions did not define or control the outcome of research programs; rather, they let the department leaders and scientists guide the research because those individuals understood (better than the administration) where research fields were heading. Successful processes (policies, practices, and procedures) set high standards for recruiting academic excellence and for consistently maintaining those standards. Being competitive is about promoting excellence and performing cutting-edge research. The more competitive institutions knew venturing into new

research areas and projects was necessary although sometimes risky in a competitive research environment.

In contrast, the less competitive research institution did not have a strong, passionate research culture, nor did it undertake risky ventures. For decades, UTMB has been the state's major medical school that educated and trained Texas' next generation of practitioners. In addition, it had the extensive tasks of providing indigent care for most of the state's counties and incarcerated care for those in the Texas Department of Correctional Facilities plus owning and managing its teaching hospitals. These tasks have taken attention, time, and resources away from any desire to be a national research competitor. Since state and private funds continued to support UTMB, it operated with the attitude that its financial needs would always be met. UTMB had not focused on or made the long-term commitment to cutting-edge research or to recruiting "fresh" faculty (Burns, 2003). UTMB's decision to focus on teaching and patient care likely explains its lower ranking and slow progress in enhancing its research activities. Of importance to this study, however, is that over the last 15 years, UTMB has made a more concerted effort to develop the ideal research environment. Several reasons may explain the need for this effort: competition from other medical institutions for limited state resources and reductions in the federal Medicare funding. While it may be too early to tell what these efforts will produce, it appears that UTMB may be growing its research program.

Next is the final chapter which provides a summary of the findings, the conclusion, and policy implications for Texas' research universities, along with suggestions for future research.

Chapter 5. Summary and Conclusions

Some institutions are more effective in competing for federal research funds. Chapter 1 described the study's purpose to determine the organizational factors which explain differences in the more and less competitive institutions' abilities to compete for federal research funding. The significance of knowing the institutional factors associated with successful research competition may help others make informed decisions about their capability to become major research competitors. In the literature review (Chapter 2), the author found few studies on this topic. A very small body of literature has studied the specific reasons behind an institution's ability to be ranked in the top 100 (of federal R&D expenditures) or the more elite top 50. For this reason, this study was designed to identify the organizational factors behind the ability of leading research universities to successfully acquire federal R&D funds.

Three medical institutions in Texas were studied and data were collected to examine and compare differences and similarities in their research activities and their development from 1971 to 2000. The medical institutions purposively selected were Baylor College of Medicine (BCM), U.T. Southwestern Medical Center at Dallas (UT Southwestern), and U. T. Medical Branch at Galveston (UTMB). These institutions have similar core purposes: teaching (educate health professionals), research (conduct biomedical research), and service (deliver patient care). Yet from a research standpoint,

the institutions differ substantially. In terms of their positions in the top 100 institutions as measured by federally financed R&D expenditures, BCM and U. T. Southwestern both were ranked in the top 50 in 2000 (25th and 48th respectively) whereas UTMB was ranked in the bottom half (90th). Over the last several decades, BCM and UT Southwestern have been more successful in acquiring federal research dollars than has UTMB.

In Chapter 3, the researcher described the design and methodology of the exploratory, qualitative study which used multiple methodologies. The qualitative in-depth case studies of three Texas medical institutions included interviews and data collection (qualitative and quantitative) to answer the three research questions:

Research Question 1: To what extent do leading and less competitive institutions of higher education differ in their ability to implement and execute successful research policies and practices?

Research Question 2: Do institutional factors explain the difference in research rankings for more and less competitive higher education institutions as measured by federally financed R&D expenditures?

Research Question 3: What particular factors make a difference in a higher education institution's ability to effectively execute its strategies or more effectively compete successfully for federal research funding than less competitive institutions?

The historical institutional information was derived from multiple sources (research reports, journal articles, and other related publications and print media covering higher education, academic health centers, and the specific institutions). Most of the quantitative performance indicators (e.g., endowments assets and faculty awards) were organized chronologically for each institution, constructed into tables, and compared across cases. Eight organizational factors were identified during the literature review and were used to structure the interview guide and to answer the research questions. The list is not exhaustive, but it encompasses eight of the most commonly identified subject areas in organizational theory (Kotter and Heskett, 1992; Stahler and Tash, 1992; Galbraith, 1977, 2000; Dunbar and Lewis, 1998; Galbraith and Lawler, 1998; Diamond, 2000; Falcone, 2001). The factors are listed below and defined in Chapter 1 (pp. 12-13).

1. Strategies (concerted plans to achieve goals)
2. Organizational Structure (micro and macro)
3. Processes (institutional practices, procedures, policies)
4. People (Faculty [key characteristics], Students [graduate and postdoctoral], Others [particular leaders])
5. Financial Support (private, discretionary, endowment, other)
6. Rewards or Incentives (compensation or enticements)
7. Research Capacity (awards and expenditures)
8. Politics (governmental or internal organizational activities concerned with debate and creating and implementing policies, or, interrelationships regarding power or influence)

The interviews were conducted with eight key medical school administrators and faculty who were close to and familiar with their respective research operations during the extended period examined (1971-2000). The semi-structured interviews contained open-

ended questions which allowed interviewees to express their own personal perceptions plus provide opportunities for other factors to emerge. Some fixed response questions and a few unstructured items sought specific institutional developmental details, particularly related to the institutions' research enterprises. The interview guide is available in Appendix E (pp. 145-146).

SIGNIFICANT FINDINGS

The three Texas medical schools studied had similar institutional missions (education, research, and patient care), but BCM and UT Southwestern were more successful in acquiring federal research funds than was UTMB. The more competitive research institutions designed effective, highly-developed research enterprises which enabled them to successfully compete for research funding. The goal of the in-depth case studies was to examine whether the eight institutional factors (plus any other factors that emerged during the interviews) explained the differences in their federal research rank. The findings as they relate to the three research questions are as follows.

Research Question 1. To what extent do leading and less competitive institutions of higher education differ in their ability to implement and execute successful research policies and practices?

The data from the three case analyses demonstrated the degree of difference among these institutions in terms of their ability to implement and execute successful

research policies and practices. While all three institutions had similar missions, the two more competitive institutions (BCM and UT Southwestern) had established and demonstrated research expertise in areas funded by federal agencies. Their missions spoke to remaining at the forefront of biomedical research. In contrast, the less competitive institution (UTMB) had not been as aggressive in competing for federal research funds nor had it established sufficient research expertise to bring about the same level of national recognition or prestige prior to and during the study period. For many decades, UTMB has been known for its primary mission of educating future health practitioners; it has an outstanding record of quality patient care in Texas, both private and indigent care as well as its treatment of Texas' incarcerated patients. This institution has had the extensive tasks of providing indigent care for most of the state's counties in addition to providing incarcerated care for the Texas Department of Correctional Facilities. These tasks, which enhanced the quality of training for practicing physicians, took attention, time, and resources away from UTMB's ability to compete as successfully as the more competitive institutions for federal research dollars. The research mission was thus a lower priority. UTMB's Development Board (promoting the school in efforts to raise private money) had not historically promoted research. Rather, the Board's focus was on education, student scholarships, practitioner development, clinical care, teaching, and serving disadvantaged populations. Only recently has the Board promoted the research enterprise. One interviewee stated:

> *[UTMB's] focus was on education and development of practitioners for the state of Texas and on excellent clinical care and teaching, and on serving*

disadvantaged populations. And the interesting thing is, up until maybe less than a year ago, our Development Board thought that way too. It has only been since we have started this new capital campaign and have been able to show our Development Board that we have research expertise that would put us…in competition with…many research intensive universities, has our own Development Board agreed to support [raising] money for research.

Basically, UTMB has not had the long-term commitment to cutting-edge research or to recruiting "fresh" aggressive research faculty (Burns, 2003). Only since the presidency of Dr. Thomas James (1987-1997) has UTMB emphasized decisions to enhance its research mission.

Research Question 2. Do institutional factors explain the difference in research rankings for more and less competitive higher education institutions as measured by federally financed R&D expenditures?

Yes, institutional factors, as described in the open systems theory of organization, do explain the difference in rankings. The more competitive institutions responded and adapted their internal design to meet external challenges. A very supportive research culture was observed in the cutting-edge, nationally recognized research institutions. That environment was created by the institution, its members, leaders, and governing bodies in making the long-term commitment to building the research enterprise. The less competitive institution operated as a closed system under a static environment and did not

attempt to adapt to the changing federal research environment. Some of the institutional factors at the less competitive institution were substantially different from those at the more competitive institutions. For example, UTMB chose to emphasize quality teaching and patient care and was effective in these missions because of its well-integrated culture. This same culture, though, impeded its ability to adapt to changing environments or to redefine its underlying mission to include an extensive research capacity.

Research Question 3. What particular factors make a difference in a higher education institution's ability to effectively execute its strategies or more effectively compete successfully for federal research funding than less competitive institutions?

Three institutional factors (people, processes, and research capacity) helped explain the differences between the more successful competitive institutions and the less successful competitive institution. In addition, the interviews revealed that a ninth factor (culture) that was not identified in the initial literature review also explained the difference. It became obvious during the interviews that possessing and maintaining a strong research culture reinforced the other organizational factors (people, processes, and research capacity). The integration of four significant factors (people, processes, research capacity, and culture) created and sustained a competitive advantage at the more competitive institutions. These factors are discussed in greater detail below. The remaining factors (financial support, strategies, organizational structure, rewards or

incentives, and politics) had less of an affect than the others and those results are detailed in Chapter 4 (pp. 75-86) along with the findings from the entire study.

1. People. Individuals who possessed particular characteristics were found to be the primary drivers in ensuring an organization's successful research mission through their work efforts and decisions. These individuals were competent scientists and/or visionary leaders with the desire, determination, dedication, and motivation to ensure excellence in research. In the more competitive institutions, distinguished faculty and administrators were mentioned as the driving force behind significant change and key successes. That inspiration was observed in the number of distinguished faculty at both institutions and in particular in the number of Nobel laureates at UT Southwestern. Leaders played a significant part in ensuring that research and excellence were concomitant goals as illustrated by this interviewee comment:

> *It starts off with somebody in a leadership position making the decision that they are going to do [research]…that was Don Seldin at UT Southwestern. He had a vision of what he was going to do and the kinds of people that he was going to grow to become excellent investigators and scientists. And he nurtured those people.*

Dr. Donald Seldin, Chairmen of the Department of Internal Medicine at UT Southwestern during most of this institution's research examination period, was identified often in the interviews as being the inspiration for programs, the department's success, and the catalyst for particular distinguished people being recruited. These people included the four active Nobel laureates who have been instrumental in sustaining the school's

national recognition that helped further recruit some of the brightest faculty. These individuals helped maintain an intellectually-rich research environment.

