MOVING UP IN THE RANKINGS*

Creating and Sustaining a World-Class Research University

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ABSTRACT

The globalization of university-based engineering education and research is associated with the creation of national and international "brands" by leading research universities. Such branding is reflected in rankings of universities and their programs. High brand visibility appears to lead to high rankings and vice versa. This paper explores this phenomenon for university-based engineering programs. Attributes associated with ranking systems are discussed and universities' abilities to influence these attributes are considered. Both moving up in the rankings and sustaining highly ranked positions are discussed. These issues are addressed both in general and for the specific case of Georgia Tech. Three fundamental conclusions are reached: research and education continue to be the key to universities achieving world class status and economic development for key stakeholders; size provides universities with the resources and abilities to pursue strategies that lead to increasing recognition; and vision and leadership both attract resources and enable the focus needed to achieve the highest levels of recognition.

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INTRODUCTION

The pre-World War II 20th century provided a hotbed of research in physical sciences and mathematics. Physics and computing are of particular note. However, the modern research university, particularly in the U.S., emerged following World War II. Vannevar Bush, a 20th century leader in engineering and science, was instrumental in defining the vision.

Bush articulated the central principles in Science: The Endless Frontier (1946):

- The federal government shoulders the principal responsibility for the financial support of basic scientific research.
- Universities – rather than government laboratories, non-teaching research institutes, or private industry – are the primary institutions in which this government-funded research is undertaken.
- Although the federal budgetary process determines the total amount available to support research in various fields of science, most funds are allocated not according to commercial or political considerations but through an intensely competitive process of review conducted by independent scientific experts who judge the quality of proposals according to their scientific merits alone.

Perhaps not surprisingly, Bush's home university, the Massachusetts Institute of Technology (MIT), was very successful in adopting these principles. James Killian, MIT president from 1949 to 1959, notes that "From MIT's founding, the central mission had been to work with things and ideas that were immediately useful and in the public interest. This commitment was reinforced by the fact that many faculty members had had during the war direct and personal experience in public services." (Killian, 1985, p. 399).

He reports that MIT's relationship with the federal government reached new heights with World War II:

- MIT took on critical challenges, e.g., the Sage missile defense system and the Whirlwind computing project
- Faculty and alumni served in important advisory roles in the federal government
- Faculty, including two MIT presidents, served in senior executive positions, on leave from MIT

As a consequence, MIT became and remains a national resource, perhaps the key player in "big science." In the process, MIT was transformed into a university. This was facilitated by several factors (Killian, 1985):

- A single, unfragmented faculty in consort with one central administration

- Close articulation of research and teaching, of basic science and applied science
- Continuous spectrum of undergraduate and graduate studies
- Mobility of ideas resulting from the high permeability of the boundaries of both departments and centers
- The extensive interconnection of its buildings

MIT, and a handful of other leading institutions such as The University of California at Berkeley, California Institute of Technology, University of Illinois, and Stanford University, led the way defining the nature and "rules of the games" for research universities. In the process, science and technology has become central to our economy. As Richard Levin, former president of Yale University, indicates, "Competitive advantage based on the innovative application of new scientific knowledge – this has been the key to American economic success for at least the past quarter century." (p. 88). He asserts that the success of this system is evident: The U.S. accounts for 33% of all scientific publications, has won 60% of Nobel Prizes, and its universities account for 73% of papers cited in U.S. patents (Levin, 2003).

However, it is not clear that this traditional model is sustainable. James Duderstat (2000), former president of the University of Michigan, summarizes several areas of concern identified in a National Science Foundation study:

- Public support has eroded with continual decline throughout the1990s
- Limits on indirect costs have resulted in cost shifting
- The focus on research funding has changed the role of the faculty
- Increased specialization has changed the intellectual makeup of academia

He argues that the real issue is a shifting paradigm for universities. National priorities have changed, although recent security concerns have moderated this trend. The disciplines have been deified, yielding a dominance of reductionism. This presents a challenge for interdisciplinary scholarship, particularly in terms of valuing a diversity of approaches and more flexible visions of faculty career paths. At the same time, undergraduate education is receiving increased attention, as have cultural considerations that, he cautions, tend to encourage "belongers" rather than "doers."

