Evaluating the Role of Science Philanthropy in American Research Universities

Fiona Murray
David B. Sarnoff Professor of Management & Technology
MIT Sloan School of Management
&
Faculty Director, Trust Center for MIT Entrepreneurship

100 Main Street – e62-470

Cambridge, MA 02142

fmurray@mit.edu

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ABSTRACT

Philanthropy – gifts from wealthy individuals or grants from private foundations - plays a major role in university-based scientific, engineering and medical research in the United States funding (in one form or another) almost 30% of this activity. And yet science patronage has been largely overshadowed by the massive rise of Federal research funding and, to a lesser extent, industry funding. Government and industry funding have drawn intensive analysis, partly because their objectives are measureable: governments generally support broad national goals and basic research, while industry finances projects likely to contribute more directly to useful products. In contrast, philanthropy's contribution to overall levels of scientific funding and, more importantly, the type of research supported by philanthropy is poorly understood. Nonetheless, one only has to look at named research buildings on campuses and multimillion dollar gifts from wealthy individuals and their foundations to recognize the pervasive role of philanthropic giving to university research. This paper provides the first empirical evaluation of the role of science philanthropy in American research universities. It analyzes the contribution of private donations and grants to universities, relative to government funds, and then examines the distribution of this funding across schools, fields and the fundamental to practical research continuum. Finally, the paper explores some of the implications of science philanthropy in today's climate of funding pressures for research.

* I would like to acknowledge the excellent research assistance provided by Sarah Wood and by Kenny Ching on this project.

I. Introduction

This paper examines the place occupied by philanthropy in the funding of science in American universities. My practical goal is to illuminate an important but largely ignored source of funding for leading edge research – in science, engineering and medicine – and its growing importance to leaders in higher education today. Recognizing that both the rate and the direction of scientific progress is of central importance (Arrow 1962), this analysis will explore both the level of philanthropic funding and its distribution – across fields, across universities, and across the spectrum of fundamental to translational research.

Conceptually, science philanthropy – gifts from wealthy individuals, or grants from private foundations to scientific research – presents a difficult puzzle for scholars interested in the economics of science and innovation. Broadly speaking, the two canonical funding sources – public sector government funding and private sector funds – have incentives for funding university research that are well understood and often complementary: government funds the earliest stages of research and industry the later, more applied stages (Aghion, Dewatripont and Stein 2008). In contrast, the factors driving philanthropic funding are more complex and highly variable. Grounded in the preferences of wealthy patrons (and their foundations) that derive from the historical traditions of science patronage (David 2008), science philanthropy is shaped by the legal arrangements that encompass charitable giving (Fleishman 2007) and by the complex and often opaque negotiations between patron, "client-savant" (as scientists were known in the Renaissance) and university administrations (David 2008). Thus, few clear predictions exist regarding the distribution of science philanthropy, and two key questions remain unanswered: does philanthropy provide funding mainly for fundamental research or for more mission-oriented projects, and does it serve to fill gaps in public (or private) resources or to supplement well funded areas of research?

Two vignettes illustrate the complex relationship between science philanthropy, public funding for research and the frontiers of scientific progress. Each one highlights the different ways in which philanthropists interact with the funding choices made by (Federal and to a much lesser extent State) government funding agencies.

Between 2002 and 2010, Paul Allen, co-founder of Microsoft and Nathan Myrvold (former CTO of Microsoft) donated over $30M to support a new telescope (to be referred to as the Allen Telescope Array) at the Hat Creek Observatory. Part of a partnership between UC Berkeley's Radio Astronomy Laboratory and the private SETI Institute[1] , its research purpose was to advance SETI – the Search for Extra-Terrestrial intelligence – by looking for signals from civilizations elsewhere in the galaxy.[2] Controversial from the start, the project had always suffered from difficulties in gaining robust, long-term government support. During the announcement of the gift, Paul Allen noted that "For the first time in our history, we have the ability to pursue a scientifically and technologically sophisticated search for intelligent life beyond Earth at the same time we are doing traditional radio astronomy...This new telescope will be the world's most powerful instrument for this search, and I am pleased to support its important work." Myrvhold viewed his philanthropy with the following argument: "While the best scientific estimates tell us the probability of intelligent life elsewhere in the universe is fairly high, there is great uncertainty and some controversy in the calculation. One thing however, is beyond dispute. That is, if we don't continue supporting projects like the Allen Telescope Array, our chances of discovery will remain at zero. While it's impossible to predict exactly what we will find with a new scientific instrument, we should remember that interesting science is not just about the likelihood of end results -- it is also about the serendipity that occurs along the way." The philanthropic funding of over $60M from Allen and others served to augment the costs of observatory operations traditionally supported from two sources: "University Radio Observatory" grants from the National Science Foundation, and the State of California's funding of Berkeley's Radio Astronomy Lab (Nature 2011).[3] However, in 2008 California state budget deficits reduced funding to the Radio Astronomy Lab. Federal funding for the ATA was cut around the same time, citing ATA's failure to reach its expected level of performance and its lower than expected levels of sensitivity. While Paul Allen stepped into the gap to provide additional patronage, SETI and Berkeley were unable to secure sufficient philanthropic funding and the project was "hibernated" in April 2011.

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1 The SETI Institute is a not for profit research organization founded in 1984 by scientists from NASA's Ames Research Center in California. It was managing the first phase of the High Resolution Microwave Survey under contract to Ames, with funding from NASA. When this public funding was cut the institute continued to look for funding, including private philanthropy, and established their link to the UC Berkeley Radio Astronomy Laboratory.

2 At the time of the press release, the Paul G. Allen Charitable Foundation was described as being "dedicated to promoting the health and development of vulnerable populations and to strengthening families and communities. The Foundation invests in projects and programs that address social challenges and promote positive change".

3 See http://www.nature.com/news/2011/110727/full/475442a.html

In 2007, MIT announced a gift of $100M from David H. Koch, an alumnus with degrees in chemical engineering.[4] Half of the gift would form the funding base to construct the modern David H. Koch Institute for Integrative Cancer Research replacing (and renaming) the well established MIT Center for Cancer Research founded in 1969 and the remainder of the money was pledged to support research projects. While building on existing strengths at MIT in to understanding the basic processes underlying cancer biology, the aims of the Koch Institute gift followed the impetus of the National Institutes of Health towards more applied, inter-disciplinary approaches to cancer, as impatience spread among the general public about the seemingly slow pace of cancer research (Groopman 2001). Although not focused on clinical work *per se*, the new Koch Institute was envisioned as having a network of relationships to the surrounding medical schools and hospitals in the Boston area. The vision of the Institute was also underpinned by considerable government funding, partly from its designation as a National Cancer Institute (NCI) cancer center - entitling it to core funding from NCI for shared laboratory facilities - and other long-term NCI Grants. Faculty in the Koch Institute also had support from over 100 grants the majority of which came from the NIH and NCI but with others from a number of foundations as well as the Howard Hughes Medical Institute. While closely following shifting Federal direction in terms of the type and direction of research activities, David Koch's funding did enable a novel organizational design on campus: it was explicitly designed to house both biology and engineering faculty – 40 labs in total - to facilitate interdisciplinary approaches to diagnosing, monitoring, and treating cancer. And, with a further donation from the family of Genentech founder Robert Swanson it supported the development of further more "translational" facilities to enable faculty to engage in more applied research activities.

These two gifts exemplify the different ways in which philanthropy has been supporting science, engineering and medical research in the United States over the past several decades: the first focused on fundamental (and controversial) research where government funds were limited and waning, the second on an area with extremely high levels of government support and an established track-record of research excellence. Compared to the historic role of science patronage in the U.S., which was critical for basic research when government support for science only focused on government-led applied research in geological surveys etc., science philanthropists today must make choices as to whether to complement and amplify fields and

[4] Much of this information is drawn from MIT Reports to the President 2007-2008: The David H. Koch Institute for Integrative Cancer Research at MIT. Accessed from http://web.mit.edu/annualreports/pres08/2008.06.10.pdf

schools already receiving generous support from government sources or to identify and emphasize funding gaps – either in specific schools, fields, or points along the fundamental to translational continuum. Thus, patrons can become either followers or leaders in particular areas of scientific progress. In this new model, giving from individuals and their foundations is combined with government funding in ways that potentially give the ultra-wealthy significant influence over blazing the scientific, engineering and medical frontiers in the United States.

The multi-billion dollar fund-raising campaigns launched by leading research-oriented universities highlight the central importance of philanthropy to higher education generally and, in particular, the university's ability to forge new activities and new models of learning and knowledge production. The important role of science philanthropy as a key, but under-appreciated, aspect of philanthropy in higher education is illustrated by the trends in funding of university research: Over the period 2005-2010, the contribution of Federal funding to university research has grown less than 1%, and State funding has declined.[5] In contrast to this study, traditional analyses of non-Federal contributions tend to focus on the role of industry (the private sector) as the complement to public-sector government funding in academia - recognizing the public good versus private benefit motivations of each in contributing to academic R&D (Arrow 1962) – even though industry contributes to less than 6% of university research funding. In striking contrast, philanthropic sources –including individual gifts, foundation gifts and grants, as well as funds draw by universities from their own endowment (typically derived from earmarked gifts for research) - make up almost 30% of university research funding and have been growing at almost 5% annually. If we consider that up to half of all industry funding is contributed via tax-deductable gifts rather than formal research contracts – thus being designated corporate philanthropy -- then the contribution of science philanthropy in its various forms is over 30% of university research funding today.

