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Innovative Universities: When, Why and How?

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Abstract

Even as investment in higher education grows across the world, America's top research universities continue to enjoy a special cachet. The very best are highly ranked and enjoy a vibrant culture of innovation. Their fundamental research has produced breakthroughs in products, processes, enterprises, career opportunities, and continuing scientific and technological advancement.

Each of the top U.S. universities is a global incubation center. Like magnets, these institutions pull in students and faculty from other countries. Other nations, despite some misgivings, do not see this temporary outflow as part of a zero-sum game. They expect that their own universities, laboratories, scientists, engineers, and enterprises will benefit from this investment in human capital.

It has taken America's top universities seventy-five or more years to reach their current pinnacle. In this paper, we will ask three questions. When did these institutions emerge? Why? And how are they sustained? Answers to these questions will be relevant to government policy-makers, leaders in higher education, the science and technology community, and those who play a role in the foundations and philanthropy.

What is required to create and sustain an innovative research university? Our paper offers answers to this question based on the American experience. Policy-makers and educational leaders in the U.S. and other nations should find our argument relevant. Both will want to learn from this examination of a significant experiment in institutional development and public policy.

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Introduction

The current challenge that universities face is to think strategically and act boldly. Universities are making changes to culture, structures and outreach that maximize their impact on society. To do this, they re-design the way faculties work, leadership is exercised, and students are recruited and instructed. They work to re-think how industry engages with education, technology enhances learning, and institutions learn from one another. As they do so, they connect globally with governments, industry, faculty, and students. Some consider the strategic thinking behind these actions a managerial revolution; others see it as entrepreneurialism (Keller, 1983; Thorp and Goldstein, 2010). We view the change-making institutions as core innovators.

Which universities in the U.S. are leading this now global process of root-and-branch innovation? They are, in my view, the private research universities. Their circumstances have made them more resourceful than the public institutions. They are, on the whole, smaller than the flagship state universities, less dependent on state funding for day-to-day operations, and much less bureaucratic. They have had to sustain themselves and grow through their own leadership, management, patronage, faculties, and governance. It is a credit to the distribution of wealth and talent in the U.S., management skills, and strong regional loyalties, that some of the public institutions have also become centers of research excellence. They have, however, been more encumbered by the politics of state funding and regulation and have, because of that dependence and constraint, been less able to chart their own direction (Duderstadt and Womack, 2003). The private research universities have had to face the challenges of the market more directly; when they plan for the future it is with a much greater sense of agency. They remain the focus of this paper.

Figure 1

Innovation has been embraced as a strategy for smart growth in no university more than Carnegie Mellon, founded in 1900 (Resnick and Scott, 2005; Schaefer, 1992). With Stanford, founded in 1891, it is the youngest of the major research universities. In little more than a century, it has transformed itself from a local and then regional technical school and arts conservatory into a cosmopolitan center of research and learning with collaborative programs around the world. When faculty talk about how this was achieved, they refer to the university's clear taste for problem-solving, and its willingness to go beyond disciplinary boundaries and seek interdisciplinary collaboration. Herb Simon, Nobel Prize laureate, saw our innovation in the founding of new departments and centers and the radical commitment to quality and excellence. (Simon, 1996, 1991). Other faculty have noted the university's work ethic, curiosity about the world, and passion for technology. Universities, however, are complex organisms, and success requires a discipline that extends through every part of the system. Are there rules for innovative universities to follow? Based on Carnegie Mellon's example, we have listed three at the end of this paper.

European Models

How did the U.S. develop research universities? American higher education owes a great debt to Europe. Before independence in 1776, the American colonies had only nine chartered colleges, almost all of which prepared students for the clergy (Veysey, 1965; Rudolph, 1962, 1990). The exception was Benjamin Franklin Academy, the forerunner of the University of Pennsylvania. After independence was declared in 1776, this small nation, then with fewer than four million people, was pre-occupied with farming, building, mining, business, exploring the Western territories, and securing its borders. Those Americans who sought advanced educational opportunities went abroad to more developed societies for courses, degrees and directed touring. When they returned, the institutes and graduate programs they established were based on European models.