Ruminating on the roles of publicly supported research universities, Duderstat suggests several possibilities for strategies that universities can pursue as a response to current challenges:

- Isolation: Stick with prestige and prosperity, e.g., MIT, Caltech, Princeton, Chicago

- Pathfinders: Participate in experiments creating possible futures for higher education
- Alliances: Allying with other types of educational institutions
- Core-in-Cloud Models: Elite education and basic research departments surrounded by broader array of entities

Derek Bok, recent president of Harvard University, addresses the future of universities in light of many recent trends (Bok, 2003). He is particularly concerned with the commercialization of the university in response to a plethora of "business opportunities" for universities. He notes "Increasingly, success in university administration came to mean being more resourceful than one's competitors in finding funds to achieve new goals. Enterprising leaders seeking to improve their institution felt impelled to take full advantage of any legitimate opportunities that the commercial world had to offer." (p. 15). He argues that this increased focus on commercialization may jeopardize the focus on education and learning.

Bok recognizes that this shift is nevertheless taking place. He cautions, however, that universities typically face several challenges that can hinder entrepreneurial aspirations. Bok summarizes these challenges, "On three important counts, the environment in most research universities does not do enough to encourage the behaviors needed for the sake of the students, the society, and the well-being of the institution itself." (pp. 23-24).

- Efficiency: "University administrators do not have as strong incentives as most business executives to lower costs and achieve greater efficiency." (p. 24)
- Improvement: "A second important lesson universities can learn from business is the value of striving continuously to improve the quality of what they do." (p. 25)
- Incentives: "Left to itself, the contemporary research university does not contain sufficient incentives to elicit all the behaviors that society has a right to expect." (p. 28)

These seem like reasonable challenges, at least for businesses. However, Bok argues "Leading a university is also a much more uncertain and ambiguous enterprise than managing a company because the market for higher education lacks tangible measurable goals by which to measure success." (p. 30). Further, he asserts "Presidents and deans are ultimately responsible for upholding basic academic values but they are exposed to strong conflicting pressures that make it hard for them to carry out this duty effectively." (p. 185).

We would expect that market forces would resolve these pressures. However, Bok reasons "Neither the profit motive nor the traditional methods of the research university guarantee that faculties will make a serious, sustained effort to improve their methods of instruction and enhance the quality of learning on their campuses." (p. 179). In other words, we cannot expect an organically based transformation of academia, despite financial and social forces for fundamental changes. There is a fundamental tension between what is naturally happening in research institutions (i.e., increased focus on the external viability of research), and the way in which this is being managed, or not managed, within the same universities. The lack of attention and process in the midst of this evolution could halt the progress and risk the outcomes of the changes.

However, successful transformation is possible. In the past 10-15 years, Georgia Tech has leaped ahead of what one would expect of incremental change and improvement. Tech has, without doubt, moved up to the "inner circle" of top five engineering programs, as reported by the most followed ranking system, ***US News and World Report*** (USN&WR). To put this example in context, we first need to explain the nature of how academic programs are ranked in the U.S. The remainder of this article then addresses how Georgia Tech accomplished its transformation and suggests how we can best understand such a leap.

RANKINGS OF ACADEMIC PROGRAMS

There are two ranking systems that receive most attention. The annual USN&WR (2003) system has become a key source for high school juniors deciding where to apply for college, and college juniors and graduates deciding where to apply for graduate study. The National Research Council (1995) performs more in-depth evaluations, roughly every ten tears. While academics tend to give more credence to the NRC rankings, the general public is much more aware of the USN&WR rankings.

For establishing the rankings of undergraduate and graduate engineering programs, there are two major views offered by USN&WR -- one ranking for overall university programs, e.g., engineering, and rankings for the different disciplines within these programs. For the overall program ranking, several variables are measured and the means are standardized, scaled and weighted so as to produce an overall score. Rankings are based on these scores. For the individual programs, the ranks are based solely on judgments of deans, chairs, and other faculty. For each of the schools surveyed in each discipline, based on the overall, quantitative ranks, the deans are asked to name the ones they feel achieve excellence in the particular disciplines. The votes are tallied and the ranks are reported.