The core thesis of this essay is that the long historical links between patronage and science continue to flourish today to support scientists across disciplines, schools and along the research spectrum, and that science's modern day patrons play a unique and significant role in U.S. scientific competitiveness. The wide-ranging influence of philanthropy arises in part because of the legal privileges allowed to individuals and foundations in their charitable contributions. On the other hand, in order to legally maintain the tax-free status of their

[5] See NSF Science and Engineering Statistics Report 2010 Chapter 5, p 10.

contributions, philanthropists must allow recipients to have high levels of scientific autonomy. Thus, science philanthropy lies at the intersection of two distinctive and yet powerful groups – the scientific elite, who garner the largest donations, and the wealth elite. Today, philanthropy's growing scale and scope potentially shape the landscape of U.S. science as it did in the nineteenth century, placing the contours of the scientific frontier in the hands of a small number of wealthy patrons. Not surprisingly, it presents challenges to policymakers as they consider science philanthropy's growing level of control over the nation's research enterprise, spurred by a few wealthy individuals whose research preferences may be highly idiosyncratic or not well matched with broader social goals.

I have chosen to consider science philanthropy through an analytic lens that highlights the ways in which philanthropy may be similar to or distinct from government funding. Specifically, I consider how philanthropic dollars are allocated along two dimensions: the first dimension maps the research continuum from more fundamental to immediately translatable types of projects (for any discipline). The second emphasizes where philanthropy is guided relative to perceptions of overall levels of (government and industry) funding (for disciplines, institutions or overall). Within this context, and as a backdrop for contemporary analysis, I trace the history of U.S. science philanthropy, from its important role in the emergence of research in the U.S. until its decline after WWII, when government dominated support of university research. The legal context for science philanthropists is relatively short and emphasizes clear (U.S.-specific) rules and definitions that structure the legal scope of charitable giving to universities, the role of individual versus not-for-profit foundation giving, and the development of clear rules within universities regarding how philanthropic interests could be matched to research activities. This legal institutionalization of science philanthropy, together with resurgent interest among the wealthy elite in supporting universities and science, created the context for modern science philanthropy and the rising support for research – science, medicine and engineering - over the past decades.

Building on this framework, my essay uses a range of quantitative and qualitative data sources to build up a coherent picture of the contribution of science philanthropy to the leading U.S. research universities. The data come from four sources: The National Science Foundation's Science and Engineering Statistics, the Council for Aid to Education's Voluntary Support of Education (VSE) survey on gifts to universities, the Foundation Center's grantmakers database of individual foundation grants to universities (derived from examining the tax returns of private foundations, which annually list key grants), and the Chronicle of Philanthropy's database of major individual gifts. From this we gain insights into the overall levels of science philanthropy. Turning to the central question of funding distribution and using the framework as an organizing approach, the paper then examines the patterns of philanthropy, both in absolute terms and relative to the role of the Federal government, along three dimensions:

- Across the Top 50 research universities, and
- Across the major research fields
- Across the fundamental to translational continuum

Based on these patterns, we will raise a number of important policy issues for consideration by Federal funding agencies (and the IRS) as well as issues for philanthropists and universities.

II. The Context of Modern Science Philanthropy

Conceptual Foundations

The allocation of funding to university research can be considered along two critical dimensions (see Figure 1). First and foremost is the traditional distinction between fundamental research and research more clearly focused on translation of knowledge to solve immediate and clearly defined problems. While Stokes highlights the fact that much research considers both dimensions (1997) for the purposes of explicating a simple framework within which to consider science philanthropy, a simple continuum from early-stage projects that initiate research lines to those later stages that move ideas and projects towards proof of concept and translation is appropriate (see Aghion, Dewatripont and Stein 2008). A second dimension salient to this analysis is the degree to which particular philanthropic research funds follow (or lag) high levels of non-philanthropic support or whether they serve to lead and highlight funding gaps. In other words, to what extent do today's philanthropists fund projects in areas with high levels of current funding – leading to a dynamic in which the wealth elite enable the rich fields, universities and individuals to get richer, or whether philanthropists explicitly to step into funding 'gaps' arising in particular disciplinary areas or schools.

		Research Continuum	
		Fundamental	*Translational*
Level of Existing Funding	*HIGH*	**Howard Hughes** Patron extending well-funded knowledge foundations	**Milken** Mission-driven patron amplifying existing funding to accelerate outcomes
	LOW	**Medici & Myhrvold** Patron filling gaps in knowledge foundations	**Gates** Mission-driven patron identifying critical gaps in translation

Figure 1: Typology of Approaches to Science Philanthropy

The relationship between philanthropic contributions to a particular research area and the existing state of funding highlights a long-term issue in the economics of science. Specifically, it raises the traditional question of the ways in which one source of funding (typically government-appropriated funds) crowds out other funding sources, such as funding from industry, or whether instead government funds are a complement that drive the contribution of *additional* money (for a thorough review see David, Hall and Toole 2000). This is a notoriously difficult to assess but has been debated science at least 1945 when Vannevar Bush, then head of the Office of Scientific Research and Development, laid out his "endless frontier" philosophy. In this report, he emphasized the responsibility of the Federal government for funding the most fundamental research projects (within universities) on the basis that industry will likely fund more applied, immediately useful and translational projects where the link between funding and outcome is more certain and easily specified (Arrow 1962). Placed in the context of philanthropic funding, this simple dichotomy ignores the significant role of what David has referred to as the "differentiated institutions supporting and shaping the conduct of scientific research" (David 2007, p. 2) – from scientists themselves, to their patrons, scientific societies and universities. Most strikingly, scholars have failed to document even the broad contours of the relationships between government (and industry) funding on the one hand and philanthropic funding for scientific research on the other.

Taken together these two dimensions suggest the existence of at least four distinctive approaches to philanthropy. First and foremost is the traditional approach taken by historic philanthropists such as Cosimo d' **Medici** in the Renaissance: recognizing the importance of fundamental intellectual enquiry and the ornamental power of individuals such as Galileo in his court, powerful patrons such as Medici and others supported their "client savant" to pursue fundamental new ideas (see David 2008 for more analysis of this period and Biagioli 2002). Today, such patrons include Paul Allen's support of SETI and Nathan Myhrvold's extensive support for underfunded areas such as paleontology.[6] **Myhrvold's** approach is clearly stated when he argues that "Giving to the usual suspects has little impact".[7]

The opposite extreme is closely associated with the recent rise in funding for specific diseases by wealthy individuals and their foundations such as **Milken** who provide significant funding for translational research in certain focused disease areas. While these types of funds certainly allow their recipients to pursue new projects, they reinforce the high levels of government and industry support for important diseases. Although in some cases, through novel funding mechanisms, they may support distinctive organizational approaches to the same research areas.

A similar approach to reinforcing philanthropy in fundamental rather than translational research has traditionally been pursued by the **Howard Hughes** Foundation (among others): by providing unrestricted funding for fundamental biological research to promising young scholars, these approaches reinforce government support (mainly through the NIH) of foundational life science projects. Again, their unusual funding approach provides an important point of distinction to the more traditional investigator-driven grant making process (see Azoulay, Graff-Zivin and Manso 2010).

The fourth philanthropic model for research funding is best exemplified by the extensive **Gates** Foundation funding provided in the area of malaria research. While governments and other sources had provided a low level of funds, the contribution of Gates funding explicitly and dramatically transformed the overall level support in malaria research but did so with a clear

[6] It is worth noting that Medici and other Renaissance philanthropists also asked those under their patronage to engage in more useful and translational activities including the construction of military technology, navigation devices, irrigation methods and maps.

[7] It should be noted that Myhrvold is a highly unusual and active scientific patron- not only does he fund research into dinosaur palaeontology, but he also does research on the topic himself. In 2000 he had a paper published in *Nature* on his co-discovery of a bird-like tail bone from a non-avian dinosaur in Mongolia!

emphasis on impact-oriented, translational research intended to identify and fill knowledge gaps that could rapidly lead to impact in the field. The recent contributions of philanthropic funds to human embryonic stem cell research in the absence of Federal funding particularly by those with specific disease-related interests provides another, contemporary example of Gates-like approaches to science philanthropy.

Historical Origins

In today's modern universities, scientists are highly reliant upon external funds because neither the university itself nor possible long-term profits derived from projects provide direct support for their research – except at a low level. While government funding is today regarded as a dominant funding mechanism and has been since WWII, other sources have traditionally included funding from industry and charitable private patronage.

Much of the patronage of the sciences that we observe today has its origins in the princely patrons of the Renaissance, whose "client-savants" provided both useful and ornamental service to the courts. In turn, the patron allowed men of science to pursue their interests in scientific progress (David 2008, Biagioli 1989, Westfall 1985, Feingold 1984). For scientists in the United States, external funding of science only developed in the mid 1800s with the emergence of a group of American "men of science" who became professional specialists rather than cultivated hobbyists. Moreover, the overwhelming focus on US universities on liberal arts and legal education meant that university support of science (aside from some support for teaching duties) was limited. Even scientific societies – modelled on those in Europe – lacked "a bounty for research"[8] – and American scholars returned from advanced studies under leading scientists in Europe, only to be discouraged by the lack of equipment, support and the emphasis on teaching. [9]

Long after their European counterparts were supported by long-term, stable, state patronage, U.S. scientists were reliant upon a wealthy commercial-industrial elite for their funding, thus patronage is intimately linked with the origins of U.S. scientific research. In approaching such patrons, scientists aimed to persuade them that to subsidize the pursuit of

[8] Alexander Dallas Bache "On the Condition of Science in Europe and the United States", available in the Smithsonian Institution Archives, cited in Miller, ibid.
[9] This part of the historical analysis draws heavily on Miller ibid; one of the few texts on scientific support during this period of U.S. history.

science was an act of patriotism that would enable the U.S. to reach parity and perhaps even overtake their European counterparts in science at a time when legislators had little interest in supporting new discoveries. [10]They also linked to emerging American traditions of fund raising and the development of expectations around the active solicitation of donations and bequests. Conceptually, therefore, the early U.S. patrons served as nineteenth century Medici being asked to fund fundamental studies in astronomy, chemistry and biology, while the government reserved its funds for translational research of immediate economic value such as coastal and geological surveys whose outcome contributed directly to national industrial prosperity.