Great Britain provided the model for America's undergraduate residential colleges, but France and Germany provided the models for graduate education (Anderson, 2004). Americans turned to France, particularly, for knowledge about how to meet the needs of a developing nation in bridges, roads, mines and dams (Emmerson, 1973). Civil and military engineering drew on the practices of the Ecole Polytechnique and the schools of mining, bridges and roads. French programs heavily influenced the curriculum of West Point (founded in 1802), Rensselaer Polytechnic (founded in 1824), and other newly created institutes of technology (Seely, 1993). Those interested in public health, sanitation and urban planning traveled to France in the first half of the 19th century, in significant numbers (Bertier de Sauvigny, 1985).

American research universities were developed on the German model in the last quarter of the nineteenth century (Geiger, 1986, 2004; Clark, 2006). Americans who went abroad to do graduate work were impressed by the passion for basic research, the organization of laboratories and the seminar as an institution. When they returned, they became the first generation of graduate faculty in the research universities, organizing disciplinary research and recruiting other faculty and graduate students. The new research universities granted masters' and doctors' degrees, maintained strong undergraduate baccalaureate programs, guided doctoral research, set up science and engineering laboratories, built up libraries,

conducted graduate seminars, and founded scholarly journals. (Brown, 1995) After these schools were created, Americans no longer had to go abroad for advanced study.

Johns Hopkins was the first American research university, founded in 1876, a century after the new nation's independence. It was a private institution, created by the benefaction of a Quaker businessman. The gift was the largest by any donor at that point in American history. The German universities, not sharply distinguished one from another in American eyes, provided the model (Hawkins, 1960). American universities, however, modified the model in many ways, making administration much less autocratic, diminishing the control of research direction by chair holders and institute directors, empowering faculty and encouraging the foundation of professional schools in areas where they had not existed before. In this way, the underlying cultural values of the new nation shaped its research-oriented university institutions.

Private Research Universities

By 1900, there were nine private research universities, out of a total of fourteen. They founded a professional grouping of public and private institutions to promote their common interests – the Association of American Universities [AAU]. The nine private founding members still active within the association are Columbia, Chicago, Cornell, Harvard, Johns Hopkins, Penn, Princeton, Stanford, and Yale. The three public members, also still active within the association, are University of California, Berkeley; University of Michigan, Ann Arbor; and University of Wisconsin, Madison. Even though subsequent membership has been by invitation only and has required the support of three quarters of the members, the rolls of the association have grown in the course of the last 110 years to sixty-one. There are currently twenty-six private research universities in this group, along with 35 public. McGill and the University of Toronto joined as Canadian members in the 1920s (AAU, 2011). A comparable group of twenty leading universities with major research achievements in the United Kingdom, known as the Russell group, was founded in 1994. Unlike the American case, all of the UK group members are state-supported institutions (Russell, 2011).

American research universities innovated in creating schools, departments and disciplines, from chemistry and philosophy to engineering and education. Research required major investments, and they understood that the cost of this research in released time to staff and equipment for laboratories was their responsibility. They would, of course, assist faculty in finding additional funds from industrial or private sources. The federal government was not yet a significant provider of funding. Although the Merrill Act (1862), the Hatch Act (1887), the Smith-Lever Act (1914), and the Smith-Hughes Act (1917) opened up small streams of federal funding for agriculture and then vocational training, most of that would be directed to public land-grant institutions.

Knowledge and skills in America were also being developed on a separate track, outside the universities. The new nation was more preoccupied with invention, questions about how things worked, and practical technical training, than it was by formal learning (Hughes, 1989). The bulk of applied research was supported by industries and localities in industrial laboratories or the burgeoning technical institutes (Servos, 1994).