In addition, USN&WR differentiates between those schools whose terminal degrees are masters, versus doctoral. The disciplines surveyed in the engineering field are: aerospace/aeronautical/astronautical, bioengineering/ biomedical, chemical, civil, computer, electrical/electronic/communications, environmental/environmental health, industrial/manufacturing, materials, mechanical, nuclear, and petroleum. As indicated later, Georgia Tech, for many years, has been ranked in the top 5 overall, and in the top 10 for at least 7 of the

12 disciplinary categories. Specifically, as discussed more in depth below, Georgia Tech has achieved the number 1 rank in the industrial/manufacturing engineering category for 14 of the past 15 years. This has been a tremendous change in the status quo, and the story of this change can provide insights to other institutions, as to how to change their ranks and reputations in a domain that seems to be characterized by much inertia.

Although there is much discussion and debate in the academic community concerning the relevance and validity of methods used to arrive at the USN&WR rankings, these rankings are certainly the most well-known and recognized of the ranking systems. Despite misgivings or beliefs of over-emphasis on this particular set of university rankings, there is still widespread recognition of the public's acceptance of these rankings as important in guiding education decisions, and therefore universities continue to spend much energy and resources on increasing their ranks in this scheme.

The 1995 National Research Council report included its findings from a four-year study on the rankings of research-doctorate programs in the U.S. The study was conducted as an update of the first such publication in 1982. The NRC conducted both reputational surveys and rankings of objective characteristics in order to arrive at compound measures of university rankings. Different disciplines were researched, providing separate ranks for humanities, sciences, and engineering, and the sub-disciplines within these broader categories. Based on both the reputational and objective characteristic surveys and ratings, Georgia Tech's Industrial and Systems Engineering program was ranked number 1 in this report. This provides some credence to the annual USN&WR rankings, but is, of course, far from a definitive assessment of the parallels between the two sources.

EXAMPLE OF MOVING UP

The Georgia Institute of Technology was founded in 1885. Up until the early 1970s, Tech's reputation was as an excellent undergraduate engineering school. Larger aspirations emerged with the presidency of Joseph Pettit (1972-1987), who arrived from having served as Dean of Engineering at Stanford University. Pettit's emphasis on Ph.D. research began the Institute's remarkable climb from being ranked a top 20 engineering program in the 1980s, to top 10 in the early 1990s, and top 5 since 1997. As later national data indicates, this is indeed quite an accomplishment.

During the last 15 years, enrollment has grown only modestly, slowing shifting the balance towards graduate education. The number of faculty has also only grown modestly. However, almost 80% of the current faculty has been hired in the past 10-12 years. This is an amazing level of turnover, especially given the tenure system in academia. Much of this change can be attributed to a progressive leadership that emphasized the need for a constant influx of new ideas and directions.

Almost 5% of faculty members have been elected to the prestigious national academies. Roughly one-eighth hold endowed chairs or professorships. Over one eighth have won coveted career awards from the National Science Foundation. Thus, the turnover has resulted in greatly increased excellence among the faculty, in addition to infusing the university with new and fresh perspectives.

During this time, annual awards of research grants and contracts have doubled, as has the Institute's overall budget. The percentage of the budget coming from the State of Georgia has continually declined, currently at roughly 25%. Decreasing state support of public institutions is a nationwide phenomenon, and all research universities have actively pursued several other funding sources so as not to suffer as a result of reduced state university budgets. Tech has been able to maintain its size, and thus access to necessary resources, despite this decrease in support. As discussed below, maintaining access to important resources is a critical factor in achieving and sustaining top rated status for universities.

The quality of incoming students has continued to rise during this period. Average scores on Scholastic Achievement Tests are approaching 1400 on a 1600-point scale. The mean high school Grade Point Average is 3.80 on a 4.0 scale. Undergraduate degrees now account for only 60% of degrees granted.