A critical starting point for science patronage in the United States was a bequest from English gentleman-chemist James Smithson in 1820 to “found at Washington....an Establishment for the increase and diffusion of knowledge”[11]. Wrangling over how best to use the bequest – on a library, museum and collection, or to actually fund the pursuit of new knowledge – epitomized the divided views in the country over the proper role of science and the meanings associated with scientific progress. John Quincy Adams (by then the former President) proposed that the capital remain intact with 6% of the income used for operations (an arrangement that would closely reflect the norm for many bequests and foundations a century later). He was also a strong proponent of those who sought to use the money for original investigations, conceiving the “Smithsonian” as a research institution, not a museum or library. After the initial charter and Board of Reagents was established in 1846, Joseph Henry (a professor of physical sciences at Princeton) became the secretary and laid out a plan to “select from the scientific men of the country a few...and furnish them with all the means of prosecuting their researches”.[12] Under Henry, a home for the institution was designed (on the Washington Mall), but the Smithsonian funds also supported scientific research and publications in both fundamental and more applied research. Henry recognized critical gaps in the government’s support of applied activities, funding an extensive system for meteorological observations – a precursor to the weather service. However, he also vigorously supported basic enquiries in areas from the physical sciences to anthropology and regularly voiced his views over the importance of fundamental enquiries. Thus at both ends of the research continuum,

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[10] Miller, Howard S. *Dollars for Research: Science and Its Patrons in Nineteenth-Century America*. Seattle: University of Washington Press, 1970. Print.

[11] Taken from J. Rhees, ed., The Smithsonian Institution, Documents Relative to its Origin and History, 1835-1899.

[12] In Joseph Henry “Programme of Organization of the Smithsonian Institution, Annual Report 1847”, in the Smithsonian Institution Archives.

the pursuit of science as a specialized, professional activity gradually prevailed with philanthropic support from the Smithsonian. This would later be successfully challenged by subsequent Secretaries who devoted an increasing amount of the benefaction to building collections of scientific apparatus, specimens from across the nation, art and later aeronautical artefacts, it nevertheless laid the foundations for patronage of scientific research in the United States.

While Henry used the Smithsonian funding to develop systematic patronage for a few individuals, most scientists found themselves acting as highly creative entrepreneurs building support for their research wherever and on whatever basis they could. Given the intimate relationship between the study of the heavens and interest in theology, it is not surprising that much of the early patronage in the United States came through the support of telescopes and observatories. Technical advances increased the magnitude (in size and cost) of the equipment U.S. scientists would need to seriously pursue astronomy. Lacking the sustained government support provided in Europe, they instead turned to wealthy friends and family members. Albert Hopkins at Williams College established the first permanent astronomical observatory in the U.S., raising funds from his college trustees. Later, the arrival of several comets in the Boston skies in 1843 provided an opportunity to gather public interest, and raise funds for scientific equipment at Harvard. In a community-form of philanthropy, a public meeting was called to "consider the felt want in this community of a Telescope" and a subscription committee was formed, which raised twenty thousand dollars. Patrons included many of the newly wealthy industrialists, including John Amory Lowell (the textile magnate) and Abbott Lawrence. Just as for Renaissance patrons, philanthropic motives were complex; some were linked to religion and the desire to study the firmament, others to issues of cultural inferiority and the need to best the Europeans.

Beyond simply providing for equipment, philanthropists also gave money for a new building and recognized the need to support salaries and research expenses through a permanent endowment, previewing the role of philanthropy today. In 1848, Edward Phillips – part of one of New England's oldest families - bequeathed to Harvard one hundred thousand dollars as a fund for observers' salaries, securing the position of astronomy at Harvard for years to come[13]. While observatories remained popular philanthropic objects, Medici-like support

[13] While difficult to compare this is probably equivalent to a gift of around $40-$60M dollars in 2010.

also went to research artefacts in other areas of fundamental scholarship including a place to maintain the specimens used and analyzed by the charismatic and prominent palaeontologist and geologist, Louis Agassiz. Agassiz had been lured to Harvard from Europe with a guarantee of his salary -- not from Harvard but from Abbott Lawrence. Many others in the community contributed to the Lawrence Scientific School at Harvard as a permanent home for Agassiz, who, like many of the most highly funded scientists of the day, was central in his own fund raising campaign, giving public lectures and participating in public scientific discourse.

Towards the 1880s, scientists realized the need for more stable support of research. Charles Eliot, president of Harvard University (1869-1909) was among those who believed strongly in the opportunity to establish the private university as a major research institution in the service of the nation with similarly specialized and professional training for its students. Among his efforts at fund raising from the wealthy business elite focused on funds to expand the laboratories and facilities for research and education. Edward Pickering, director of Harvard's Observatory, was among those who like Eliot, aimed to introduce a greater degree of security and regularity into research funding. Taking the organizational approach of business leaders of his time, he sought to build an endowment whose income might support ongoing research. At first few patrons were interested in such a scheme, since this was lacking in ornamental promise or even clear practical application. Instead, wealthy self-made men of commerce preferred to build more and greater observatories. (Only a few wealthy patrons showed "Gates-like" sympathies emphasizing the practical utility of science as the basis for navigation and insurance premiums in their gifts). Nonetheless, with patronage -from wealthy scientists themselves, some endowments were sizable enough to focus on giving annual grants for original investigations for fundamental research (based on decisions made by members of the academies). This laid the basis for endowment-based research funding and the tradition of grant-making familiar to us today. Nonetheless, the philanthropic contribution to science was still a small fraction of giving to higher education at universities more generally – around $3M in the period from 1875 to 1903, compared to $153M for education[14].

By the late 1800s, the majority of science patronage for fundamental research was controlled by three institutions: Harvard, the Smithsonian and the National Academy.[15] But it

[14] Miller (ibid)
[15] US Commissioner of Education annual reports cited in Miller 1970 Chapter 6 and Survey by the Carnegie Institution footnotes 55 and 56.

had been established by an elite circle of wealthy manufacturers and industrialists who, as Tocqueville foresaw formed an "aristocracy of manufactures" using their wealth to exercise control over some of the most important educational and research institutions in the nation (Tocqueville 1945, 2:169). Government support was limited and narrowly focused on scientific pursuits of a strong practical bent, mainly for researchers outside the academy whose work held obvious economic appeal such as geological and nautical work. Not surprising given such limited funds, heated debate developed over the appropriate role of government in science: Many saw central Federal control of science as antithetical to the prevailing political philosophy of the day and argued that federal science was "a formidable and crushing competitor of private students of science" (7:25). On the other hand, as the (privately wealthy) Alexander Agassiz argued, a strong government agency was the more appropriate agency to create and control knowledge; he questioned whether the "genius of only the wealthy be employed in advancing the boundaries of human knowledge" (7:42). The boundary between public funding and philanthropy was contentious, with disagreements (that continue today) over the potential chilling effect of public funding on private (in this case philanthropic) dollars. What emerged, however, was general agreement that science could not rely only on the whims of private individuals, even though it would be many years before the public funding of science reached significant levels.

At the start of the twentieth century with the debate unresolved and the gap unfilled (at least for fundamental research) another organizational shift arose that shapes science philanthropy to this day: the emergence of the large, professionally managed, "foundation" devoted to funding science (among other activities). It was an idea espoused by John D. Rockefeller who, with the help of his Baptist minister, Rev. Frederick Gates, viewed charity as a way of remaking society and not ameliorating evil. Other foundations followed suit in supporting science, including the Carnegie Institute of Washington, founded in 1902 to support the expansion of university facilities, as well as funding the "exceptional men" of science and supporting their research and publishing, with over $22M in endowment. The goal, as Andrew Carnegie put it, was to "change our position among Nations" in science.[16] In the end,

[16] Andrew Carnegie (Scottish-American industrialist, businessman, and entrepreneur who led the enormous expansion of the American steel industry in the late 19th century) founded the Carnegie Institution of Washington in 1902 as an organization for scientific discovery. His intention was for institution to be home to exceptional individuals—men and women with imagination and extraordinary dedication capable of working at the cutting edge of their fields. Today, Carnegie scientists work in six scientific departments on the West and East Coasts.

individual grants proved to be too complex to manage and instead, the Institute developed a number of independent research departments, where scientists worked in teams on major problems. Once again these early foundations selected fundamental research areas with little of no secure funding base: Carnegie established research centers in geophysics, geomagnetism, plant biology and embryology as well as providing support for several observatories. This level of support freed the scientist of the responsibility to act as his own business manager and public relations expert but also put more control of research choices in the hands of others: Professional foundation staff could command the resources necessary to shape the increasingly complicated and expensive search for knowledge.[17]

In spite of the growth in philanthropy, science philanthropy remained "benevolent work at a distance" – it was impossible for the industrial-commercial elite to keep in touch with the frontiers of knowledge. Indeed, with the exception of astronomy (which continued to hold ornamental appeal), scientific progress became more daunting for patrons to comprehend and asses - a characteristic that had also hampered the efforts of Renaissance patrons with the rise of mathematics (David 2008). As a result, university scientists failed to build consistent support for fundamental science. [18] It was only with the incursions of government into science during the First and Second World Wars that more stable, Federal, support for science in the U.S. developed, predicated - as it had been during the period of support for Geological and Coastal Surveys - on the promise of translatable practical results but with a greater emphasis on the importance of fundamental research as the starting point.