Thomas Edison founded Menlo Park, America's first industrial laboratory, in the same year that Johns Hopkins was established (Israel, 1998). More than twenty independent technical institutes and engineering colleges were founded from 1824 to 1900. Some—like

Massachusetts Institute of Technology (MIT, founded in 1861), California Institute of Technology (Caltech, founded in 1891 as Throop University), and Carnegie Institute of Technology (Carnegie Tech, founded in 1900, predecessor of Carnegie Mellon)—would later transform themselves into technological universities and form an association to advance their common interests in engineering and technology-based education. The AAU, however, remained the principal voice of America's research universities. Carnegie Mellon joined the association in 1982.

Growth after the Second World War

America's research universities did not grow very much in the interwar period, the second half of which was marked by the longest and deepest recession in U.S. history. The picture changed 1939-45, however, when university scientists and engineers began their ongoing collaboration on a very large scale with federal agencies. The main wartime effort, the Manhattan Project, came to federate many others (Groueff, 1967; Rhodes, 1986). An extraordinary feat of engineering—an American, British and Canadian research and development effort—with more than 100,000 people employed at more than thirty sites to develop an atomic bomb. Vannevar Bush (Zachary, 1997), who had been Dean of Engineering at MIT and an inventor in his own right, was a key figure in the policy-making that made this project possible. He served as President Roosevelt's unofficial scientific advisor and was Director of the Office of Scientific Research and Development, bringing some six thousand scientists into the war effort. The President asked him to develop a post-war plan for carrying forward into peacetime the wartime collaborative relationship of industry, universities, and the military.

Science, The Endless Frontier (Bush, 1945,1960), the title of the report that he submitted, has served as the blueprint for post-war development in areas that ranged from basic research funding to national security and public investment in the education and training of engineers and scientists. "Basic research," Bush argued, "leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science." (Bush, 1945, p. 19)

Industry itself dominated the field of applied research, but basic research belonged to the universities and would make its own contribution to applications. Given the pragmatism of American culture and the unknown outcomes of research, basic research would yield technological advances. "Today," he wrote, "it is truer than ever that basic research is the pacemaker of technological progress. In the nineteenth century, Yankee mechanical ingenuity, building largely upon the basic discoveries of European scientists, could greatly advance the technical arts. Now the situation is different." (Bush, p. 19)

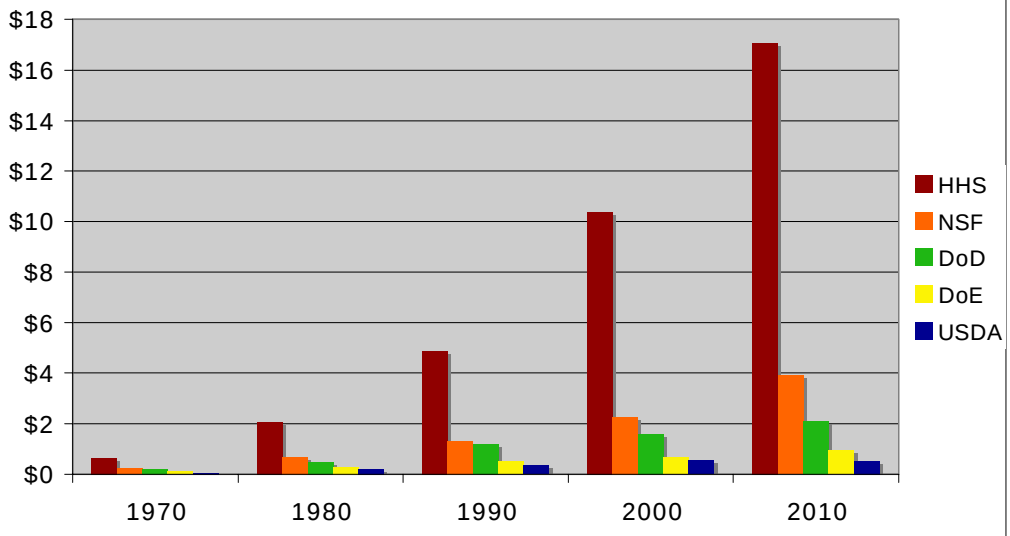
Bush, who had worked both in universities and industry, knew that industry rarely allowed investigators to push ahead on their own agendas. Freedom to investigate was lacking in the industrial laboratories but essential for progress: "Industry is generally inhibited," he wrote, "by preconceived goals, by its own clearly defined standards, and by the constant pressure of commercial necessity. Satisfactory progress in basic science seldom occurs under conditions prevailing in the normal industrial laboratory. There are some notable exceptions, it is true, but even in such cases it is rarely possible to match the