Drs. Michael DeBakey and Richard Gibbs were the two most cited people associated with BCM's research successes. Drs. Thomas James, Jack Stobo, and David Walker were those most cited behind recent changes at UTMB leading to an enhanced research focus. Outstanding people stimulate and foster intellectually rich research environments.

2. Processes. Established and implemented processes (the institution's practices, procedures, and policies) to promote research were viewed as critically important in facilitating the research enterprise. The governance processes directed how choices were made and who made them. The governance process established policies and implemented procedures that promoted excellence (i.e., in recruiting high quality faculty, promoting high quality research production standards, and maintaining the research commitment). A reduced teaching and administrative load was one process that allowed researchers and scientists greater time for research. Other processes included the administrative procedures and policies for managing paperwork, setting up contracts and accounting records, expediting purchases, and processing the reviews for human subject research. The more competitive institutions expedited the Institutional Review Board's (IRBs) reviews for human research proposals or the Institutional Animal Care and Use Committee's (IACUC) reviews for animal research. Another example was the Grants Management and Accounting offices rapidly setting up the awards and new accounts so faculty had access to funds to commence their research projects in a timely fashion. The

administration understood the importance of facilitating research objectives. As noted at the more competitive institutions, the people in contact with the research enterprise

...understand that their job is to support the enterprise.

3. Research Capacity. Research capacity was required to conduct research and allows an institution to respond to federal research funding opportunities. Research capacity was defined in this study as the ability to conduct research based upon both individual and institutional core competencies and capabilities (e.g., skills, technical expertise) and physical assets (equipment, buildings, land, or unrestricted funds). Research capacity is dependent upon several ingredients. The first ingredient included qualified scientists and/or visionary leaders who have the desire, determination, and dedication to ensure a successful research mission. A second ingredient was physical assets (i.e., equipment, buildings, land, or unrestricted funds). Regardless of the type of facilities (animal or other lab space), research institutions require space where investigators can work. An institution is unable to respond to federal research funding opportunities without an adequate research capacity. The institution cannot take advantage of expanded research opportunities if the proper people and physical assets do not exist. With these conditions in place, the administration creates and implements deliberate processes to facilitate and support the research mission. The more competitive institutions created and maintained an effective organizational design that included the appropriate research capacity and continually streamlined administrative processes to service and support the research enterprise. This was observed by departments continually servicing the research activities and working to simplify and expedite the

processing time for grant applications and awards. Complex bureaucracies can be restrictive and slow to move because of their multi-layered routing and approval structures. Regardless of these structures, the more competitive institutions ensured that all layers were committed to the research mission and were effective at strengthening the research capacity. Noted in one interview:

> *[Baylor College of Medicine] is a very slow moving place… quite restrictive… [But] I'd characterize what this institution has done in our area [genome] as phenomenal by institutional standards.*

The more competitive institutions' abilities to be proactive and respond quickly to their environments facilitated their research enterprises. In contrast, the less competitive institution lacked the organizational capabilities and core competencies to conduct and support extensive research as described in one interview:

> *Once you know that [the institution is] going to be heavily invested in research, you're going to have to have certain elements in your organization that can provide necessary support…meet the regulations…process the paperwork…What really works best is if there is no sense of partitioning between the infrastructure and the purposeful work of the institution…I don't think UTMB has achieved this yet, but we're moving in that direction.*

One example of an institutional capability provided BCM a competitive advantage others did not have. The administration desired to reduce its research animal (mouse) maintenance cost. BCM determined a new care and storage method that would reduce the daily mouse cage cost by $0.21. BCM presented a request to the Board of Trustees

for approval. The larger new mouse facility provided even further savings and increased research capacity, as noted:

> *Baylor College of Medicine…had an extraordinarily strong genetics department… [with]… strengths…in the creation of transgenic mice…and…in the discovery of human disease genes. [The] limiting thing to doing that research was how much it cost to keep a mouse in a cage a day. [BCM built] a large mouse facility [that reduced experiment costs] and for…four or five years, [BCM] had the lowest…or the second lowest per diem rate of any institution in the country. [Researchers were able to] do five times the experiments at Baylor than anywhere else.*

When the more competitive institutions realized their research capacity was at a critical stage, they addressed these concerns. As noted during one BCM interview:

> *We need to build more facilities…We think we'll lose key investigators because we are not able to meet those needs. We intend to meet the need.*

4. Culture. Organizational culture is difficult to quantify although it is evidenced through strong shared institutional beliefs and values among its members. One cultural attribute is being responsive to external environments and pursuing opportunities that may at times appear risky. Another attribute is having a passion for academic excellence and cutting-edge research, the standard promoted at the more competitive institutions. These characteristics revealed an intellectually-rich culture that promoted, stimulated, and invigorated the research enterprise and created an attractive environment for both research scholars and research leaders. The more competitive institutions' cultures

promoted a strong passion and commitment to an intellectually-rich environment that encouraged cutting-edge research. These cultures reinforced the other three important factors (people, processes, and research capacity) and ensured the more competitive institutions' ability to execute their research strategies effectively. These cultural traits were noted in one interview:

> *Institutions are supposed to be reactive....But not very many go out…and do something forward thinking.*

And further developed:

> *This is where the flexibility of the institution is paramount and that is where this institution really counts. Its asset has actually been its freewheeling way.*

A culture of excellence in science and research was prevalent throughout the more competitive institutions. Particular people established and ensured that this philosophy thrived. Particular leaders impacted the institutions' histories as did the achievements of faculty and scientists (including Nobel laureates). The depth of passion and the determination to maintain an intellectually stimulating research environment exceeded any one leader who may have participated in creating that setting. These institutions have been extraordinarily successful because in large part their core purposes have been excellence in research, with that excellence driving and dominating teaching, clinical work, and service. This attention to research excellence was noted in one interview:

> *It's very important…to keep one's eye focused on where you're going…If you want excellence…you have to remember that…however you may deviate,*

> *[whatever]… the important issue of the moment may be [parking, elevators, and other important issues]… that is not the purpose of the institution. You have to recognize … all your efforts at the moment…to satisfy the requirements of this or that constituency… are not the core purposes of the institution.*

Many of the day-to-day management issues create "crises of the moment" that take away time from the institution's core purpose, but these issues are not allowed to redirect the institution's purpose. Such statements give a glimpse of the core ideology and culture. In contrast, the less competitive institution had not developed a culture that promoted a strong passion and commitment toward extensive cutting-edge research. This culture was more intense at the more competitive institutions throughout the period studied.

DISCUSSION

This study has shown that highly competitive institutions are better prepared and more responsive to their external environments by adapting and aligning their strategies to meet the changing needs of agencies which fund research. Despite many decades of expanding federal R&D support, universities and colleges are impacted differently because of shifts in national R&D priorities and fluctuations in federal agency R&D budgets. As NIH funding has increased, having a medical school as part of the university has been an important element to being competitive. Biomedical research has been a national priority for almost four decades and during that time, most institutions with improved research rankings have been medical institutions. The national emphasis on medical research has recently been increased with the NIH doubling its R&D budget

from 1998 to 2003. From 1979 to 2000, the total R&D budget (obligations) for NIH increased 435% in comparison to the DoD's budget increase of 208% (Table 8). This

Table 8. Total Research & Development Budget (Obligations) by Federal Agency: 1979, 1986, 1993, 2000

(Millions of Current Dollars)

	1979		1986		1993		2000		% increase
	Amount	%	Amount	%	Amount	%	Amount	%	From 1979
DoD	$12,958	43.0	$35,000	64.0	$38,848	53.0	$39,960	48.0	208.4
NIH	3,222	11.0	5,412	10.0	9,891	14.0	17,234	21.0	434.9
NASA	4,559	15.0	3,729	7.0	8,815	12.0	9,494	11.0	108.2
DoE	5,442	18.0	5,540	10.0	7,444	10.0	6,956	8.0	27.8
All Others	4,270	14.0	4,940	9.0	7,930	11.0	10,125	12.0	137.11
Total R&D	$30,451	100.0	$54,621	100.0	$72,928	100.0	$83,769	100.0	175.09

Source: American Association for the Advancement of Science (AAAS), (2001). Report XXVI: R&D FY2002, Washington, D.C. http://www.aaas.org/spp/rd/xxvi/rd02main.htm Historical data on federal R&D, FY 1976-2003.

expansion of federal R&D funds has broadened the competition for those funds. The results of this study are consistent with the work of Geiger (1990), Graham and Diamond (1997), and Falcone (2001) who maintained that research opportunities have increased because of particular research environments (i.e., increased federal funding opportunities). Graham and Diamond (1997) found that some universities not historically established in research developed expertise in unique areas that aligned with expanding federal research dollars. The two more competitive institutions in this study aligned their research expertise to meet federal agency needs.

Some higher education leaders believe that the key to success in being a highly competitive research university is performing biomedical research. This study has shown

that not all medical institutions rank at the top. Currently, medical institutions are being affected by changing national priorities (slower budget growth and decreasing emphasis on health research funding). Though one half of the NIH R&D funds support academic research, federal program and funding level changes create a volatile environment that requires institutions to adapt to make effective use of specialized resources. President Bush's 2004 budget proposal increased NIH spending by only two to three percent over his 2003 proposal; this could dramatically affect institutions that received funds during the NIH expansionary period (Brainard & Borrego, 2003). Some programs are experiencing reductions in funding while other programs are losing their entire funding. For BCM, the result of the changing national priority has been a doubling of institutional requests for interim funding (Berger, 2004). This interim funding comes from the school's own research budget for those faculty members without grants who want to keep their labs operating. These funds must be temporary because no institution can afford to support "unfunded" research for very long. Adjustments will be required with what are now excess specialized resources or research capacity (i.e., faculty, staff, lab space, equipment) acquired during the expansion. Principal investigators who received NIH support over the past four years face uncertain futures as their research grant requests are denied (ibid).

A major part of an institution's success is changing and improving internal factors (ensuring their best alignment) to enhance its ability to respond to its external environment. Performing at higher levels requires change and improvements to the organization's design or infrastructure and often requires increased research capacity.

The four factors (people, processes, research capacity, and culture) identified in this study are the most important aspects that explained the more competitive institutions' success in being highly competitive in the federal research marketplace. Organizational theories helped explain different organizational behaviors that shaped research competition. Following is a discussion of the results from this study in the context of previous work and theoretical explanations in organizational theory.

Findings Related to Theoretical and Conceptual Explanations

This study's findings support existing organizational theory and further expand the knowledge base in terms of how three medical institutions competed in the federal research marketplace and achieved their respective rankings. The more competitive institutions were able to respond to their environments because of their organizational designs and their decisions to support and to ensure an effective research enterprise.