During WWI, the National Research Council was instrumental in research directed towards critical national security goals, including research in producing a sound-based method of detecting submarines, as well as other military innovations. Though gradually decoupled from the military, the NRC was retained at the end of the war and was able to build a strong coalition for government research funding. [19] This rise in visibility not only increased Federal support but also led foundations to invest $100 million in science between World Wars (1918-1939), primarily to universities. By 1925, at least a dozen large foundations began to sponsor

[17] Nielsen, Waldemar A. *The Golden Donors*. New York: Truman Talley Books, 1985. Print.

[18] Kohler, Robert E. "Philanthropy and Science." *Proceedings of the American Philosophical Society* Mar. 1985: 9-13. *JSTOR.* Web. 1 Nov. 2011. http://www.jstor.org/pss/986975.

[19] The Research Council is currently administered jointly by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, and its work is managed by a Governing Board and an Executive Committee.

academic research on a large scale, including the Rockefeller Foundation via the General Education Board[20]. From a research perspective, the goal of such foundations continued to be the large-scale support of fundamental research in this period via block grants to organized, cooperative groups of scientists or to departments in a few leading research centers. For example, between 1918 and 1925, the GEB invested $20 million in astronomy, physics, chemistry, and biology.[21] In a move that would preview today's Gates-like philanthropists, the Carnegie Corporation and Rockefeller Foundation each gave $8 million to the NRC for cooperative research supporting practical and applied projects to supplement what they viewed as limited government funds. These changes together previewed the intertwined dependency of science on both public government support and philanthropy.[22]

The advent of WWII again galvanized support for science in the U.S.: On June 12, 1940, MIT's Vice President and Dean of Engineering, Vannevar Bush[23] accelerated a plan he had developed for an agency devoted to cooperation among civilian scientists and the military. Approved by President Roosevelt in only ten minutes, the National Defense Research Committee (NDRC) was established and less than a year later subsumed into the Office of Scientific Research and Development (OSRD) – a powerful office which controlled the Manhattan Project until 1943 and which also coordinated scientific research during World War II. At one time, OSRD (under Bush's direction) oversaw 30,000 men including two-thirds of all the nation's physicists! Of the war, Bush said, "... The scientists, burying their old professional competition in the demand of a common cause, have shared greatly and learned much."[24]

WWII had focused funding and scientists on practical matters of national importance.

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[20] The General Education Board (GEB) was established in 1903 by John D. Rockefeller to aid education in the U.S. "without distinction of race, sex or creed." The program included grants for endowment and general budgetary support of colleges and universities, support for special programs, fellowship and scholarship assistance to state school systems at all levels, and development of social and economic resources as a route to improved educational systems. Major colleges and universities across the U.S., as well as many small institutions in every state, received aid from the Board. The emphasis, however, was on the South and the education of Blacks. Offices were established in Richmond, Virginia and Baton Rouge, Louisiana to give GEB agents closer contact with southern communities. The Board was especially active in promoting the public school movement in the early part of the 20th century. After 1940, programs other than those for southern education were brought to a close; funds were nearly exhausted by the 1950s, and the last appropriation was made in 1964.

[21] Ibid (Kohler)

[22] Ibid (Kohler)

[23] Vannevar Bush (March 11, 1890 – June 28, 1974) was an American engineer and science administrator known for his work on analog computing, his political role in the development of the atomic bomb as a primary organizer of the Manhattan Project, the founding of Raytheon, and the idea of the memex, an adjustable microfilm viewer which is somewhat analogous to the structure of the World Wide Web.

[24] Vannevar Bush, As We May Think, *The Atlantic Monthly*, 176(1):101-108, July 1945.

OSRD contributed many advances in the medicine - mass production of penicillin and sulfa drugs - as well as nuclear weapons, sonar, radar, and amphibious vehicles. In the aftermath leading figures in research aimed to shift government funding from the translational to the fundamental and put funding on a stable footing. On May 3, 1945 before a chapter of the Society of Sigma Xi[25], Dr. L.C. Dunn, Professor of Zoology at Columbia University

> *The war ... brought into high relief an important fact which has been dimly recognized for many years: there has been in the United States no orderly means for the continuous support of fundamental scientific research, and no policy or method for the deliberate utilization of science by our society. Science has been a hardy plant which grew where and how it could, thriving in the comfortable greenhouse of a research institute, or turning ample fertilizer into real fruit in an industrial laboratory, or in the more usual case struggling for sustenance in the thin soil of colleges and universities, occasionally enriched by temporary growth stimulants from a foundation or private donor. Except in the case of certain industrial developments and in a few government departments, the support of science in the United States has not been the result of decision but of chance, operating in a milieu [that] contained good scientists and good deal of fluid wealth.*[26]

Bush took up a similar call to end the reliance upon unpredictable science philanthropy when he presented his call for government support of fundamental research in his *Science, The Endless Frontier*, report to the President. Writing that: "new products ... 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!"[27]

The sentiments expressed by Bush and others laid the groundwork for the post-WWII period that persists today and creates to funding context for modern science philanthropy. With the 1950 passage of the National Science Foundation Act, whose stated mission was "to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense," both the funding and the institutional arrangements were created to support fundamental research. In addition, other specialized agencies with a remit to support more translational research whose budget and remit expanded during this period included the National Institutes of Health (medical research), the U.S. Atomic Energy

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[25] Sigma Xi: The Scientific Research Society is a non-profit honor society which was founded in 1886 at Cornell University. Members elect others on the basis of their research achievements or potential. Despite the name, Sigma Xi is neither a fraternity nor a sorority.

[26] Organization and Support of Science in the United States. Dunn. *Science* 30 November 1945: 548-554. DOI:10.1126/science.102.2657.548

[27] United States. Office of Scientific Research and Development. and Bush, Vannevar, *Science, the endless frontier*. A report to the President by Vannevar Bush, director of the Office of scientific research and development. July 1945 U.S. Govt. print. off., Washington, 1945

Commission (nuclear and particle physics) and the Defense Advanced Research Projects Agency (DARPA). Together these agencies would provide strong and growing Federal support for university research across the fundamental to practical continuum that continues today (see Gans and Murray 2012). In doing so, the government (together with more limited industry funding) left private philanthropists with two options –fill narrower funding gaps or supplement already well funded research agendas. Regardless of the allocation of philanthropic dollars, from the mid-1950s until late 1990s, philanthropic support from private donors stabilized at around 10 percent of total research expenditures at U.S. universities.[28] It was only with the dramatic expansion of wealth among high-technology entrepreneurs and the expansion of the endowments that this has risen back up to almost 30% at the start of the twenty first century.

Legal Foundations

While modern science philanthropy has its origins in the complex historical traditions of patronage, altruism and the mingling of the scientific and commercial elites, since the 1960s science patrons have also been guided by a set of legal rules that tightly shape the incentives, boundaries and contracts of their giving. The tax incentives for philanthropy encompass giving to many different organizations pursuing a range of social purposes: religious, charitable, scientific, literary, or educational purposes. Nonetheless, these rules, coupled with the legal and institutional rules guiding universities, intimately shape the precise contours of science philanthropy.

The legal basis of American philanthropy in the U.S. can be traced to the English Statute of Charitable Uses, enacted in 1601 and part of a legislative package of poor laws passed by Parliament to deal with an economic and political crisis that threatened the Tudor regime. The Statute's primary purpose was to provide a mechanism to make trustees accountable for the appropriate administration of charitable assets, which in turn would encourage increased private charity for the relief of poverty, lessoning the tax burden of poor relief.[29] Certain charitable beneficiaries were favored and others disadvantaged to spur private sector resources to resolve public problems, an approach used in the United States through tax incentives.[30]Nonetheless, at

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[28] Leslie, Larry L. "Donor Behavior and Voluntary Support for Higher Education Institutions." Journal of Higher Education Mar. 1988: 115-132. JSTOR. Web. 1 Nov. 2011. http://www.jstor.org/pss/1981689.
[29] http://digitalcommons.pace.edu/cgi/viewcontent.cgi?article=1486
[30] See A History of Philanthropic Foundations, Randal Givens, http://grantprofessionals.org/professional-development/journal/journal-articles-past-articles/77-gpa/267-a-history-of-philanthropic-foundations

least until the mid 1800s, many of the states across America limited the power of the courts to enforce trust provisions thus constraining the scope of charities (Hall 2006). For example it was not until 1874 that the Massachusetts charities statute extended property tax exemption to any "educational, charitable, benevolent or religious purpose" including "any antiquarian, historical, literary, scientific, medical, artistic, monumental or musical" purpose; to "any missionary enterprise" - and other states (such as Pennsylvania) were far more ambivalent towards charities and associations and narrowly prescribed the importance of operating free from profit motives and to benefit those legitimate subjects of charity (Hall 2006). For the purposes of this essay it is useful to understand the legal context for philanthropy as providing rules both for the "patron" i.e. the donor of wealth, and for the "client organization" i.e. the recipient of such contributions who will in turn carry out the charitable work (particularly given that for the purposes of scientific progress, patrons are generally giving indirectly to the "client savant" via a university). The legal framework for the "client" has been in place in the U.S. since the late nineteenth century and focuses specifically on the definition and scope of organizations whose purpose allow them, under a provision in the 1894 Revenue Act (later formally ratified in the Sixteenth Amendment to the United States Constitution in 1913), to be tax exempt. Specifically, the U.S. definition is such that organizations with charitable, religious, or educational purposes are exempt from Federal income tax – a provision that has been included in all subsequent Federal tax code.[31]