universities in respect to the freedom which is so important to scientific discovery." (Bush, p. 19)

Implementing the Vannevar Bush Plan

University spending for basic research between the two world wars had increased by only one-half, and work in the endowed research institutes had declined. Bush estimated that in 1940, industrial spending was about $250 million, internal government research spending $69 million, college and university spending $31 million, and research spending in endowed research institutes $4.5 million (Bush, 1945, pp. 6-7, 20). To change the research environment after the war ended in 1945, he proposed a federal expenditure that would rise to $50 million per year after a 5-year period and stay at that level (p. 22). The first appropriations by Congress, however, were below that level. The funding patterns did not change radically until the launching of Sputnik in 1957.

Figure 2
Federal Funding by Agency of University Research
1970-2010



Sources: NSF Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1951-2002, Table B and Table 11; Federal Funds for Research and Development, Fiscal Years 2007-2009, Table 10.

Bush's main agenda was three-fold: creation of a national research foundation, later called the National Science Foundation, to oversee investment in science and education; funding for medical research; and support for scientific research on military projects. Members of the AAU were the agents best equipped to carry forward this ambitious science and technology plan. They would provide the means for replacing research in a war-battered

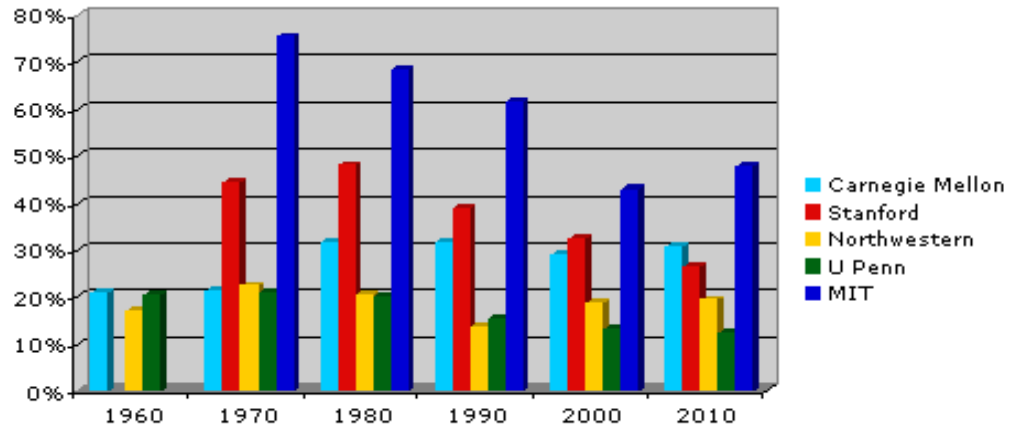
Europe with American knowledge. Their efforts would advance national goals in science, education, health and security.

This vision started to describe reality in key areas after the Soviet Union launched a satellite into space. An estimate $20B per year in 2000 constant dollars made its way to the universities from the late fifties to 2004. Medical research, the sciences, defense, and technology were the principal beneficiaries, as the attached figure showing funding by the major federal agencies indicates.

Federal research funding, in turn, came to account for a large share of research university budgets. In retrospect, we note that heavy support for basic research created a tight and dependent relationship between federal agencies and the strongest universities.

The attached figure, based on data collected by the author of this paper, illustrates this development for five front-running schools, 1970-2010.