Prior to 1960, most organizational theorists presumed there was one best way of departmentalizing and structuring labor (by tasks), and centralizing decisions and authority. Organizations were recognized as operating in closed, rational systems, i.e., organizations had fixed boundaries, were fully rational in all decisions, and were independent of any environmental factors (Scott, 1981).

For many years, UTMB operated as a closed system under a static environment. It did not attempt to adapt to the changing federal research environment and relied primarily on state appropriations and patient care income. UTMB had few challenges beyond its medical practitioner training and patient care missions and little reason to

change. Competition was minimal, if any, and state funds were readily available to accomplish its primary missions of teaching and patient care. Such a stable environment presented few challenges. When UTMB's funding environment changed (i.e., continual loss of state funding with expanding state needs and the development and funding of additional medical institutions), the volatility of its funding source was recognized. An interviewee said:

> *Yes…[we're] public…but we cannot expect public support to be sustained at that level and that's a reality*.

Since 1960, researchers who questioned the closed-system models developed the open-systems models that recognized the important impact of environment on an organization. These theorists argued that organizational design was dependent on the environment in which the organization operates. Organizations, like living systems with many interrelated parts, are vulnerable to the influence of their environments (Armel, 1997). Economic pressures require research universities to adapt to changing environments for their survival. Research university survival is dependent on federal support. As noted:

> *You can't survive without federal grants…in the sense of the NIH, that is the gold standard. If you don't have the gold standard, the meaningful and significant NIH funds, you don't have a credible research program.*

The most competitive institutions adapt to prevailing federal R&D initiatives to survive environmental changes. This behavior can be explained by the Contingency

Theory developed by Lawrence and Lorsch (1967), which focused on organizations as open systems that differ structurally in their response to environmental challenges and opportunities (cited in Johns, 1996). By developing differentiated units or structures within the university, these interrelated units are allowed to adapt to specific environmental changes with little disturbance to other organizational units. The three academic health institutions had identical overall purposes: teaching (educate health professionals), research (conduct biomedical research), and service (deliver patient care). Yet, each institution organized and operated differently based upon which mission it was achieving.

Different functional activities require different kinds of task organizations (Wilson and McLaughlin, 1984). Patient care and teaching are two activities that require central control, consistency, stability, standard curriculum and care guidelines that are predictable over time. These activities characterize well-integrated systems (i.e., tightly coupled) leaving little room for discretion, autonomy, and innovation. Patient care and teaching do not respond quickly to change. In contrast, research activities need loosely-coupled systems that provide room for discretion and autonomy which encourage creativity and innovation in response to dynamic environments, with little disturbance to other organizational units. These findings are best explained by Weick (1976), Pajak and Green (2003), and others, who have described organizations and their interrelated parts as loosely coupled systems, where "loosely coupled" means weak (or relatively absent) control, influence, coordination, or interaction among events, components, and processes.

Weick (1976) maintained that loosely and/or tightly coupled properties within organizations serve appropriate purposes in different functional activities.

The open-systems model and coupling concept explain how the more competitive institutions (BCM and UT Southwestern) were more effective in responding to ever-changing environments. Their effectiveness can also be explained by Denison and Mishra (1995) who identified cultural behaviors as "useful predictors of performance and effectiveness" (p. 204). The culture and management practices of an effective organization, they argued, must reflect four characteristics (involvement, consistency, adaptability, and mission). How well the internal operations or systems are integrated is based on cultures that emphasize high *involvement* of the organization's members and *consistency* or stability of its shared values (or culture). In addition, how well an institution responds to its external environment is based on having a culture which emphasizes *adaptability* and a shared sense of *mission*.

UTMB chose to emphasize quality teaching and patient care and was effective in these missions because of its well-integrated culture (i.e., a tightly coupled system). This same culture, though, impeded its ability to adapt to changing environments or to redefine its underlying mission to include an extensive research capacity. The positive aspect of consistency is that it allows integration and coordination, but the negative aspect is that it is the most resistant to change and adaptation. UTMB was well integrated and coordinated in producing physician practitioners, but that consistency limited UTMB's ability to adapt internally for extensive research activities. The more competitive institutions' cultures positively influenced governance decisions and their

abilities to adapt to changing national research priorities; at UTMB, that was not generally the case.

An institution's governance process is impacted by its culture. Kennedy (1993) described governance as "the organizational context that directs how choices are made, and who makes them" (p. 127). Through various multi-level bodies, institutions make and act on decisions in response to their environments. Likewise, Kezar and Eckel (2004) emphasized the importance of governance as a crucial internal process of policymaking and macro-level decision making. In general, institutions make choices when they commit to support an intensive research enterprise. They establish policies, allocate resources, and choose the next research initiative. The multi-level governing bodies (often described as a shared or disjointed governance structure) suggest that shared decisions facilitate flexibility and agility (Kezar and Eckel, 2004; Mallon, 2004). The decision-making bodies are able to function independently from the whole. For example, faculty senates can make decisions about faculty appointments without impacting the entire institution while the administration is able to make decisions that may not affect the faculty. Others (Berdahl, 1991; Birnbaum, 1991) have argued that the overlap of authority and roles (dual systems) helped streamline the governance process and accommodate different faculty and administrator perspectives (Kezar and Eckel, 2004).

Mallon (2004) argued that university research centers and institutes have changed the traditional university governance structure. The governance structure has been broadened and more structures and layers can cause delays. Weick (1976), Mintzberg

(1979), and Birnbaum (1988) have argued that the coupled systems concept (loose or tight) allows for balancing decentralized and centralized authority and governance structures. Loose coupling provides decentralized decision-making structures their needed autonomy, allowing for innovation and flexibility, although the structures are slower and the processes less efficient. Cutting-edge research requires innovation responsive to change (loosely coupled systems) whereas routine service areas (teaching curriculum and patient care standards) require centralization and tight control for more efficient operation (tightly coupled systems). The findings of this study are consistent with Weick's coupled systems (1976) and Mallon's disjointed governance work (2004) that claim units and centers are able to adapt and be more responsive to external pressures without influencing the institution's core.

The work of Galbraith and Lawler (1998) has been widely used to explain an institution's effectiveness and ability to possess a unique competitive advantage which distinguishes it from others. These researchers maintained that the result of successful alignments of four elements (strategy, core competencies, organizational capabilities, and environment) was an effective institution. When the environment changed (i.e., federal R&D initiatives changed), the more competitive institutions in this study aligned the other three elements to establish the appropriate research capacity and to ensure that their competitive advantages were exploited. Core competencies and organizational capabilities establish an institution's research capacity which enables the institution to compete for federal research funds.

An example beyond the period of this study illustrates this alignment model. The attack on the World Trade Center in September 2001 and the ensuing anthrax poisonings made biological terrorism defense a national priority (environment). Research for this initiative required "highly secure 'biocontainment' laboratories for the safe study of dangerous microbes" (Brainard, 2003). At the time, UTMB had a less secure laboratory where scientists were studying infectious microbes (organizational capabilities). Based on its ability to achieve the federal government's objectives successfully, UTMB decided to respond to the national initiative (strategy) because of its world-renowned expertise in infectious diseases (core competency); it did so rapidly by putting together a convincing program (organizational capabilities). This effective alignment provided UTMB with a unique competitive advantage to capitalize on a new funding source.

The Galbraith and Lawler (1998) model addresses the environment from an external perspective although it could be addressed from an internal perspective. Most of the interviewees confirmed that institutions retain faculty because they offer a stimulating intellectual climate and not because they pay their salaries or fund their research. Competitive salaries and financial support for research are important; however, external grant money (for the most part) funds the scientists' salaries and research efforts. For scientists, it is the opportunity to do their research among other intellectuals that matters most. One faculty member said:

> *Good people will choose based upon the intellectual environment, the specific nature of the opportunity, and then the money…[S]alary is not the critical thing…It is more about supporting their research.*

The findings of this study also suggest that a thriving research environment is ensured by aligning the other three elements (core competencies, organizational capabilities, and strategies). Core competencies are attributable to people, their skills, and their technical expertise. Organizational capabilities are the institution's abilities to operate (through processes) in response to challenges and include its ability to encourage, nurture, and foster a growing research enterprise. The Galbraith-Lawler model is consistent with the factors identified in this study (people, processes, research capacity, and culture).

Galbraith's (1977) earlier model depicted five key organizational design elements as they relate to choices: strategy, structural form, management processes, reward systems, and people. The findings of this study support the view that organizations are effective when critical factors are aligned with each other: people, processes, research capacity, and culture. An underlying differentiating feature of the more competitive institutions' (BCM and UT Southwestern) research success was their ability to appreciate the importance of research programs to the entire institution: ensuring excellence in research has driven excellence in other purposes (teaching, clinical work, and service). These institutions continued to ensure that the research enterprise prospers through the decisions regarding the *strategies* to implement, the *processes* to streamline, the *rewards* or incentives to offer, the *people* to recruit, and the *structural form* to develop. This was also stated in one interview:

> *Once you know that [the institution is] going to be heavily invested in research, [you] have to have certain elements [in place] that can provide [the] necessary*

support…meet the regulations…process the paperwork…What really works best is if there is no sense of partitioning between the infrastructure and the purposeful work of the institution.

Lawler (2003) contends culture is not a key organizational design element. Rather, culture is influenced by all of these elements. During an institution's formative stages, this researcher agrees with his assertion based on the results of this study. However, once these internal factors are established, they become (and sustain) the culture (Kotter and Heskett, 1992). In that sense, culture (the factor identified from the interviews in this study) is perhaps the single most important organizational factor in explaining the success of the more competitive research institutions. Some overlap and interplay exists among these models and theories.

The results of this study are also consistent with the work of Collins and Porras (2002) who identified two key concepts behind visionary companies: preserve the organizations' core values and purpose (primary reason for being) and stimulate progress (new ideas and innovation) to ensure a competitive advantage. The companies' successes were attributable to having a solid foundation (core values and purpose) that had been preserved while encouraging continued progress. Combined, the four most important factors identified in this study (people, processes, research capacity, and culture) preserved the more competitive institutions' primary reasons for being (i.e., generating and transmitting new knowledge through academic excellence) and continued to stimulate new ideas and progress (i.e., cutting-edge research) in an intellectually-rich, research environment. BCM and UT Southwestern's competitive advantages were their

strong quality-driven values and purposes and their push for progress. During the 28 years studied (1972-2000), these two institutions had been extraordinarily successful because their focuses were on excellence in research; this excellence has driven and dominated their teaching, clinical work, and service. These institutions advanced into the more competitive group (the elite top 50), climbing 24 and 55 positions, respectively. In contrast, the focus for UTMB was on teaching rather than research excellence and, consequently, UTMB, although it climbed 27 positions, remained in the less competitive group (see Table 1, p. 4).