The legal arrangements shaping the tax treatment of "patron" i.e. the wealthy with money to contribute to charitable client, were defined in 1917, only four years after Federal income tax was first imposed, when the Federal government raised the top tax rate to 77%. At the same time, the individual income tax deduction for charitable donations was ratified to encourage taxpayers to make donations to charitable (tax-exempt) entities.[32] The narrow

[31] See 26 USC § 501 - Exemption from tax on corporations, certain trusts, etc. including any organization "operated exclusively for religious, charitable, scientific, testing for public safety, literary, or educational purposes, or to foster national or international amateur sports competition (but only if no part of its activities involve the provision of athletic facilities or equipment), or for the prevention of cruelty to children or animals, no part of the net earnings of which inures to the benefit of any private shareholder or individual, no substantial part of the activities of which is carrying on propaganda, or otherwise attempting, to influence legislation (except as otherwise provided in subsection (h)), and which does not participate in, or intervene in (including the publishing or distributing of statements), any political campaign on behalf of (or in opposition to) any candidate for public office." (i.e. 501(c)3.

[32] It is simple but worth noting the underlying calculus of charitable giving under this regime: The deduction subsidizes giving by lowering the price that people must pay privately to support charitable organizations. A charitable contribution of one dollar that is deducted from taxable income lowers the donor's tax bill and thus decreases the resources available for the donor's other consumption, the price, by less than a dollar. For example, if

purpose of this rule was to offset higher tax rates set, which might have otherwise reduce giving to organizations providing social goods (Wallace and Fisher 1977).[33][34] In 1936, the federal government further incentivized patrons' charitable giving by permitting corporations to deduct charitable donations from income. The overall intent of deductions was of course to reallocate private resources to public purposes. In the case of contributions to science these are assumed to have a public purpose as they increase the general level of knowledge, the speed of technological progress and the overall level of knowledge spillovers.

In 1969, the government turned its attention to the charitable giving activities of private foundations. Private foundations are organizations that are tax-exempt themselves due to their charitable purpose but rather than act directly as "client" in carrying out charitable activities, instead are a non-operating vehicles for more formalized and professionalized giving consistent with a charitable mission. They serve as an intermediary between patron and client. Since 1969, their status has derived from the same part of the tax code defining tax exempt organizations (501(c)3), but with a clear understanding that by not soliciting the public for funds they are private foundations rather than public charities.[35] Up until this time, foundations in the U.S. had operated on an *ad hoc* basis (although the notion of a foundation or charitable trust had been embodied law for centuries) at least part because of widely held suspicion towards growing concentrations of wealth. In the early 1900s however, Rockefeller, Carnegie and Olivia Slocum Sage were among the first to conceive of a more formal, professionalized foundation structure with directors who, as Rockefeller described, "make it a life work to

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a donor's marginal tax rate is 30 percent, a deductible one-dollar cash gift to charity will reduce the donor's taxes by 30 cents, so the price of the gift to the donor will only be 70 cents.

[33] Types of deductible contributions include cash, financial assets, and other noncash property such as real estate, clothing, and artwork. In general, the law limits gifts of cash or other non-capital gains assets to no more than 50 percent of the (slightly modified) adjusted gross income. Contributions of capital gains property are generally limited to 30 percent of adjusted gross income. Both individuals and corporations can carry forward contributions that exceed the limits and use them as deductions in later years. http://www.taxpolicycenter.org/taxtopics/encyclopedia/Charitable-Deductions.cfm

[34] Under current law, donations to charitable organization are tax deductible only for taxpayers that itemize.

[35] The Foundation Center defines a private foundation as a nongovernmental, nonprofit organization having a principal fund managed by its own trustees or directors. Private foundations maintain or aid charitable, educational, religious, or other activities serving the public good, primarily through the making of grants to other nonprofit organizations. Every U.S. and foreign charity that qualifies under Section 501(c)(3) of the Internal Revenue Service Code as tax-exempt is a "private foundation" unless it demonstrates to the IRS that it falls into another category. Organizations that are not private foundations are public charities- they generally derive their funding primarily from the general public, receiving grants from individuals, government, and private foundations. Although some public charities engage in grantmaking activities, most conduct direct service or other tax-exempt activities. A private foundation usually derives its principal fund from a single source - individual, family, or corporation - and is a grantmaker. http://www.grantspace.org/Tools/Knowledge-Base/Funding-Resources/Foundations/Private-foundations-vs-public-charities

manage, with our cooperation, this business of benevolence properly and effectively." [36] In a controversial decision, the Rockefeller Foundation was formalized in 1909 and (along with the Russell Sage Foundation) became one of the first formal tax-exempt foundations in the U.S., granted a (New York) state charter for an open-ended set of activities combining grant making with active charitable involvement based on an endowment of over $100M.

Of course with this level of funding, these foundations, along with those that followed, had the potential to shape the research and educational agendas of universities and other institutions with which they engaged, calling into question the relationship between industrial wealth, public life and intellectual pursuits. Certainly they had a marked impact on fields from the social sciences to medicine. By the mid-1960s, however, the public standing of foundations reaching a low point; far from overreaching change agents, it appeared to many that wealthy families were forming foundations entities only to avoid paying taxes and to garner additional benefits rather than create in meaningful philanthropic activities. Patrons' reluctance to discuss their activities made private foundations "symbols of secret wealth which mysteriously used the levers of power to promote obscure, devious, and even sinister purposes" (Commission on Foundations and Private Philanthropy). Government intervention followed: US Congressman Wright Patman instigated a Senate Finance Committee hearing on regulation of private foundations.[37] The 1969 Tax Reform Act established elaborate rules "covering everything from public reporting to diversification of assets and the lessening of interlocking relationships among foundations, donor companies, and donor families" and gave the Tax Exempt & Government Entities Division of the IRS authority to police the operations of all private foundation activities.[38] In other words, all charitable organizations exempt from income tax are expected to permanently dedicate their assets to charitable purposes and in doing so were required to distribute 4% of the foundation's income each year.

[36] Cite speech to University of Chicago 1899

[37] Examples of his accusations include: 1) overvaluing property contributed to foundations, 2) falsely claiming gifts never made to foundations, 3) no reporting of self-dealing, 4) speculative investments made by foundations without downside risk, 5) excessive expenses made by foundations administration, and 6) foundations influencing the outcomes of elections with tax-shielded dollars.

[38] Nielson, W.A., 1985. *The Golden Donors: a New Anatomy of the Great Foundations* First. E.P. Dutton, eds. New York, NY: Truman Talley Books.

Indicator	***Indicative of a GIFT***	***Indicative of a GRANT***
Source	Individuals Non Profit Organizations Corporations Corporate Foundations Donor Advised Funds Family foundations are generally treated as individuals	Government Agencies Voluntary Health Organizations (American Cancer Society or American Heart Association) Non Profit Organizations Corporations Corporate Foundations
Description	"Contribution " (unconditional transfer of cash which is voluntary and non-reciprocal)	"Exchange transaction" (each party receives commensurate value)
Relatedness to provider	Directly related to recipient's mission, indirectly related to donor's business	Directly related to sponsor's business activities, may or may not be directly related to recipient's mission
Value Exchange	No nominal value for funding provided Indirect benefits such as tax advantages, business or personal goodwill, and benefits derived from donor club status are immaterial	Particular value to provider, may include reports, IP rights, publication rights, data, etc
Timing of cash inflow	Money received up front	
Paperwork	Gift Agreement	Award Letter Grant Agreement
Overhead charged	None	U.S. Dept of Health & Human Services "indirect cost rate" (~68%)
Control over expenditure	None	High
Reporting	No obligatory reporting restrictions Details of how, when, and to whom funds were disbursed can be used for donor stewardship	Reporting requirements can include research reports, progress reports, budget reports, and reprots of unused funds
Use timing	N/A	Specified time period of use
Uses	N/A	Matching for government-funded project Research, program operation, curriculum development, training, community service, planning, or other specific activity Activities that use University facilities
Excess Funds	N/A	May be required to return to sponsor
Penalties	N/A	Penalties may exist for failure to reach milestones or use funds
Synonyms	Unrestricted, Donation	Awards, Sponsorship

Under the tapestry of charitable tax codes, science's patrons have a number of avenues available to them for science philanthropy. Broadly defined, the patron-client context allows for two forms of giving: gifts and grants. Wealthy patrons (and indeed any individual who under itemizes their deductions) can make a direct "gift" to universities (and other 501(c)3 organizations) that can be tax deductable - in the form of cash donations or property.[39] They can also use their own private foundation as the vehicle for the gift which has a number of advantages; most prominently, the foundation allows the patron time to make decisions

[39] Hopkins, B. & Blazek, J., 2002. *The Legal Answer Book for Private Foundations*, John Wiley & Sons Inc. Commission on Foundations and Private Philanthropy, 1970. *Foundations, Private Giving, and Public Policy*, University of Chicago Press. Labovitz, J., 1973. *The Future of Foundations*, The American Assembly. Spectrum Press.

regarding charitable contributions and can employ professional staff that assist the patron in selecting particular scientific areas and defining the landscape of possible funding opportunities. The second mechanism is for the private foundation to contribute to scientific activities in the form of a grant to a particular academic institution. Such grant-making activity is much more significant among the larger foundations (rather than small family foundations) and typically (although not always) requires a large and expert staff to sort through grant applicants and make choices. Moreover, grants tend to be more structured and focused on narrow programmatic activities rather than, for example, large gifts which aim to shape the universities broader agenda.