Although much of the emphasis has been on increasing quality of graduate education and research, the undergraduate student body still acts as the foundation of the school. Because of this, there has also been much attention placed on improving quality of undergraduate education, thus attracting students of the highest caliber. The prime focus of the undergraduate initiatives is creating an environment where the students can supplement their academic education through study abroad, undergraduate research, leadership studies, and volunteer activities. In addition, the university offers first year orientation and extensive tutoring services for all.

The changes initiated by Pettit and enhanced by his successors, John P. Crecine (1987-1994) and Wayne Clough (1995-present), can be summarized as follows:

- Greatly increased emphasis on PhD programs and sponsored research
    - Plus increased emphasis on multi-disciplinary research & education
    - Plus substantial increase of endowment, e.g., faculty chairs
    - Plus substantial expansion and upgrade of research & education facilities
    - Plus increased emphasis on university's role in economic development
- Top-down vision and leadership with bottom-up strategy and execution
    - Plus clear institutional direction

- Plus prioritization of opportunities
- Plus embracing pursuit of innovative strategies
- Plus support of strong entrepreneurial institutional culture

Also of note is the 1996 Olympics hosted by Atlanta. This resulted in substantial investments in the Institute's infrastructure, ranging from new dormitories and athletic venues, to greatly enhanced landscaping across campus. In parallel, a Capital Campaign targeted to raise $300 million dollars during this period yielded almost $800 million, and safely concluded before the Internet "bubble" burst. One of the primary uses of these resources was a dramatic increase in the number of chaired positions, thereby enabling the attraction of the "best and brightest." This relates directly to our conclusions about size elaborated below.

DETERMINANTS OF RANKINGS

It is natural for an engineer or scientist to wonder what actually affects rankings of educational programs. The influences just summarized for Georgia Tech represent a consensus of current and past leaders of the Institute. However, these conclusions are far from scientifically rigorous. What do we really know about the determinants of rankings?

This question caused us to explore in depth the available data for one field – industrial engineering and manufacturing. The School of Industrial and Systems Engineering (ISyE) at Georgia Tech has enjoyed the top ranking in this field for many years, in fact for all the years that these rankings have been reported, save one over ten years ago.

As chair of this school, the first author was interested in why the ***U.S. News & World Report***, and other well-reputed ranking systems, awards ISyE this ranking, as well as what we should do to preserve this position. Based on the different methods of ranking overall university programs and disciplines within these programs, it is clear that the latter are rather subjective. Therefore, we wanted to explore whether the subjective rankings could be predicted by or correlated with more quantitative, objective measures. We had the good fortune to be able to address this question in some depth due to the availability of data from a long-standing annual benchmarking study performed among all the leading programs in this field.

The a priori expectation is that certain variables, such as those that measure size of school and research dollars, will be correlated and/or able to predict changes in rankings, after a certain time period. Deans are generally aware of major changes within their peer group of schools, and although it may take a few years for the changes to reflect in the rankings, we believe that there should be some predictability in the changes of school rankings based on previous changes in benchmark data.

Each year, we email all the top programs a spreadsheet that includes entries for the following items:

- Degrees Awarded – number and type
- Enrollment – for undergraduate, masters and doctoral programs
- Student Information – SAT scores, etc.
- Teaching Loads
- Sections Taught
- Number of faculty – full, associate and assistant professors
- Faculty Honors & Awards – National Academies membership, etc.
- Faculty Salaries
- Research Support
- Staff
- Space

There are also a variety of subitems within each of the categories. These data were available for all the top-ranked programs for roughly the same 15-year period for which rankings have been published.

Statistical analysis of these data via time series analysis and non-parametric, rank-order correlation matrices indicated several interesting conclusions. First, over 95% of the variance in any university's ranking is explained by their ranking the previous year. Thus, year-to-year, there is a very high level of inertia in the system. This suggests that Georgia Tech's climb during the past 10-15 years is truly unusual.