Collins and Porras argued that these two concepts (preserve the core and stimulate progress) are more important than the organizational members who come and go. This argument is consistent with Birnbaum's (1989) research on presidential influence (cited in Levin, 1998). Birnbaum contends that if presidential impact is so important, a departure should have measurable consequences on performance. People leave their mark on a company; but it is the cumulative effect of human contributions, the mission, and the achievements that make companies successful. In response to a follow-up question, "Do you think the Presidents have made an impact?" one interviewee commented:

> *All Presidents have their own styles…Each president contributed something very, very different that was appropriate to the time.*

After BCM became independent in 1969, Dr. Michael E. DeBakey served as its first president. He was instrumental in establishing a partnership agreement with the State of Texas to provide medical education for Texas residents that would provide BCM state

appropriations for student enrollment. Drs. DeBakey (1969-1979) and William T. Butler (1979-1995) both had presidential terms exceeding ten years and both continue to serve as officers of the BCM Board of Trustees. Dr. DeBakey's role on the institution's successes was documented in one interview:

> *A key person…[in bringing] in some extremely prominent people [and building] this core strength that expands and grows [and acquiring] federal funds to build buildings…was Dr. DeBakey.*

While Dr. DeBakey was instrumental in the formative stages by acquiring state and federal support, Dr. Butler was instrumental in continuing the momentum and in leading during "a period of unprecedented growth and national and international recognition" (Baylor College of Medicine, 2003). This cumulative effect was similarly described at UTMB where past presidents had contributed to the school's national recognition as one of the better medical schools for training physicians. The current and preceding presidents have enhanced the school's efforts to obtain national research and funding. Key people (whether an administrator, a president, a dean, a department chairman, or faculty member) at formative stages can make contributions that enhance an institution. Their actions are appropriate for the time and their contributions enhance a strong foundation.

The more competitive institutions in this study succeeded because of the competitive nature of their environment and their ability to align their core competencies and capabilities to match the funding sources. Four institutional factors (people, processes, research capacity, and culture) explain the difference in competitiveness for

federal research funds by these individual research universities; these findings support and expand the work of Krohn (1992), Stahler and Tash (1992), and Diamond (2000), who identified similar factors at other institutions that ascended in research rank. Diamond identified the factors attributable to the research success of the University of California-Santa Barbara, Brandeis University, and Emory University as "…successful exploitation of geographical advantages, a dedication to a research mission, the acquisition of a critical number of talented research faculty, a research agenda that matched federal funding priorities, and an appropriate research infrastructure" (p. 434). Krohn (1992) found 29 advancing research universities whose research market percentage and engineering capabilities increased during expanded opportunities funded by DoD, industry, and by the institutions themselves. Krohn's analyses of Georgia Institute of Technology, Rensselaer Polytechnic Institute, and Virginia Polytechnic Institute and State University identified five successful strategies (two initiating and three sustaining) that facilitated their advancement: developing a research mission, building the faculty, accommodating the mission, securing funding, and conducting research in expanding fields. Stahler and Tash (1992) compared 30 institutions' ranks in 1983 and in 1990 (in total R&D expenditures) and found the most important factors for their increased research activity and enhanced reputations were research support by top academic administrators through policies, expanded facilities and new equipment, and new faculty hire packages in selected fields. Altogether, these studies showed institutions adapting and making decisions to support their research missions in response to their

external environments similar to this study's findings and consistent with the theoretical and conceptual explanations discussed in this section.

FUTURE RESEARCH

This study provided understanding in the area of research competitiveness by determining the institutional factors that facilitated national prominence and acquisition of research funds. Further research opportunities can be suggested from this study. More recently, UTMB has undertaken management changes that include a commitment to extensive, cutting-edge research, to create an environment and establish an infrastructure that fosters research and ensures its effectiveness. In 1997, UTMB began building expertise in the specialty of infectious diseases by recruiting the arbor virus group from Yale University. Over the ensuing years, UTMB built strength and dominance in this scientific expertise that few others could match. One interviewee stated:

> *[We] had the people who were this country's if not the world's…experts in these organisms that make up the whole biodefense field.*

In addition, UTMB in the last five years eliminated a structural weakness (the misalignment between the administration and research units) that had created problems for the research-oriented faculty to achieve their research directives. It is too early to fully evaluate the results, but these actions more closely address the four factors identified in this study (people, processes, research capacity, and culture) as factors critical to the more competitive institutions' successful competition for federal research

dollars. UTMB could be examined over the next ten years to see whether these initiatives change its research competitiveness.

This study examined three freestanding medical schools in Texas that were not attached to undergraduate university campuses. Another study of additional medical schools with university campus connections could enrich understanding whether the university influences the medical school's competitiveness or vice versa. Another study could examine and compare research universities that dropped in rank to note whether the drop was correlated with a change in national goals or the institutions' inabilities to realign research activities to prevailing funding sources. In addition, the organizational factors identified in this study could be examined to determine whether the descending institutions lacked the four factors (people, processes, research capacity, and culture) that predict research competitiveness.

Examining external factors such as federal resources and funding amounts could give understanding to what type of research gets funded and whether specific expertise was established or rapidly developed at highly competitive institutions to exploit an opportunity. Although many federal agencies exist, only four have dominated the federal research budget: DoD, NIH, National Aeronautics and Space Administration (NASA), and the Department of Energy (DoE). For example, budgetary expansion periods for the NIH would appear to benefit all NIH recipients. Yet, several public institutions without medical schools (i.e., University of California at Berkeley, the University of Illinois, and the University of Texas at Austin) experienced a decrease in NIH support as noted in the

Graham and Diamond (1997) study. Determining what occurred at these institutions and within NIH resulting in these decreases would be beneficial.

CONCLUSIONS AND RECOMMENDATIONS

The initial findings of this study illustrated that no one particular factor (e.g., money) is the sole indicator of success. Much of the literature suggested the obvious: essential resources (money, facilities, and faculty) are needed to successfully compete for research funds. When one examines several institutions, it is noted that many possess these resources. However, an abundance of money and great facilities does not ensure first-rate research. In fact, many distinguished faculty initiated their research in small laboratories and many institutions, including UT Southwestern, at one time, did not have great facilities. In addition, the best laboratories will not make a difference if outstanding people are not taking advantage of them.

Instead, a variety of examples and explanations were given in the more competitive institutions' interviews to suggest that building a strong core foundation with a culture that promotes academic excellence in research was as important as ensuring that the organization's design accommodated that philosophy. When that supportive research environment is in place, individuals can take risks, support new programs, and grant departments autonomy to accomplish their goals. Such actions appear to reveal the core ideology and the entrepreneurial culture of the institution. Many institutional factors are related. Prevalent throughout the interviews was the view that one variable (how good you are) is totally dependent on two other variables (the intellectual caliber of the faculty

and how well the institution supports the faculty's work). These variables speak to the four factors identified in this study: people, processes, research capacity, and culture. Support was characterized by an institutional environment that allowed research to flourish: a stimulating intellectual atmosphere, investment funds for young investigators, a facilitating infrastructure, and a passion for research. Organizational structures can have many layers making processes slow and restrictive, but the highly competitive institutions ensured that their structures are efficient, flexible, and foster open communications between administrative, research, and academic units. Interviews at the more competitive institutions revealed that the entire organization understood the importance of research. Respondents said that if an institution does not create and maintain the ideal research environment, little can be done to recruit or retain bright scientists. Lastly, if the ideal environment does not remain in place, resources may not be used effectively and distinguished or potentially prominent faculty may leave. One interviewee asserted:

You keep [faculty] here because they are in a great intellectual environment.

Highly competitive institutions have cultures that promote and nurture research and administrations create systems to facilitate the research. For example, a defined strategy (concentrate research in the targeted areas being funded) must address the ever-changing environment (e.g., increased defense but decreased biomedical research). Institutions and scientists, attuned to the direction of research fields, will adjust and apply their research programs and disciplines based upon the needs of the time (Keefe, 2003).

Many institutions want to emulate successful organizations. Benchmarking the top 50 highly competitive research organizations is one logical approach because of their successful research-intensive programs. Without a research emphasis, institutions cannot make major scientific advances; to make advances, an institution needs active research programs that require creative faculty members. Building the research expertise requires a major effort and commitment; accordingly, an institution that desires national ranking must focus attention and resources on obtaining and retaining intellectual talent. Some faculty members have innate abilities for visionary research (i.e., they are extremely intelligent and insightful) whereas others lacking these qualities may stimulate their own progress working along side these intellectuals. This affirms that the appropriate working environment can stimulate progress. The findings of the study revealed two reasons why talented and prominent scholars leave institutions: the working atmosphere is no longer invigorating or a greater opportunity is provided elsewhere. An institution can control the first reason (internal environment) by creating an environment that encourages recruitment and retention of good talent. The institution cannot control the second (outside opportunity), but it can diminish the attractiveness provided elsewhere by maintaining its attractiveness.

Increased funding initiatives have allowed more institutions the opportunity to experience the benefits from performing research. Previously, institutions trying to increase their research efforts were inhibited to some degree from entering the research marketplace. Awarded grants covered long periods of time with some upwards of ten years. Long-term grants create barriers to enter the federal research marketplace as

committed grant money is unavailable for competition. Institutions could not compete until the next proposal request was solicited near the completion of the grant (five or ten years later). That is not the case today due to shorter grant periods allowing for more frequent proposal solicitations. This does not mean, however, that all institutions can or should try to become national competitors.

Some argue that generalizations cannot be inferred for other academic research-intensive institutions, because their overall structures and purposes are different. With patient care a major purpose, academic health institutions are unique in that most training is performed in hospitals rather than in a university campus setting. Similarities germane to this study could allow generalizations. Research-intensive institutions (regardless of type or size) possess the same crucial ingredients (researchers, scientists, and graduate students) and are competing and participating in the peer-reviewed research process when competing for federal grants. Most academic institutions also possess the same general missions: teaching, research, and service. Thus, the results of this study may be generalized to other institutions competing for federal research dollars.

Policy Implications

Knowing the strategies associated with research advancement has profound implications for those needing to make informed decisions about their capability to become major research competitors. Some national, politically motivated initiatives have attempted to level the playing field by having federal agencies fund specific states that historically have not received federal research monies (Brainard, 2002). Similar

initiatives have even occurred at the state and local levels. Nevertheless, research competition is intense, resources are limited, and the environment is volatile. Under these circumstances, the best policy should not be to distribute limited resources to many institutions in an attempt to level the playing field. In such a scenario, those limited resources would be spread too thin to be effective.

Governors, legislators, and higher education leaders aware of the requirements to become major research competitors may more easily exclude particular institutions from consideration. Deciding who should attempt to become the next nationally ranked research institution is a difficult choice. However, management approaches attributable to success have been identified in this study. Examining these management approaches, decision makers can determine which institutions are better prepared to perform competitive research at the national level. This action ensures that only the more capable institutions would be allocated available resources to seek research grants, acquire first-rate faculty, and support the best students. Reducing the futile efforts of want-to-be institutions will increase the effective use of limited institutional, state, and federal resources.