From the perspective of universities, philanthropy must be received in such a way as to not imperil the charitable status of the university. At its core, this means providing clarity over the degree of control and oversight – specifically the lack thereof – allowed the patron. In general gifts have little control except for the initial designation of the uses to which the gift can be placed reflecting a limited sense of exchange i.e. gifts provide no formal or documented "benefits" to the patron and simply serve to reflect the creation of public goods and private benefits in the form of altruism, ornamentation or social capital. On the other hand, grants are more transactional and are meant to provide knowledge and other related scientific outputs in return for the grant.

III. Evaluating Trends in Science Philanthropy

Favourable tax structures for philanthropy together with a tradition of philanthropy providing of public goods with private wealth has lead the United States to boast the most robust charitable sector in the world. According to the National Center for Charitable Statistics, there were approximately 1.6 million tax-exempt organizations in the U.S. in 2010. This includes over 1 million public charities such as universities and colleges. Giving to these organizations totalled almost $290 billion in 2010. [40] The greatest portion of charitable giving, $211.77 billion, was given by individuals or household donors. Gifts from individuals represented 73 percent of all contributed dollars, a slight increase from 2009 figures. Charitable bequests totalled $22.83 billion or 8 percent of total giving. Foundations gave over $40 billion, accounting for 13 percent of all philanthropy in the USA.

[40] Charitable Giving and Universities and Colleges: Internal Revenue Code Section 170. Association of American Universities. May 2011. Web. 16 Nov. 2011. http://www.aau.edu/WorkArea.

Foundations form a small percentage of overall U.S. philanthropy, i.e. about 13 percent. However, the over 76,000 grantmaking foundations in the United States account for about $46 Billion in giving (in 2010) – relative to the 17% loss in their assets in the period from 2008-2009 (see Figures 1a and 1b for more details regarding overall Foundation giving and levels of foundation assets). [41]

<Insert Figures 1a and 1b about here>

Science philanthropy – giving focused specifically on the provision of funds for scientific, engineering and medical research activities - is however, only a very small fraction of charitable giving. According to a 1999 survey of the 8,000 foundations in the Foundation Directory, only 300 indicated that science and engineering were among their primary interests. [42] While hard to estimate precisely, *Science* magazine suggests that 5 percent of the grant volume from the nation's private foundations goes to science and engineering (in other words around $2 Billion in 2010) although some estimates put this at closer to 10% with the rise in very large foundations such as the Gates Foundation and other foundations with a strong orientation towards science, engineering and medicine. In particular, over the past fifteen years, among the grants of more than $50Million, the top fifty (by size), include ten directed to building the research capabilities of specific universities. Among the others includes significant funding from the Gates Foundation to the Global Alliance for Vaccines and Immunizations, the Global Health Initiative and the Medicines for Malaria Venture which indirectly support university research at a massive scale.[43]

Major foundation grants to research also mirror major individual giving which has a strong directive towards science and engineering (particularly when defined to include medical research), and is the area of considerable attention for some of the U.S.'s leading individual donations. Data from the Chronicle of Philanthropy[44] reflects the fact that major science and engineering gifts to universities to extend the scientific frontier have amounted to over $195BN

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[41] According to Giving USA, figures on American philanthropy in 2010 showed that Americans gave more than $290.89 billion in 2010. Individual, bequest and estimated family foundation giving combined were approximately $254.10 billion or 87 percent of total giving. Corporate giving, which is tied to corporate profits, rose an estimated 10.6 percent to $15.29 billion. This reflects an increase in corporate in-kind donations. Corporate giving accounted for 5 percent of all charitable giving.

[42] http://www.philanthropyroundtable.org/topic/excellence_in_philanthropy/the_scale_of_private_support_for_science

[43] This data is drawn from The Foundation Center Statistics Information Service table on Grants of $50Million of more 1973-2010.

[44] *The Chronicle of Philanthropy* covers the nonprofit world. It develops The Philanthropy 400 – an annual ranking of the nation's largest nonprofit groups based on the amount of money they raise.

in the past decade years. In the overall compilation of major gifts, gifts to universities (ranked in the top 10 of R&D expenditures) amounted to more than $29BNin the period 2000 to 2011. By amount, gifts to university science, engineering and medicine constitute about 50% of major gifts (over $10M) to universities recorded each year.[45]

Science Patrons' Funding in Context

The analysis that follows puts philanthropic contributions into perspective, particularly with regards to the scale relative to the large (and rising) amount of government funding for university science and engineering research. To do so, we have compiled statistics on the contribution of philanthropy to scientific research at leading U.S. universities in the past decade, examining both the absolute magnitude of the contributions and their relative importance to the entire research funding activities. Our focus is on the top 50 research universities in the United States (henceforth referred to as *Top50*) - as defined by the National Science Foundation on the basis of their annual level of science and engineering R&D spending (from all sources).

We start by outlining the scope of S&E research funding for U.S. universities - the modern academic engines of scientific progress. In the period from 1972, the combined R&D expenditures of U.S. universities grew from $2BN to over $50Billion a year in 2009 (in 2009 dollars). In real terms this means about a fourfold increase in spending over the period, with a particularly sharp increase in the late 1990s to the end of 2009. [46] From the perspective of an individual research university, from a 1970 baseline of around $4M per year, the decade from 2000 until 2009 saw a dramatic growth in university R&D expenditures from an average R&D expenditure of $47M in 2000 to an average expenditure on R&D of $79M per university in 2009.

These average statistics mask a striking feature of this increase - the divergence in

[45] Statistics compiled from the Chronicle of Philanthropy database on major (over $1M) individual gifts.

[46] *Research and development* expenditures are defined as including all direct, indirect, incidental, or related costs resulting from or necessary to performing R&D by private individuals and organizations under grant, contract, or cooperative agreement. *R&D plant* includes all projects whose principal purpose is to provide support for construction, acquisition, renovation, modification, repair, or rental of facilities, land, works, or fixed equipment for use in scientific or engineering R&D. *Facilities and equipment for S&E instruction* include all programs whose principal purpose is to provide support for construction, acquisition, renovation, modification, repair, or rental of facilities, land, works, or equipment for use in instruction in S&E. *Fellowships, traineeships, and training grants* include all fellowship, traineeship, and training grant programs that are directed primarily toward the development and maintenance of the scientific workforce. *General support for S&E* are funds used for scientific projects and support for activities within a specified discipline; explicit purpose is not specified. *Other S&E activities* include all academic S&E obligations that cannot be assigned elsewhere and activities in support of technical conferences, teacher institutes, and programs aimed at increasing precollege and undergraduate students' scientific knowledge.

resource levels for the top 50 university recipients of R&D funding compared to all other recipients (i.e. the remaining 900 of so universities). Among the Top10[47] leading S&E universities, spending has increased to almost a billion dollars a year for science and engineering. (To put this into a global context, the annual Singapore government R&D spending is $2BN - for all university and research centers in the country!) Specifically, the "Top 10" increased their average expenditures to over $961M in 2009 and the Top10-40 to $480M, while the remaining universities have seen almost no increase in real terms with expenditures of only $45M annually in 2009 (see Figure 2 for a breakdown by different university category from 1970 to 2009).

<Insert Figure 2 about here>

In cumulative terms for the decade from 2000 to 2009, this means that the average non-Top50 has $371M in R&D expenditures compared to $3.86BN for the Top10-40 NSF universities and $7.53BN for the Top10. R&D Expenditures in universities come from a wide range of sources. For reporting purposes, the National Science Foundation considers five: Federal, State, Industry, Institutional and "Other". Federal together with State/Local funding constitute traditional *public* support of research (with State/Local responding to local research needs and to the desire to support local (particularly public) universities as in the case of the State of California funding for the SETI telescope efforts described earlier). Industry funding is generally understood to be the dominant *private* funding source that funds research in order to reap corporate benefits (while nonetheless being aware of spillovers are typically generated due to open disclosure etc.) and it is the relationship between public and industry (private) funding that is generally the focus on attention among observers of university research funding. The two final categories - Institutional and Other - have not been closely examined.