Figure 3
Federal Grants and Contracts as a Portion of Total Operating Expenses for Five Selected Private Universities 1960-2010



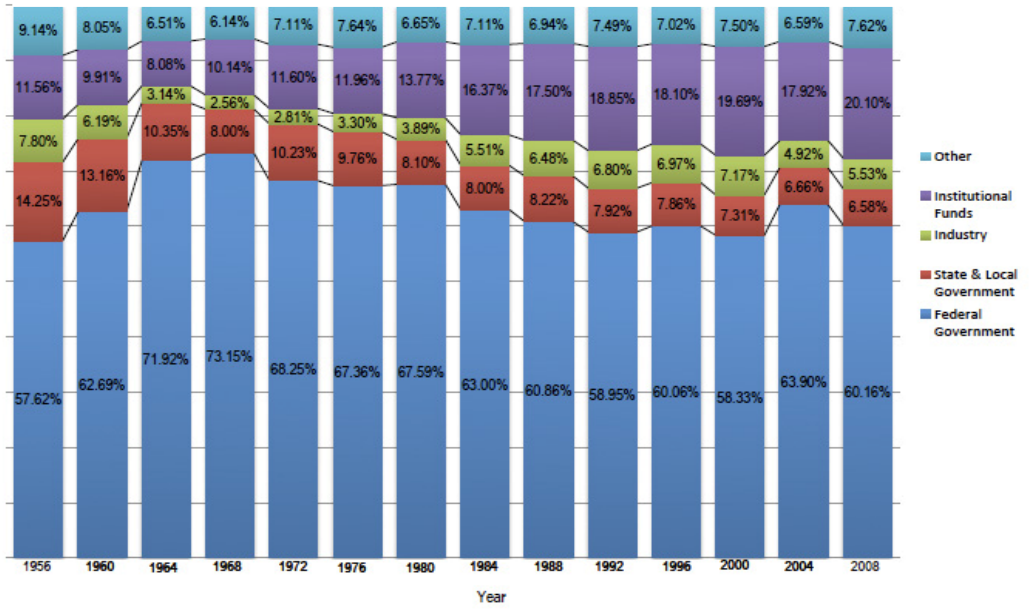
This chart utilizes 'Federal Grants and Contracts' and 'Total Operating Expenses' data gathered from five private universities: Carnegie Mellon University, MIT, Northwestern University, Stanford University and the University of Pennsylvania.

Spending rose and fell within agencies, uncoordinated by central oversight, creating problems of continuity, space and staffing for the universities. Federal grants did not pick up all indirect costs. Overhead recovery was capped below actual outlay, as universities found themselves responsible for an ever-increasing share of research expenditures. Robert Berdahl, President of the Association of American Universities, highlighted these and other problems in his 2009 report to the National Research Council Committee on Research Universities. The attached figure accompanied that report (Berdahl, 2009).

The leading research universities were innovative. They were able to incorporate new programs, compete for funding, modify faculty size, diversify, and sustain lively undergraduate programs in the face of both opportunity and uncertainty. They were well prepared for a partnership in which 70 federal agencies in all provided a total of 31.2 billion dollars to America's colleges and universities in 2010 (Berdahl, 2010). How did these

universities manage growth and further innovation? From the lessons of their experience, we can extract a few rules: plan strategically, benchmark performance and reward achievement. Carnegie Mellon embraces these precepts enthusiastically, even though they appear in no rulebook or manual.

Figure 4
Proportion of R&D funding at Colleges and Universities Over Time



Plan strategically

Universities move forward by seizing opportunities or creating them. Yet, the great distraction of innovative universities is opportunism. To stay on track, universities develop strategic plans. These plans establish priorities for investment in sites, programs and people, and a rationale for decision-making. At the beginning of the process, there may be disagreements; at the end there will be consensus.