Increasing interest from institutions and legislators to develop the next nationally ranked research institution was another stimulus for this study. Presently, many institutions want to compete in the national research market. In 1999, the top 50 institutions expended 57% of federal R&D funding ($15.6 billion) whereas the next 50 institutions spent only 23% ($6.5 billion) (NSF, 2002). Said another way, the second 50 spent 42% of what the top 50 did. Undeniably, a state's or institution's return on its

investment needs to be considered; most institutions are not likely to achieve this very competitive goal. For example, the Texas Legislature, in its 2003 session, asked if Texas should have more research universities. If so, what are the costs and requirements? The answer to the question of should Texas have more research universities is yes. But the state can most effectively implement this action by developing those institutions with a highly supportive research environment and a strong research culture. The cost will be less if the state focuses on the few institutions that already have developed a strong research culture. However, it will be more expensive if the state spreads its limited resources to institutions that presently lack the capability to compete for federal funds.

Also, the increased research emphasis comes at a time of serious budget reductions at both the federal and state levels. Research has shown that only a small number of nontraditional research universities have become major competitors for federal funding opportunities. This finding suggests that supporting the more established research institutions and the few that have demonstrated the characteristics (i.e., people, processes, research capacity, and culture that support extensive research) required to compete successfully for federal funds is the best action. Dr. Susan Garges (2004), NIH National Institute of Allergy and Infectious Disease Program Officer, recently presented funding criteria that speak to this issue. The National Institute of Allergy and Infectious Diseases is the NIH agency principally responsible for bioterrorism-related research (Brainard and Borrego, 2003). The funding criteria are based on two questions. The first focuses on the national priority of threat assessment and asks, "What agent (e.g., virus) is the federal government (and its scientific experts) most worried about?" The second,

"How far along is the science the agency is considering funding?" Unless there is substantial evidence that a project will produce the desired results, this agency will not place money into the project. Limited resources and tightening budgets require that governing boards, legislators and donors be even more selective in supporting those institutions capable of being successful in this highly competitive research environment. An objective examination of the internal management structure of institutions being considered for advancement into the national research arena needs to be made.

Recommendations

Based on the findings of this study, several recommendations are evident. First, before deciding to spread resources to the many institutions, consider the effectiveness of such an action. If it is determined that resources would be better concentrated among more developed institutions, identify those institutions that could more easily go on to produce cutting-edge research. To do that, one would need to consider the four factors identified in this study: people, processes, research capacity, and culture. There must be a commitment, a consensus, and an infrastructure that ensures success. Furthermore, governors, legislators, and higher education leaders must maintain their political commitment over a long period of time. As Kerr (1994) noted, outstanding research universities have developed "in areas with effective and committed political leadership" (e.g., Governors Rockefeller, Brown, Kean, and Congressman Magnuson in New York, California, New Jersey, and Washington, respectively) (p. 171). A state cannot fund a program to develop research excellence in one year only to abolish the fund four years

later; building research capacity requires a long-term commitment. In addition, while some institutions can overcome their geographic location obstacles, others can not, and that makes recruitment more difficult. As part of the process to determine which institution is more established for competitive research, location should be considered as some sites have a better probability for success. Some area characteristics increase the likelihood of developing outstanding research universities: aggressive industrial leadership, larger hub cities, growing centers of progressive activity, and a rich cultural establishment (Kerr, 1994). Since it takes time to develop a strong research culture, a better initial choice for limited resource allocation would be to those institutions that are currently more research intensive.

These suggestions are illustrated in an interview response to the question, "What factors do you believe differentiate the institutions that improve in rankings from those that do not?"

> *If you can't do those things [recruit good talent, have facilities and financial resources to grow] or you don't have the vision to do those things, those schools are not going to grow. They'll grow some but…not in major steps. They lack resources…space…the faculty…the ability to recruit top faculty for whatever reasons. It may be because of where they're located. If they're located in North Dakota…the chances of…a major research center, medical research institution...is slim and none…If you look at the geographical distribution of the top 50 schools, they're on both coasts and there are pockets in the middle of the country. But there aren't very many…in fairly rural areas, for a lot of reasons.*

You can't really develop a major biomedical and medical center in a rural area. It just doesn't work. The resources are not there…The patients aren't there.

Lastly, a state should consider the policy implications for its public universities. Dunbar and Lewis (1998), Falcone (2001), and others have shown that private universities rank higher than their public counterparts in terms of faculty research productivity. However, in this study, the private-public distinction was not noted to be a factor for the more competitive institutions, although, the private institution did have the highest rank in terms of federally financed R&D expenditures. Institutional explanations (e.g., policies that free time for research) do not seem likely to explain the difference in rank. A better explanation may be state imposed (hiring, admission, and teaching load) requirements. Lacking the independence and adaptability to pursue a research mission or to remain focused on research impairs an institution's ability to perform research. During stringent budgetary times, institutions look to users and benefactors (i.e., federal government, students, private industry, foundations, and donors) for increased funding to counteract reduced funding. If one funding source is the federal government, then institutions must have the ability to act independently to compete for federal research funds (MacTaggart, 1998; Morphew and Baker, 2004). Tight state control does not allow public institutions to be proactive and respond quickly to market conditions.

Historically, states want their institutions to provide affordable, quality education for their citizens, and finance their own research agendas. Furthermore, these institutions must be accountable and responsive to taxpayers while simultaneously increasing access and maintaining significant faculty teaching loads (Jencks and Reisman, 1968). It must

be noted that some state goals (e.g., controlling faculty instructional hours to enhance undergraduate education) are incompatible with research universities. State controls on teaching (often in response to the public's outcry for improved undergraduate education) places pressure on institutions, faculty, and researchers to teach more while making it more difficult to support graduate students doing research (Murray, 2002). Similarly, Alpert (1985) contends "as universities become more dependent on external sources of support (e.g., research funding), their internal expenditure patterns will emphasize the functions that correspond with these sources of support (e.g., graduate education and the administration of research) while deemphasizing other functions such as instruction" (cited in Morphew and Baker, 2004, p. 368). Research universities attempting to simultaneously meet these goals may find them incompatible with success as a national research competitor.

If Texas wants to develop more nationally recognized research universities, then the governor, legislators, and higher education leaders need to first seek and obtain consensus on this goal and maintain a long-term commitment to it. The more established research-intensive institutions that possess the factors identified in this study (people, processes, research capacity, and culture) must be selected and supported.

Appendix A: List of Acronyms

BCM	Baylor College of Medicine
DoD	Department of Defense
DoE	Department of Energy
FY	fiscal year
IACUC	Institutional Animal Care and Use Committee
IRBs	Institutional Review Boards
MCAT	Medical College Admission Test
NIAID	National Institute of Allergy and Infectious Disease
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NSF	National Science Foundation
R&D	research and development
S&E	science and engineering
SAT	Scholastic Aptitude Test
TQM	Total Quality Management
U.S. N&WR	*U.S. News and World Report*
U. T.	The University of Texas
UT M. D. Anderson	U. T. M. D. Anderson Cancer Center
UT Southwestern	U. T. Southwestern Medical Center at Dallas
UT System	The University of Texas System
UTMB	U. T. Medical Branch at Galveston
WebCASPAR	Web Computer-Aided Science Policy Analysis and Research

Appendix B: Histories of the Three Texas Medical Institutions

BAYLOR COLLEGE OF MEDICINE

Organized in 1900 as the University of Dallas Medical Department (although no University of Dallas existed), BCM is the only private medical institution in Texas (Brown, 1984). In 1943, the medical college moved and was the first medical school to locate in Houston. Affiliated with Baylor University (Waco, Texas) in 1903, BCM separated from the university in 1969 to broaden its base of support, becoming an independent, nonsectarian, nonprofit corporation governed by a self-perpetuating board of trustees. Once independent, Dr. Michael E. DeBakey served as the first president. That same year (1969), BCM signed a partnership agreement with the State of Texas to provide medical education for Texas residents. Since 1971, BCM has received state appropriations for student enrollment. Baylor College of Medicine is affiliated with nine teaching hospitals and has three schools: School of Medicine, School of Allied Health Sciences, and Graduate School of Biomedical Sciences. Since 1969, BCM has had four presidents. Of these four, Drs. Michael DeBakey and William T. Butler both had long terms in office (10 and 17 years, respectively) and both continue to serve as officers of the BCM Board of Trustees. The current president, Dr. Peter G. Traber, was recruited from outside the institution (GlaxoSmithKline. having served as that company's Senior Vice President of Clinical Development and Medical Affairs).

Histories of the Three Texas Medical Institutions-Continued

THE UNIVERSITY OF TEXAS SOUTHWESTERN MEDICAL CENTER AT DALLAS

UT Southwestern was founded in 1943 in Dallas as a private medical school named Southwestern Medical College. The medical school replaced the exiting Baylor University School of Medicine when it moved to Houston. Many of the Baylor voluntary clinical faculty and about 100 students remained in Dallas and joined the new medical college. The institution started with meager resources, using World War II barracks as its facilities. Southwestern Medical College became part of The University of Texas System in 1949 and received its current name in 1987. UT Southwestern has three schools: School of Medicine, School of Allied Health Sciences, and Graduate School of Biomedical Sciences. The four hospitals on its campus are affiliated with other hospitals in North Texas. The University of Texas System oversees this institution and is governed by a Board of Regents whose nine members are appointed by the Governor of Texas. In 1972, the medical school's name and scope was changed during reorganization to The University of Texas Health Science Center at Dallas. The reorganization included having a president as Chief Executive Officer. Since the restructuring, UT Southwestern has had only two presidents: Drs. Charles C. Sprague and C. Kern Wildenthal (current), each with terms exceeding 14 years. Both were recruited from within the institution from their positions as Dean of the Medical School.

Histories of the Three Texas Medical Institutions-Continued

THE UNIVERSITY OF TEXAS MEDICAL BRANCH AT GALVESTON

The 17th Texas legislature authorized the founding of The University of Texas in Austin and the university's Medical Department in Galveston. Organized in 1890, UTMB opened in 1891 with one hospital and one school. Today, UTMB has six hospitals and four schools: School of Medicine, School of Allied Health Sciences, Graduate School of Biomedical Sciences, and School of Nursing. The UTMB governance structure is the same as UT Southwestern's. The University of Texas System oversees UTMB and is governed by a Board of Regents whose nine members are appointed by the Governor of Texas. Since 1975, the first year examined in this study, UTMB has had four presidents, three with terms of 10 or more years. The current president, Dr. Jack Stobo, was recruited in 1997 from his position as Vice Dean for Research at Johns Hopkins University.