Careful analysis suggests that they can broadly be considered as constituting **philanthropic** funding sources. The rational for this designation is found in the details of the NSF definitions and the ways in which universities themselves designate their funds. First, "Other" funds are defined by the NSF as including, but not limited to, grants and contracts for R&D from nonprofit organizations and voluntary health agencies (such as the American Heart Foundation) and can be thought of as grants largely made through Foundations for specific

[47] Top10 include 1) Johns Hopkins University, University of Michigan, University of Wisconsin, University of California, San Francisco, University of California, Los Angeles, University of California, San Diego, Duke University, University of Washington, Pennsylvania State University and University of Minnesota.

research projects (as described above). Second, "Institutional" funds are defined by the NSF to encompass (1) institutionally financed research expenditures and (2) unrecovered indirect costs and cost sharing. A close analysis of university philanthropy suggests a close correspondence between gifts for current operations coming into the university from individual gifts for current operations restricted to research purposes. It is also the case that institutional funds may sometimes be taken from the endowment for research– typically from gifts that have been designated as being strictly for research activities. The research "accounting" for the Massachusetts Institute of Technology provides a useful case in point to illustrate the allocation of research funds (see Box "Science Philanthropy at MIT" below).[48]

Combining NSF definitions of "Other" and "Institution" as a lower bound estimate of the contribution of philanthropy to S&E research expenditures (the data are higher if we assume that as with MIT some industry funding is contributed via philanthropic, tax-deductable routes), then together, these *philanthropic* sources amount to an average of 30% of support for science and engineering in the nation's leading universities - derived from gifts and grants from not-for-profit foundations (Other) and from the endowment which is supported by foundation and individual giving. Specifically, the breakdown for the Top10-50 (Top10) in 2009 shows the dominance of Federal funding at 59% (63%), but also highlights the combined role of philanthropy; Institutions (individuals) at 18% (17%) and Other (foundations) at 9% (10%).

Moreover, while totally decoupled from the university's perspective, and linked to individual rather than national views on the importance of science funding, they have kept pace with the rapid increase in government funding during the period from 2000 to 2009. (See Figures 3a and 3b for the relative contributions of these funding sources over time to Top10 and Top10-50 respectively).

<Insert Figures 3a & 3b and Figure 4a & 4b about here>

[48] Our year of enquiry is 2007 – this was a fairly typical year in terms of overall giving to universities in the Research 50 (i.e. the top 50 universities ranked by the NSF according to their overall levels of research funding from the Federal government) – it is also the year before the 2008 financial crisis and prior to the Madoff scandal - both of which potentially disrupted philanthropic flows. To gather this data together we use the 2007 results from the Council on Aid to Education (CAE) Voluntary Support of Education (VSE) survey. This is linked to the FY 2007 MIT annual report and the 2008 National Science Foundation R&D Expenditures by Colleges survey. We use the 2008 NSF data on the basis that money received into MIT in 2007 is not spent until 2008 and therefore reported as part of 2008 research expenditures.

Science Philanthropy at MIT

In 2007, MIT's endowment was valued at just under US$10Billion ($9.98Bn). Led by President Susan Hockfield, the institute had expenditures of $2.1 Billion, a headcount of 10,049 FTE students, a recorded alumni base of 121,735 and a faculty of approximately 1000 professors. MIT's total academic R&D expenditures in 2008 were $660M of which $638 was for S&E academic R&D (MIT expenditures on non S&E R&D amounted to $22M in 2008). Of this $660M, the $489 came from Federal sources, $87M industry financed, $10M from the institution itself and $66M from "other" sources (predominantly not-for-profit foundations). The $489 in Federal sources included $22M for equipment (out of a total of $31M) and $6M for non S&E activities. In other words, $460M was committed by the Federal government for S&E research and development activities inside MIT (placing it 17th in the nation).

Of the remainder, a significant fraction can be linked to philanthropy: Of the $87M in research activities funded by industry, about half ($34M) can be linked to giving from corporations (the remainder presumably provided in the form of sponsored research contracts rather than gifts or grants). The $66M from "other sources" accords well with the amount recorded in 2007 as gifts to current operations from foundations restricted to research purposes (under VSE survey definitions this was $69M). Lastly, the $10M from the "institution" accords closely with individual giving for current research. In other words, fully 20% of the funds for MIT research in 2007 came from philanthropy.

To put the role of science philanthropy in perspective of MIT's overall fund raising in that year, in 2007, the **total giving** to MIT amounted to $329M: According to the CAE, almost 30% came from alumni ($96M) and 10% from other individuals. A significant fraction – 45% came from foundations ($149M) and 14% from corporations (not including corporate partnerships or sponsored research contracts) ($45M)[1]. Of this giving, 48% was directly allocated to current operations. Research constituted by far the single largest category of gifts to current operations - approximately $125M of current operations gifts (78%) were restricted for research i.e. the day to day research projects that take place in laboratories. The fine grained breakdown of sources to current research gifts was as follows– alumni 10% ($12M), foundations 56% ($69M) and corporations 27% ($34M). Of the remaining $166M allocated for capital purposes - $48M was designated for buildings and $118M into the endowment. These gifts can be further categorized according to their contributions to MIT's research activities.

Accordingly science philanthropy in the form of gifts or grants from foundations and individuals to MIT for current research represents around 12% of the total R&D spending on science and engineering in the institute. If we include industry philanthropy this raises the total to almost 20% of the research operating budget (compared to 8% for gifts as a fraction of the overall expenditures). This 17% is potentially important beyond even its magnitude– to the extent that is supports a variety of early-stage, innovative and cutting-edge activities that might not be able to obtain funding otherwise.

In particular, Institutional funds (largely derived from individual and some foundation giving) have increased steadily from 12% in 1972 to 19% in 1991. They have since remained at roughly that fraction since then. In 2009 this translated to an annual average of $161M and $103M to Top10 and Top10-50 universities respectively. Other (foundation) funds account for 9% of Top50 funding - an annual average in 2009 of $94M ($54M) per Top10 (Top50) university in 2009, a level that has stayed stable since 1972. For 2009 in aggregate terms this is total contributions to the Top50 of $15BN from the Federal government, Institutional funds of $4.3BN, Other (foundation) funds of $2.4BN, Industry $1.7BN and states $1.5BN.

Distribution of Science Philanthropy across Universities

The scale of S&E resources from philanthropy hides the enormous skewness in the distribution of philanthropic dollars to a small number of universities suggesting that most philanthropy operates along the lines of Hughes and Milken rather than Medici and Gates. Foundation resources like Federal dollars have become highly concentrated: For the 1972-1980 period, the total allocation of Federal dollars was concentrated 19%:36%:45% to Top10, Top10-50 and other (800 of so universities). In the past decade (2000-2009), Federal resources were allocated 21%:31%:48% suggesting that the rich (Top10) did indeed get richer. Similarly concentrated, Foundation dollars are allocated 21%:34%:45% suggesting a significant increase for the Top10 from the 1972-1980 distribution of 16%:38%:46%. In other words, both for Federal and Foundation dollars, Top10 increased their share considerably (at the expense of the Top10-50.

The concentration of foundation funding is mirrored by highly concentrated wealth among Foundations themselves. To examine this issue we turn to more detailed data on grant making by foundations available from the Foundation Center which takes it information from the IRS 990 tax filings made by private foundations on their individual grants.[49] This data will not provide a comprehensive picture of the entire scope of foundation funding for R&D as it does not include non-US foundations. Nonetheless, the data are surprisingly accurate – listed individual grants to the Top50 schools for 2009 (our data cover 2003-2009) amounted to an average of $40M per university (compared to an NSF "Other Funds" average for the same

[49] Data is based on the Grantmakers database of the Foundation Directory.

Top50 schools of $54M).50 Overall then a total of more than $2BN a year (with a high of $2.9BN to the Top50 in 2007) is provided by Foundations to the Top50 research universities. Using this data we find that grants (over $20,000) have been made by over 5,900 different foundations to the Top50 schools in the period 2003-2009. As shown in Figure 5, we then developed a histogram to show how many foundations provided the each decile (10%) of the funding. The histogram shows each funding decile (1-10, 10-20 etc) and the number of different foundations contributing. The distribution is highly skewed: 50% of the support for science, engineering and medicine in the Top50 schools is provided by just over 30 foundations. Even more importantly for our analysis of the influence of Foundations on S&E activities in universities, only 10 foundations contribute 30% of the funds - a total of $3.9Billion (of a total of $13.8BN) of funding to the Top 50 over the period 2003-2009: The Bill and Melinda Gates Foundation, the Robert Wood Johnson Foundation, The Duke Endowment, the Andrew W. Mellon Foundation, the Lily Endowment, the William and Flora Hewlett Foundation, the Annenberg Foundation, the Keck Foundation, the Gordon and Betty Moore Foundation and the David and Lucile Packard Foundation.

< Insert Figure 5 about here >

Data from the Council for Aid to Education[51] provides another powerful window into the funding of American higher education from which we can trace philanthropy into science and engineering beyond Foundation grants to include individual philanthropic giving. We draw our data from CAE's Voluntary Support of Education (VSE) Survey which collects self-reported data on giving to US higher education. Our analysis covers the survey years 2000-2011 focused on the 270 research universities in America which award research degrees and breaking out the Top50 and Top10 as designated above.

When philanthropists select specific universities for science philanthropy, they follow government funding trends and select top research universities i.e. overall they contribute to the upper quadrants in the matrix - Hughes or Milken - selecting places (not necessarily fields)

[50] In other words, our Foundation grant data under counts NSF "other" contributions by about $15M per university in 2009 – a figure that is likely accounted for by foreign foundations and also some family foundation grants that are counted as gifts by the institution and therefore categorized as "institutional" funds by the NSF.