Second, over many years, the best predictors of a university's ranking are:

- Number of faculty – rank-order correlation of 0.3-0.5, with a typical lag of 4-5 years
- Number of graduate degrees awarded – rank-order correlation of 0.5-0.6 with a typical lag of 1-2 years
- Number of undergraduate degrees awarded – rank-order correlation of 0.5-0.6 with a typical lag of 1-2 years

Clearly, size matters[1]. We explore possible interpretations of this conclusion below. The fundamental implication of size is that it provides the resources that

[1] With one exception, the NRC report found similar correlations and associations as did we in our analyses of benchmark versus rank data. Both size – as measured by the number of faculty and graduate students – and involvement in research were found to be highly correlated with the quality assessment and rank of a program.

enable cultivation of characteristics that help universities achieve world-class status.

Third, contrary to the NRC findings, level of research support per faculty member was negatively correlated, albeit weakly (0.1-0.2), with a university's ranking, particularly for the less recent years. This was due to two lower-ranked programs – but still top ten – having once had much higher levels of support than the other highly ranked programs. This illustrates the problems of small data sets – 15 years of data for 10 universities.

Interestingly, our data set was rather unusual. These types of data are seldom available for such a long period of time. In other words, this data set was about as good as it gets, but still insufficient to avoid possibly anomalous results. Of course, lack of data has not deterred various pundits from articulating "truths" about rankings. Our experience is that expertise in one particular science or engineering discipline appears to enable experts in that discipline to reach conclusions about social and organizational phenomena without any data to support these assertions.

Returning to the issue of size, we have developed several hypotheses about the underlying phenomena. Faculty size, for example, predicts rankings because, we think, having more faculty members increases the likelihood of having more well known "stars." These stars, we hypothesize, provide the impetus for higher rankings rather than the simple number of faculty members, especially given the subjective and reputational bases of these rankings.

Similarly, number of graduates is not the underlying predictor. We hypothesize that the larger number of graduates increases the probability of outstanding leaders in academia, industry, and government who provide perceived evidence of the excellence of the university. Size matters because it provides more opportunities for excellence.

In other words, size provides more opportunities for "tipping points" where big differences suddenly happen (Gladwell, 2000). Hoards of faculty and graduates are not the driver of rankings. However, these hoards provide increased opportunities for the people who make big differences in the world to be associated with your university.

Of course, talent also counts. So, what you want is hoards of very talented people. This <u>almost</u> guarantees excellence. The question then becomes one of how to get the most talent into your university. MIT, for example, has known how to do this for 50 years or more. Georgia Tech has figured this out over the past 10-20 years. Given that talent is not unlimited, the determining competency is the ability to get the talent to choose you.

It is also important to emphasize that excellence comes in many forms, many of them not academic. Large numbers of talented graduates that pursue industry and government careers will tend to yield large numbers of leaders who create strong economic impacts, both for their enterprises and themselves. Both forms of economic success provide sources of increased resources for their alma mater.

Finally, it is essential to note that the characteristics of success seldom emerge on their own. Vision and leadership are needed to recognize and foster intellectual synergies that transform a collection of talented faculty and resources into a coherent set if initiatives with high potential impact. Of course, as noted above, vision and leadership are also needed to attract the resources to attract the talent.

CONCLUSIONS

It is clear that research and education continue to be the keys to world-class status for a university and economic growth for its key stakeholders. World-class status provides a wealth of opportunities for the university to serve the public. Economic development has long been a central element of such service. Universities' international initiatives are also becoming increasingly important in their quest for broader impacts as well as the resources to fuel these initiatives.

Achieving world-class status requires excellent faculty and students, innovative programs, enormous resources, and lots of friends. Size tends to provide more opportunities, but not guarantees, for realizing these characteristics. The heterogeneity of research universities' constituencies makes it difficult to balance and satisfy competing interests. Consequently, Bok (2003) indicates that, even at Harvard, "There is never enough money to satisfy their desires." (p. 9).

This argues for the importance of vision and leadership in building a great university. World-class status is now much less likely to slowly emerge from intelligent people independently doing good work over many decades. This status is more likely to be attained when university leaders articulate focused strategies and cultivate the resources to attract the best people to pursue these initiatives.

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