Appendix C: Federal Science & Engineering (S&E) Support to the 100 Universities and Colleges: Fiscal Year 2000

Table B-12. Federal obligations for science and engineering to the 100 universities and colleges receiving the largest amounts, ranked by total amount received, by agency: fiscal year 2000

[Dollars in thousands]

Institution and ranking	Total	USDA	Com	DoD	ED	DOE	EPA	HHS	NASA	NSF	Other [1]
Total, all institutions	19,879,155	1,080,910	313,563	2,007,117	182,687	696,197	148,334	11,319,347	1,015,881	2,823,651	291,468
1 Johns Hopkins Univ.	933,245	590	275	371,852	470	1,921	2,384	429,786	95,997	20,158	9,812
2 University of Washington	444,625	4,305	11,496	35,150	0	14,385	4,643	314,050	8,900	48,009	3,687
3 U of CA Los Angeles	398,565	0	50	25,282	0	21,288	6,016	300,569	10,218	34,903	239
4 Stanford University	377,918	185	57	37,637	2,966	20,664	2,348	213,023	48,231	52,385	422
5 U of Michigan	377,574	663	4,680	28,248	4,232	11,613	3,678	266,461	8,014	46,241	3,744
6 U of Pennsylvania	373,963	783	0	12,630	2,800	7,566	336	326,247	1,429	21,829	343
7 U of CA San Diego	357,629	112	413	30,991	0	10,423	267	194,140	22,202	95,460	3,621
8 Harvard University	330,683	157	526	11,591	2,701	6,303	3,817	262,323	8,265	29,705	5,295
9 U of Colorado	324,210	675	33,024	14,517	1,148	5,784	1,175	167,775	59,269	38,988	1,855
10 U of CA San Francisco	314,973	0	0	1,384	0	717	0	308,949	431	3,492	0
Total 1st 10 institutions	4,233,385	7,470	50,521	569,282	14,317	100,664	24,664	2,783,323	262,956	391,170	29,018
11 Columbia U City NY	309,933	0	0	6,677	0	8,149	1,721	231,239	11,838	50,047	262
12 U of Minnesota	309,632	29,126	1,516	41,993	1,550	10,943	854	177,488	4,637	38,561	2,964
13 Washington University	303,684	1,135	6	1,364	1,605	2,229	3,838	280,983	4,303	8,218	3
14 U of WI Madison	303,126	29,059	1,709	9,444	0	22,256	1,233	170,742	12,222	54,557	1,904
15 Yale University	279,540	1,033	50	7,805	286	9,439	453	243,200	2,879	14,370	25
16 Cornell University	271,564	34,094	440	19,368	0	3,831	718	127,719	6,029	78,218	1,147
17 MA Inst of Technology	269,030	0	2,925	54,303	0	58,428	3,181	75,237	21,536	51,725	1,695
18 PA St U University Park	264,262	22,959	815	103,398	653	7,236	2,121	73,871	16,001	34,232	2,976
19 U of Pittsburgh	261,984	212	0	8,910	1,367	2,601	381	229,637	2,919	15,317	640
20 U of NC Chapel Hill	254,736	1,021	100	4,934	3,415	1,413	4,332	218,010	1,201	15,685	4,625
Total 1st 20 institutions	7,060,876	126,109	58,082	827,478	23,193	227,189	43,496	4,611,449	346,521	752,100	45,259
21 Duke University	245,017	1,007	286	11,944	900	6,774	515	202,861	1,160	19,202	368
22 U of CA Berkeley	223,085	3,980	0	23,556	0	8,274	896	99,339	23,716	61,551	1,773
23 U of Southern California	215,200	0	2,880	57,320	1,396	1,702	0	123,252	4,588	22,297	1,765
24 Baylor Col of Medicine	197,295	1,083	0	4,121	300	750	210	173,421	16,821	589	0
25 U of AL Birmingham	196,225	0	0	6,576	589	2,886	0	167,901	13,329	4,544	400

Federal S&E Support to the 100 Universities and Colleges: Fiscal Year 2000-Continued

[Dollars in thousands]

Institution and ranking	Total	USDA	Com	DoD	ED	DOE	EPA	HHS	NASA	NSF	Other [1]
26 U of IL Urbana-Champaign	189,713	29,727	41	21,535	0	4,279	670	37,587	4,048	88,458	3,368
27 Case Western Reserve U	188,829	120	30	4,255	0	1,837	0	172,257	4,766	5,564	0
28 U of CA Davis	182,208	35,139	74	6,437	0	17,433	2,630	79,630	2,289	38,008	568
29 University of Arizona	181,579	13,488	645	14,668	332	3,430	902	89,459	18,663	37,427	2,565
30 Ohio State U	162,313	28,844	1,272	11,130	1,791	6,374	149	80,016	2,859	24,922	4,956
Total 1st 30 institutions	9,042,340	239,497	63,310	989,020	28,501	280,928	49,468	5,837,172	438,760	1,054,662	61,022
31 University of Rochester	161,689	0	428	5,399	0	35,581	1,999	108,788	1,377	8,117	0
32 Northwestern University	160,832	195	72	15,400	900	5,094	432	111,185	1,526	25,009	1,019
33 U of TX Austin	159,849	11	50	73,248	1,265	11,653	5,225	26,488	10,797	29,963	1,149
34 Emory University	159,705	0	0	1,293	0	875	0	148,434	122	8,751	230
35 University of Chicago	157,500	430	0	1,047	342	3,342	125	124,080	3,495	23,963	676
36 Vanderbilt University	151,449	0	0	9,883	680	1,522	0	130,335	1,103	7,926	0
37 CA Inst of Technology	150,366	0	85	19,930	0	11,367	102	30,523	29,323	58,133	903
38 University of Florida	150,337	27,995	429	14,752	0	4,835	292	74,904	3,425	21,376	2,329
39 University of Iowa	148,421	152	206	3,010	0	1,985	221	128,988	4,668	9,053	138
40 Boston University	147,263	0	93	11,610	125	3,602	36	112,701	4,008	15,004	84
Total 1st 40 institutions	10,589,751	268,280	64,673	1,144,592	31,813	360,784	57,900	6,833,598	498,604	1,261,957	67,550
41 Scripps Rsch Inst, The	142,016	0	0	3,324	0	970	0	134,782	1,330	1,610	0
42 U of MD College Park	139,673	11,642	7,290	13,186	1,443	9,131	3,986	17,029	36,553	37,834	1,579
43 NY University	136,888	0	103	8,387	0	3,006	2,581	109,369	479	12,963	0
44 Indiana U	135,090	330	226	2,453	80	6,254	11	98,090	1,110	26,223	313
45 U of Virginia	133,785	57	644	8,204	2,211	2,861	440	96,375	5,093	15,643	2,257
46 University of Utah	133,033	73	893	5,352	0	5,088	180	100,642	2,075	17,767	963
47 U of TX SW Med Ctr Dals	126,389	0	0	2,199	0	0	0	123,190	616	384	0
48 University of Miami	125,383	0	7,613	7,511	250	606	891	90,618	5,394	12,291	209
49 CUNY Mt Sinai Schl of Med	123,679	0	0	2,434	0	115	698	119,398	1,034	0	0
50 Oregon Hlth Sciences U	118,421	0	0	599	0	10	0	116,672	260	880	0
Total 1st 50 institutions	11,904,108	280,382	81,442	1,198,241	35,797	388,825	66,687	7,839,763	552,548	1,387,552	72,871
51 U Corp for Atmosph Rsch	116,680	0	16,986	919	0	2,077	127	0	3,677	92,875	19
52 Yeshiva University NY	115,841	110	0	881	0	376	0	112,721	915	838	0
53 Michigan State University	114,848	29,692	431	2,554	702	6,296	1,092	28,275	2,628	41,760	1,418
54 U of IL Chicago	111,829	0	181	2,354	0	1,904	292	91,075	922	14,802	299

Federal S&E Support to the 100 Universities and Colleges: Fiscal Year 2000-Continued

[Dollars in thousands]

Institution and ranking	Total	USDA	Com	DoD	ED	DOE	EPA	HHS	NASA	NSF	Other [1]
55 Purdue University	107,299	29,131	1,811	12,731	375	5,883	925	29,705	1,750	22,423	2,565
56 Rutgers St U of NJ	105,843	12,955	2,606	7,330	2,824	5,958	457	38,371	4,670	29,935	737
57 U of Kentucky All Cmp	103,344	20,181	0	1,499	0	4,501	150	63,385	1,016	11,983	629
58 U of CA Irvine	102,447	218	20	4,801	0	5,821	320	68,050	7,494	15,723	0
59 U of MD Baltimore	99,000	0	509	3,290	0	278	1,993	91,626	125	688	491
60 LA St U All Campuses	98,363	15,780	2,841	19,630	0	2,090	2,221	40,990	1,990	9,486	3,335
Total 1st 60 institutions	12,979,602	388,449	106,827	1,254,230	39,698	424,009	74,264	8,403,961	577,735	1,628,065	82,364
61 U of Missouri Columbia	98,332	24,789	117	3,284	0	6,354	2,154	29,607	16,124	15,128	775
62 Carnegie Mellon U	95,881	77	197	30,978	0	3,514	3,436	12,943	8,122	36,484	130
63 U of Med & Dent of NJ	95,291	150	0	623	0	3,000	431	89,757	372	657	301
64 Princeton University	94,086	0	2,474	13,659	0	8,861	476	29,809	4,622	33,834	351
65 U of New Mexico	92,780	42	123	24,878	442	4,165	977	43,662	5,899	12,200	392
66 U of TX MD Anderson Cancr	92,691	0	0	4,135	0	0	0	87,854	383	319	0
67 Texas A&M U	91,167	38,533	3,313	9,536	463	3,382	159	12,556	5,880	12,458	4,887
68 Georgetown University	91,160	0	56	24,548	0	0	0	60,585	13	1,323	4,635
69 NC State U	90,745	34,400	4,827	11,552	635	3,105	1,307	10,253	2,421	19,457	2,788
70 SUNY at Stony Brook	89,734	436	333	5,039	0	6,837	90	52,803	1,954	22,193	49
Total 1st 70 institutions	13,911,469	486,876	118,267	1,382,462	41,238	463,227	83,294	8,833,790	623,525	1,782,118	96,672
71 U of TX Houston Hlth Sci	88,990	0	0	484	0	0	288	86,867	846	505	0
72 Colorado State University	84,728	16,471	7,874	6,499	333	2,741	1,440	29,182	4,107	14,214	1,867
73 U of Hawaii Manoa	84,431	8,006	10,356	5,233	0	344	127	28,473	10,216	21,676	0
74 U of Cincinnati	83,383	200	0	3,790	421	1,156	760	71,070	804	5,167	15
75 University of Georgia	82,911	29,916	1,770	824	125	3,694	611	24,383	298	17,477	3,813
76 Oregon State University	81,357	16,056	6,454	6,148	0	2,279	3,922	9,250	6,777	23,807	6,664
77 Wayne State University	78,815	0	204	4,412	149	1,043	0	62,642	457	9,893	15
78 U of MA Worcester	77,743	0	0	1,574	0	0	0	75,457	541	171	0
79 U of TX Hlth Sci S Anto	77,731	0	0	10,608	0	0	504	65,557	313	749	0
80 Wake Forest University	77,267	0	0	754	0	0	0	75,105	205	991	212
Total 1st 80 institutions	14,728,825	557,525	144,925	1,422,788	42,266	474,484	90,946	9,361,776	648,089	1,876,768	109,258