The creation or renewal of a strategic plan is high on the agenda of an incoming president. In the planning process, the president shows his or her ability to engage with different university constituencies and mobilize them. The president will work with trustees, faculty, staff, alumni, and students to develop a mission statement, a set of priorities and an implementation strategy. As leadership teams are appointed in each area of concern, the president learns where investments need to be made and who can be the most effective leaders. Planning begins with a vision. Strategic plans need to be reviewed periodically, and Carnegie Mellon posts its plan and milestones in the planning process online (Carnegie Mellon Strategic Plan, 2008).

Benchmark Performance

Faculty members belong to departments, centers, schools and institutes. In an innovative university, the institution demands quality and excellence. Some areas will need to expand and others to shrink. The best way to validate internal judgments of quality and need is to invite assessments by external peers who have talked on-site with faculty and students, reviewed documentation, and discussed their impressions and judgments with advisory board colleagues before presenting them to the president and provost.

Through the advisory board visits, many goals are achieved. The units are led to review their own goals, priorities, successes and needs in preparing for the visit; the president and provost receive the best external assessment available on the strengths and needs of a unit; and individual members of the Board of Trustees gain the information they need as stewards through an in-depth, up-close view of an academic unit. Carnegie Mellon has posted a detailed description of its advisory board process online (Carnegie Mellon President's Advisory Boards, 2011).

Reward Achievement

Innovative private universities are corporate entities, but they are also communities—online and face-to-face. They share news of achievement, new arrivals, seasonal rituals, retirements and, inevitably, deaths. The campus media provide a rich information network to keep faculty, staff, students and alumni apprised of what is happening, and encourage them to celebrate the successes of others.

Faculty receives awards for research and teaching, students are acclaimed for receiving fellowships, and staff are elected to lead professional associations. All these happenings are noted, and many are followed by receptions, dinners and symposia. Although researchers may work in isolated settings, breakthroughs are immediately noted and widely heralded. In these celebrations, all receive the recognition and respect that they merit.

Undergraduate research at Carnegie Mellon is celebrated through an annual Meeting of the Minds symposium, with presentations and prizes. It is rare to find a university event that does not offer refreshments of some kind, and students on limited budgets with voracious appetites will congregate at these events. A Carnegie Mellon undergraduate this past year developed an application for mobile devices that machine reads university digital calendars to direct undergraduate users to on-campus meetings with free food. Needless to say, students at peer universities were very interested in this application. This was an unanticipated by-product of a campus that celebrates community achievement.

Conclusion

Visitors to the U.S. in the 1830s, like Alexis de Tocqueville, found it unlikely that Americans would have any reason to prize higher education and intellect. The cultivation of intellect was not a goal of American society, and its seemingly boundless resources seemed to require little schooling to exploit. The growth of science, technology and competition began to force changes in the kind of education that was valued, but the process moved slowly. Some Americans have not yet been convinced that the federal government needs to be the major investor in basic research and that this investment will benefit America and a larger world. The reminder of Vannevar Bush in 1945 is still timely. "Today it is truer than

ever that basic research is the pacemaker of technological progress. In the nineteenth century, Yankee mechanical ingenuity, building largely upon the basic discoveries of European scientists, could greatly advance the technical arts. Now the situation is different." (Bush, 1945, viii)

America's research universities, like its liberal arts colleges and technical institutes, are important contributors to the culture of America, its economic growth, and the know-how of its work force. The research universities, specifically, have produced inventions, processes, tools and innovations that seem innumerable. John Cole, former provost of Columbia, has done an excellent job of presenting them (Cole, 2009). Moreover, many research universities have provided links to assessments of their contributions on the AAU website, http://www.aau.edu/. The great universities, however, live with a paradox. The federal research support that has made so much of their achievement possible has also created a deep dependence.

There are signs that the interest of other nations in America's great research universities and their investment in their own national institutions will encourage continuing American government support for its university sites of excellence. Private and public research universities alike look forward to renewing, extending and enhancing their partnership with the federal government. With that kind of support, American research universities will continue their international outreach and the dynamic of innovation will be sustained.

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