Federal S&E Support to the 100 Universities and Colleges: Fiscal Year 2000-Continued

[Dollars in thousands]

Institution and ranking	Total	USDA	Com	DoD	ED	DOE	EPA	HHS	NASA	NSF	Other [1]
81 Woods Hole Ocean Inst	76,935	0	6,480	18,962	0	816	645	435	913	48,186	498
82 U of CA Santa Barbara	75,745	27	114	19,799	0	3,615	164	8,750	7,716	32,756	2,804
83 U of Connecticut	73,292	6,006	2,817	5,344	0	827	477	46,015	784	9,847	1,175
84 Dartmouth College	69,694	1,570	854	4,641	150	473	10	53,158	1,628	7,210	0
85 Thomas Jefferson U	69,652	0	0	2,235	0	366	0	66,710	224	117	0
86 Medical Col of Wisconsin	69,561	0	0	0	0	0	0	68,686	42	333	500
87 Georgia Inst of Tech	69,539	0	4,093	25,085	0	1,364	1,399	5,213	4,636	27,586	163
88 University of Kansas	69,527	120	100	3,591	3,880	3,673	149	45,000	1,657	11,083	274
89 U of TX Med Brnch Galvstn	66,512	0	540	428	150	619	0	63,346	846	583	0
90 Mississippi State U	66,293	25,363	3,085	15,290	639	5,336	1,187	415	7,684	6,932	362
Total 1st 90 institutions	15,435,575	590,611	163,008	1,518,163	47,085	491,573	94,977	9,719,504	674,219	2,021,401	115,034
91 Iowa State University	64,805	31,019	2,080	1,626	904	3,661	740	9,507	2,274	11,465	1,529
92 University of Vermont	64,370	8,038	0	1,132	701	750	918	48,754	534	3,305	238
93 Virginia Poly Inst & St U	63,910	17,122	251	13,625	0	8,149	576	3,900	1,984	14,408	3,895
94 Medical U of S Carolina	63,745	180	8,325	803	0	1,522	124	51,490	259	1,042	0
95 Brown University	62,581	0	106	8,793	294	2,649	38	34,719	2,549	13,353	80
96 Virginia Commonwealth U	62,096	0	0	1,608	803	221	284	51,893	3,015	2,755	1,517
97 Rockefeller University	59,749	0	0	284	0	910	0	57,682	0	873	0
98 U of Oklahoma	57,714	218	7,828	3,315	0	1,786	100	30,531	1,705	11,434	797
99 Washington State U	56,833	20,656	110	4,553	487	5,772	64	14,895	944	8,393	959
100 Utah State University	56,736	8,674	0	26,222	2,233	185	229	6,281	7,542	4,528	842
Total 1st 100 institutions	16,048,114	676,518	181,708	1,580,124	52,507	517,178	98,050	10,029,156	695,025	2,092,957	124,891

[1] See General Notes.

KEY: USDA = Department of Agriculture Com = Department of Commerce DoD = Department of Defense
ED = Department of Education DOE = Department of Energy EPA = Environmental Protection Agency
HHS = Department of Health and Human Services NASA = National Aeronautics and Space Administration
NSF = National Science Foundation

NOTES: Tied institutions are listed in alphabetical order.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions, Fiscal Year 2000

Appendix D: Federal Support and Expenditures Data for the Three Texas Medical Institutions Examined: Fiscal Year 1971-2000

Federally Financed R&D Expenditures Rank (Dollars in thousands)

	1972	2000					1972	1973	1974	1975	1976
BCM	49	25					11,560	13,235	15,650	18,118	20,549
UT Southwestern	103	48					4,379	4,941	5,349	6,898	11,760
UTMB	117	90					3,705	4,224	4,430	5,841	6,283

Total R&D Expenditures

	1972	1986	1999	2000			1972	1973	1974	1975	1976
BCM	65	52	28	24			13,056	15,134	17,172	19,643	22,923
UT Southwestern	116	69	53	52			5,484	6,258	6,969	8,436	14,476
UTMB	119	115	96	98			5,345	6,534	7,649	9,099	10,409

Federal Obligations for S&E

	1971	1972	1999	2000		1971	1972	1973	1974	1975	1976
BCM	51	58	29	24		14,334	13,721	16,473	21,967	20,273	19,659
UT Southwestern	68	----- -	49	47		9,783	0	9,594	12,618	12,648	13,111
UTMB	124	129	84	89		4,092	4,370	4,215	6,395	6,680	6,741

CONTINUED

Federally Financed R&D Expenditures

		1977	1978	1979	1980	1981	1982
BCM		21,063	21,330	26,304	31,211	34,054	35,852
UT Southwestern		13,383	15,673	17,872	20,871	23,890	25,121
UTMB		7,219	7,618	8,702	10,387	11,349	10,632

Total R&D Expenditures

		1977	1978	1979	1980	1981	1982
BCM		23,355	27,431	33,676	37,908	44,733	48,661
UT Southwestern		16,755	19,719	22,613	26,586	29,868	32,058
UTMB		11,858	11,899	13,835	16,041	17,612	18,272

Federal Obligations for S&E

		1977	1978	1979	1980	1981	1982
BCM		21,641	27,689	30,887	33,279	36,815	38,686
UT Southwestern		17,252	18,388	22,782	24,734	26,352	26,161
UTMB		8,219	9,012	11,533	12,368	10,875	10,617

Federal Support and Expenditures Data for the Three Texas Medical Institutions Examined: Fiscal Year 1971-2000--Continued

CONTINUED

(Dollars in thousands)

Federally Financed R&D Expenditures

Institution	1983	1984	1985	1986	1987	1988	1989	1990	1991
BCM	36,772	37,378	41,749	46,729	49,834	60,825	69,336	75,793	78,752
UT Southwestern	26,561	29,175	34,087	38,504	45,382	48,357	51,254	54,965	57,746
UTMB	10,428	11,595	13,876	15,307	16,738	19,717	23,152	21,693	20,974

Total R&D Expenditures

Institution	1983	1984	1985	1986	1987	1988	1989	1990	1991
BCM	54,986	56,746	63,197	68,993	90,179	106,814	134,681	155,122	161,084
UT Southwestern	36,456	42,461	46,671	52,619	62,907	70,392	79,920	85,919	94,511
UTMB	19,011	19,515	22,273	23,312	24,351	33,047	38,717	40,610	45,086

Federal Obligations for S&E

Institution	1983	1984	1985	1986	1987	1988	1989	1990	1991
BCM	37,062	41,272	48,321	50,125	58,377	66,127	72,715	76,110	87,593
UT Southwestern	30,281	35,294	40,443	43,274	49,564	50,233	52,642	54,616	59,837
UTMB	11,422	13,727	17,846	17,987	20,911	22,752	24,253	21,652	26,345

CONTINUED

Federally Financed R&D Expenditures

Institution	1992	1993	1994	1995	1996	1997	1998	1999	2000
BCM	85,734	87,623	92,404	94,197	92,294	97,829	110,610	141,111	193,249
UT Southwestern	61,499	67,943	71,468	78,892	81,468	89,357	97,200	101,996	109,165
UTMB	24,281	30,555	32,775	33,204	38,323	42,006	48,588	55,061	61,357

Total R&D Expenditures

Institution	1992	1993	1994	1995	1996	1997	1998	1999	2000
BCM	167,998	172,252	186,865	190,375	184,613	192,744	216,528	272,198	334,175
UT Southwestern	102,263	114,258	118,398	125,301	130,162	140,589	153,711	165,520	189,216
UTMB	57,672	67,998	72,773	72,569	73,759	77,683	86,488	93,580	97,896

Federal Obligations for S&E

Institution	1992	1993	1994	1995	1996	1997	1998	1999	2000
BCM	89,304	92,755	104,211	91,209	98,072	105,115	134,066	167,954	197,295
UT Southwestern	63,950	65,314	77,368	78,776	88,488	96,489	96,585	106,689	126,389
UTMB	31,505	29,748	33,821	39,014	45,223	49,292	51,081	55,880	66,512

Source: National Science Foundation, Survey of Federal S&E Support to Universities, Colleges, and Nonprofit Institutions

Appendix E: Interview Outline

May I have your permission to record this interview? I would like to transcribe it and have it available for future reference.

In my research, I define competitive research institutions as those institutions that are ranked in the top 50 in federally financed research and development expenditures. Less competitive institutions are ranked in positions 51 or lower. Highly competitive institutions are those that consistently improve their rankings. Based on your experience, what would you say are the success factors for being a major research competitor?_____
What factors do you believe differentiate the more competitive institutions from the less competitive institutions ranked in positions 51 to 100?_____
What factors do you believe differentiate the institutions that improve in rankings from those that do not?

Eight themes have been identified in my literature review that may be relevant to an institution's ability to compete for research dollars. I would like to get your opinion on these.

1. In your experience, are institutional STRATEGIES an integral part of your institution's ability to acquire and maintain research capacity? If so, what role does it play? Please describe any strategies or concerted plans that allowed your institution to be a major competitor. What competitive advantages were identified at your institution? How were those advantages exploited?

   Were the strategies successful? If so, why? If not, why not? Please describe the events (unforeseen or anticipated) that created a need for the institution to change direction or revise strategy.

2. Do you believe an institution's ORGANIZATIONAL STRUCTURE can contribute to or restrict its capability to perform research and successfully compete for research grants? By "successfully compete" I mean acquiring research grants to be ranked at least in the top 100 as measured by federally financed research and development expenditures. How would you describe your administration and management structures? How is your institution organized to identify its competitive advantage(s) in changing environments? How is your institution organized to exploit its competitive advantage(s)?

   Describe your institution's governance structure and governing board. What characteristics of your institution's organizational structure facilitated or impeded the institution's ability to be ranked in the top 100 or to improve your ranking? How is the administration able to support research? What roles do research institutes and centers play relative to academic departments and colleges?

Interview Outline-Continued

3. Do you think your institutional PROCESSES can impact the institution's ability to be a major research competitor? By "processes" I mean the institution's practices, procedures, and policies. If so, how, and would you please give specific examples? Do any of these processes reinforce or weaken the cultural values of the research organization?

4. Do you consider particular PEOPLE to have been critical to your institution's ability to acquire research dollars? If so, tell me about the individuals that you have found to be especially important in either a positive or negative way. What did they contribute and what were their most significant personality characteristics?

   How would you compare the people today to those of the past three decades? What personal characteristics would you look for in recruiting and/or developing the critical individuals in a research institution? Would you look for different personality characteristics in a top ranked institution than in an institution with aspirations to move into the top ranks?

5. How critical is financial SUPPORT from non-federal sources in your institution's ability to acquire federal research funds? How is it most effectively used? What role does it play? How necessary is it for cost sharing, for preliminary studies, to recruit and develop new talent before the institution can compete for federal funds? If grants don't exist at the time of recruitment, what funds absorb these increased expenditures until a grant is in place to cover such costs? Are some funding sources more important than others? If so, which ones?

6. Do you feel that particular REWARDS OR INCENTIVES are necessary to attract and to maintain talented researchers? If so, what types of rewards and incentives are required? What are the most important factors in recruiting and retaining research talent?

7. RESEARCH CAPACITY is an institution's ability to perform research because of its expertise, established record, and reputation. It is revealed through awarded research grants and the amount of research expenditures. How has an established research capacity given you a competitive advantage as national priorities have changed? What has your institution done to build capacity to address research that may be fundable in the future?

8. The last theme is POLITICS. Do you believe politics had any impact on your institution's ability to be a major research competitor? If so, why? If not, why not? Please provide some examples to clarify your point? At what level, national, state, or local, has politics been most important?

Appendix F: Interviewee List

Name/Current Association	Position and Term in Office
Perrie M. Adams, Ph.D. UT Southwestern	Associate Dean for Research (1985-present) Professor, Psychiatry (1985-present) Acting chair, Biomedical Communications (1992-present) *Dr. Adams also was employed at UTMB (1970-1985). His professorial roles at UTMB: Psychiatry and Behavioral Sciences and Pharmacology and Toxicology
Bobby R. Alford, M.D. BCM	Executive Vice President and Dean of Medicine (1967-present) Chairman, Otorhinolaryngology & Communicative Sciences Professor (1967-present)
Richard Gibbs, Ph.D. BCM	Director, Human Genome Sequencing Center (1996-present) Professor, Department of Molecular and Human Genetics (1991-present)
James W. Patrick, Ph.D. BCM	Executive Vice President and Dean of Medicine (1998-present) Chairman, National Space Biomedical Research Institute Professor and Head, Division of Neuroscience (1989-present) Professor, Molecular Physiology & Biophysics (1989-present)
Adrian A. Perachio, Ph.D. UTMB	Vice President for Research (2001-2004) Professorial roles: Otolaryngology, Physiology & Biophysics, and Anatomy & Neurosciences (1979-present)
Don W. Powell, M.D. UTMB	Chairman, Internal Medicine (1991-2002) Professor, Physiology and Biophysics (1991-present)
Donald Seldin, M.D. UT Southwestern	Professor and Chairman, Internal Medicine (1952-1988) Professor Emeritus, Dept. of Nephrology (1988-present)
David H. Walker, M.D. UTMB	Professor and Chairman, Dept. of Pathology (1987-present) Executive Director, Center for Biodefense & Emerging Infectious Diseases (1987-present)

Appendix G: Case Study Comparisons of Total Research & Development Expenditures by Source of Funds: 1975 to 2000

Institution	2000	2000 % Total	1995	1990	1985	1980	1975	1975 % Total
Baylor College of Medicine								
(Presidents & terms)		Ralph Feigen (1996-2003)		William T. Butler (1979-96)			Michael DeBakey (1969-79)	
Total	334,175,000	100.0%	190,375,000	155,122,000	63,197,000	37,908,000	19,643,000	100.0%
federal government	193,249,000	57.8%	94,197,000	75,793,000	41,749,000	31,211,000	18,118,000	92.2%
state & local govt	2,714,000	0.8%	4,606,000	4,409,000	0	0	1,000	0.0%
industry	17,578,000	5.3%	12,217,000	7,746,000	4,241,000	2,801,000	124,000	0.6%
institutional funds	49,443,000	14.8%	24,331,000	17,600,000	8,034,000	836,000	0	0.0%
all other sources	71,191,000	21.3%	55,024,000	49,574,000	9,173,000	3,060,000	1,400,000	7.1%
Federal Obligations	197,295,000		91,209,000	76,110,000	48,321,000	33,279,000	20,273,000	
U. T. Southwestern Medical Center at Dallas								
(Presidents & terms)		C. Kern Wildenthal (1986-present)					Charles Sprague ([1967] 1972-86)	
Total	189,216,000	100.0%	125,301,000	85,919,000	46,671,000	26,586,000	8,436,000	100.0%
federal government	109,165,000	57.7%	78,892,000	54,965,000	34,087,000	20,871,000	6,898,000	81.8%
state & local govt	11,320,000	6.0%	6,531,000	31,000	30,000	686,000	0	0.0%
industry	14,861,000	7.9%	14,986,000	8,537,000	3,967,000	1,319,000	538,000	6.4%
institutional funds	5,317,000	2.8%	1,364,000	4,633,000	64,000	75,000	0	0.0%
all other sources	48,553,000	25.7%	23,528,000	17,753,000	8,523,000	3,635,000	1,000,000	11.9%
Federal Obligations	126,389,000		78,776,000	54,616,000	40,443,000	24,734,000	12,648,000	
U. T. Medical Branch at Galveston								
(Presidents & terms)		John Stobo (1997-present)		Thomas James (1987-97)			William C. Levin (1974-87)	
Total	97,896,000	100.0%	72,569,000	40,610,000	22,273,000	16,041,000	9,099,000	100.0%
federal government	61,357,000	62.7%	33,204,000	21,693,000	13,876,000	10,387,000	5,841,000	64.2%
state & local govt	8,588,000	8.8%	9,785,000	5,519,000	1,002,000	818,000	1,402,000	15.4%
industry	6,146,000	6.3%	5,991,000	2,260,000	917,000	467,000	397,000	4.4%
institutional funds	11,236,000	11.5%	15,027,000	6,088,000	4,756,000	2,784,000	0	0.0%
all other sources	10,569,000	10.8%	8,562,000	5,050,000	1,722,000	1,585,000	1,459,000	16.0%
Federal Obligations	66,512,000		39,014,000	21,652,000	17,846,000	12,368,000	6,680,000	

Sources: National Science Foundation/DSRS, Survey of Federal S&E Support to Universities, Colleges, and Nonprofit Institutions, and Survey of R&D Expenditures at Universities and Colleges.

Description: Federally financed R&D expenditures: awards for R&D in S&E, including direct & reimbursed indirect costs, by all agencies of the Federal government. S&E Totals include R&D; R&D Plant; Facilities & Equip for instruction; Fellowships, Traineeships, & Training Grants; General support for S&E; other S&E activities.

Appendix H: Cross-Case Comparisons of Research Performance Indicators for the Three Texas Medical Institutions Examined

	BCM	UT Southwestern	UTMB
Total Student Headcount (2000)--	1192	1505	1927
Enrollment (1988-89)+	1068	1458	2161
Enrollment (1980-81)(#)	857	1322	1586
Enrollment (1976-77)(#)	739	1240	1190
Enrollment (1970-71)(#)	477	503	811
Full-time Faculty (2000)**	1696	1114	890
Full-time Faculty (1997)**	1422	1021	896
Faculty (1984-85) (#)	1182	953	974
Faculty (1976-77) (#)	702	565	699
Faculty (1970-71) (#)	520	318	450
Nobel Laureates on Faculty (2000)	0	4	0
Nobel Laureates on Faculty (1975)	0	0	0
American/National academy mbrs (1996-2000)*	4	6	1
American/National academy mbrs (1986-95)	9	15	1
American/National academy mbrs (1976-85)	1	9	0
American/National academy mbrs (in 1975)	0	3	0
Faculty awards (2000)--	13	19	1
Faculty awards (1999)--	15	28	1
Doctorates granted (2000)--	61	55	35
Doctorates granted (1998)--	49	65	30
Postdoctoral appointees (2000)--	430	543	215
Postdoctoral appointees (1998)--	406	400	285
Endowment Assets, Market Value (2000)--	1,044,685,000	713,253,000	342,602,000
Endowment Assets, Market Value (1999)--	1,029,156,000	406,415,000	243,849,000
Endowment Market Value (1988-89)+	NA	56,688,758	57,866,420
Endowment Market Value (1982-83)+	92,900,000	11,228,667	14,348,667
Endowment Market Value (1977-78)+	23,621,370	Not in report	Not in report
Endowment and Gifts Revenue (2000)**	72,323,852	19,219,509	9,388,798
Endowment and Gifts Revenue (1999)**	49,055,281	13,055,876	5,977,264
Endowment and Gifts Revenue (1998)**	51,727,679	10,517,023	4,882,071
Endowment and Gifts Revenue (1997)**	28,648,254	10,697,547	5,249,925
Endowment Income (2000) **	41,641,882	13,776,231	5,968,223
Endowment Income (1997) **	18,025,271	5,854,665	1,739,945

Cross-Case Comparisons of Research Performance Indicators for the Three Texas Medical Institutions Examined-Continued

	BCM	UT Southwestern	UTMB
Annual giving (2000)--	92,078,000	115,033,000	34,969,000
Annual giving (1999)--	63,647,000	64,393,000	24,380,000
Total Annual Giving (1988-89)+	19,715,450	20,522,748	26,799,916
Total Annual Giving (1982-83)+	16,226,918	16,527,311	10,846,632
Licensing Income 1999	12,280,879	4,856,751	108,857
(# Licenses & Patents) 1999	(110 & 25)	(57& 27)	(10 & 21)
Licensing Income 1998	7,247,178	3,865,940	NA
(# Licenses & Patents) 1998	(102 & 18)	(52 & 33)	
Licensing Income 1994	1,900,000	2,673,000	NA
(# Licenses & Patents) 1994	(76 & 8)	(27 & 12)	
Median MCAT (data was not accessible)			

Sources: NSF/DSRS, Survey of R&D Expenditures at Universities & Colleges; NSF/DSRS, Graduate Students and Postdoctorates in Science and Engineering: Fall 2000 (Table B32); Mullins (2002, June); The Chronicle of Higher Education Almanac Issue 2001-2, August 31, 2001, Volume XLVIII, Number 1; 2002-3, August 31, 2002, Volume XLIX, Number 1

*The National Academies, National Academy of Sciences (NAS) and Institute of Medicine (IOM), accessed 3/17/04: http://www4.nationalacademies.org/nas/naspub.nsf/urlinks/$$institutionA?OpenDocument&Count-50000 http://www.iom.edu/directory.asp;

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