[51] The Council for Aid to Education (CAE) is a nonprofit organization based in New York City, established in 1952 to advance corporate support of education and to conduct policy research on higher education. CAE is the nation's sole source of empirical data on private giving to education, through the annual Voluntary Support of Education (VSE) survey and its Data Miner interactive database.

that already have an extremely strong public funding base. In the last decade, the Top50 (Top10) universities have received on average $196M ($269M) per year in total philanthropic giving to support their research and educational missions compared to $70M for all research universities (around 278 listed in the CAE data as PhD granting). Moreover, not only is the absolute amount of giving to the top Universities higher on average, it is also more focused on research. While the VSE survey does not explicitly categorize research-restricted giving over all, it has various measures that we use to isolate *science philanthropy* from more general philanthropic support of higher education (which has been the subject of much more extensive analysis). These measures link to the different channels used for giving by individuals (alumni and other), foundations and corporations: Gifts can be allocated in terms of their contributions to current operations or capital - endowment and buildings. Within current operations and endowment, contributions can be further broken down into those with and without restrictions – directions in gift agreements shaping the use of philanthropy e.g. dedication to the scientific frontier. We therefore define science philanthropy as current operations funding restricted to research (which accords closely to foundation giving), endowment funding restricted to science (in the form of restricted endowment to support academic divisions, faculty and research) and building support (of which we assume that at least 50% goes to research - a figure that is likely a lower bound estimate). The Top10 receive a much higher fraction of their gifts in the form of science patronage. For them, over 40% of the philanthropy is explicitly directed towards research related activities i.e. **science philanthropy** compared to less than 20% in other research universities (see Figure 6 for the trends across different types of universities in the fraction of philanthropy directed to science).

<Insert Figure 6 about here>

Giving to current operations restricted to science is critical for universities as it makes an important contribution to the overall flow of research funding used by the university each year. On average, each Top50 (Top10) university had $23M ($57M) of its annual giving earmarked for current operations funding for research (compared to $9M overall). This makes up a sizeable fraction of the total current operations giving (23% and 36% for Top50 and Top10 universities respectively)[52]. Giving for current operations in science and engineering comes

[52] Consistent with the data culled from Foundation 990 tax returns by the Foundation Center, university self-reporting on aid to education suggest that Foundations contribute disproportionately more to the top universities current research operations giving –reported as foundation contributions to current operations 2011).

from several sources: Foundations (as noted above), corporations and individuals. (Figure 7a and 7b provide data on the contributions to science-restricted current operations from these three sources to Top10 and Top10-50 respectively).

<Insert Figure 7a and 7b about here>

A number of striking patterns emerge: First, corporate funding in the form of (tax-exempt) giving has grown in significance and are an under examined aspect of industry giving (as captured by the National Science Foundation) suggesting that our perspective on industry funding as a source of private benefits may overlook the countervailing tax treatment of less restricted gifts and philanthropic contributions in kind. Second, individual giving to current research is small but significant particularly for Top10 schools. Third, foundations, as noted above, make substantial contributions to the research base of these schools.

Science-restricted Endowment support is also critical to research because it adds to the long-term endowment from which institutional contributions to research (as defined by the NSF) are made. On average, the Top50 Universities have received endowment contributions restricted for research of over $14.7M per year. The Top10 are also enriched by philanthropy receiving more than $30M per year in philanthropic gifts to research endowment. In sharp contrast, the average (PhD granting) university outside of the Top 50 received only $3.5M for science-restricted endowment. (See Figure 8 for a breakdown of current and endowment research giving for Top10 and Top50 and other research universities).

< Insert Figure 8 about here >

Overall then, the CAE data suggest that philanthropic funding has become increasingly skewed toward the Top10 schools. Both in terms of funding for current research expenditures and science patronage of endowments, Top10 schools now garner an average of over $100M each year for science philanthropy compared to only $50M for Top50 schools and less than $5M for other research universities. This raises serious questions as to the distributional consequences of highly concentrated funding, particularly when it follows patterns that are closely linked to Federal funding patterns. Of course one way in which philanthropy may be distinctive is to emphasize less well funded fields (albeit funded within universities that are the “usual suspects”).

Science Philanthropy across research fields

The *distribution* of science philanthropy across different types of research is more difficult to determine than overall levels from distinctive sources. To provide some insights into allocation across scholarly research fields we examine data from the Chronicle of Philanthropy data on major gifts. This data capture gifts of over $1M to all causes each year from 2005 onwards. From the data we extract gifts to universities and then code all those focused on science according to the research field: fundamental fields including life sciences, computer science, physical sciences (including mathematics) and social sciences, as well as more translational fields including medicine, engineering, and energy. A final category was used for "interdisciplinary" gifts that cover research in a variety of fields. In total between 2005 and 2011, gifts over $1M to universities amounted to $23 Billion. Of this, over $19B was given in gifts over $10M. The $19M can be broken down into $9B for non-research purposes and 10B for science philanthropy. (See Figure 9 for the breakdown)

< Insert Figure 9 about here >

Of the $10B, an average of 70% is directed towards translational applied research in medicine, engineering and (to a much lesser extent) energy thus underscoring the emphasis of today's science patrons acting in the Milken and Gates "quadrants" by giving to practical research focused on meeting specific needs and solving problems of personal interest. In particular medicine gathers an average of 53% of the translational philanthropy. With regards to the 24% devoted to fundamental research, an average of 12% is devoted life sciences (a surprisingly small fraction but one that reflects the greater appeal of medicine as a context for philanthropy). The remaining 6% is focused on inter-disciplinary or cross-campus research. Interesting, 2011 saw three of the largest gifts to higher education in US history all three to support broad cross campus initiatives focused largely on supporting the fundamental foundations of research and education. Two of these gifts came from William S. Dietrich II who gave $225M to Carnegie Mellon University and $125 to the University of Pittsburgh (of which he is an alumnus). The gifts support the College of Humanities and Social Sciences and the College of Arts and Sciences respectively. They are among the top 10 gifts to higher education in U.S. history. The third such gift in 2011 was from David and Dana Dornsife; $200M to the University of Southern California – an unrestricted gift to the College of Arts, Letters and Sciences.

The distribution of philanthropic gifts over the past seven years (for which data are easily accessible) contrasts with Federal funding allocations to different research areas. (see Figure 10 for a detailed analysis by research discipline).

< Insert Figure 10 about here >

These comparative statistics (which only illustrate the part of science philanthropy devoted to major gifts over $10M designated to specific fields) provide further evidence of the emphasis of philanthropy to translational fields compared to the Federal government – 73% versus 56%. In particular the data suggest a particular emphasis on medicine – 57% versus 35% compared to the distribution of Federal funding. Interestingly, both the physical sciences and life sciences are underrepresented compared to Federal funding levels (4% versus 14% for physical sciences and 15% versus 26% for the life sciences). It should be noted that given the lack of completeness of the philanthropic data encompassed by large gifts (compared to say Foundation grants), the relative allocation is more interesting than the fraction of overall funding provided by philanthropy compared to Federal funding.

III. Conclusions & Policy Implications

Conclusions – Challenges & Opportunities

Overall, the analysis of science philanthropy suggests a number of important patterns. First, compared to the patrons of science who first supported the emergence and professionalization of research in the United States in the mid- to late-eighteen hundreds, today's patrons generally work to supplement Federal funding across fields rather than filling gaps where there is limited or no funding. In doing so, their actions are much more consistent with the patterns developed by Hughes or more recently Milken than those of Medici or Gates. A case in point is funding for the physical sciences particularly mathematics, physics and computer science; not only do these fields receive limited funding from the Federal government, but compared to traditions of the past where philanthropists stepped in to fund telescopes, mathematicians (see David 2008) and chemists, today such philanthropy is the exception rather than the rule. There are of course some noted exceptions to this trend. For example, in 2001 placed a hold on all funding of hESC proposals solicited by the NIH that had been solicited by the prior administration based on a recent legal ruling on the legality of such research projects.[53] In August 2001, President Bush introduced his administration's policy:[54] It offered federal support for hESC research, subject to significant limiting conditions on research materials but placed no restrictions on the use of private, philanthropic or state funding for hESC research purposes. In a clear gap from the researcher's perspective, universities turned to private philanthropists to secure what they saw as much needed additional funding, and funding with many fewer restrictions on their activities. Harvard research scientists turned to wealthy individuals to provide philanthropic support for their research creating the Harvard Stem Cell Institute (HSCI) whose 2005 Annual Report argued that "we will need individuals to fill the fiscal gap left by a government that views science through a political lens. And that indeed provides a unique philanthropic opportunity."[55] They had already been supported by science philanthropy of over $40M including a $5 million commitment to launch HSCI by Howard and Stella Heffron in the form of a challenge grant that created the momentum to reach $40 million in philanthropic support in less than two years.

Having established that science philanthropy generally follows Federal government patterns across fields rather than looking for gaps (with notable exceptions), it is important to understand the extent to which philanthropy is highly concentrated to a greater degree than Federal funding in two arenas: across schools and across the fundamental to practical continuum. With regards to schools, philanthropy, particularly from individuals, is disproportionately garnered by the Top10 schools for their research activities and certainly by the Top50. The concentration of philanthropy is more pronounced than Federal funding - a trend that seems to have been magnified over the past decade. Secondly, philanthropy not only maps to Federal funding trends, but it also emphasizes then particularly with regards to an emphasis on translational applied research with 73 cents in every dollar of science philanthropy going to translational research (particularly) medicine compared to less than 55 cents from the Federal government. To the extent that this reflects individual interests in specific problem areas, it does suggest that philanthropists highlight areas that they consider to be

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53 This shift from prior NIH funding policies was based on an opinion provided by Harriett Rabb, then General Counsel at the DHHS, to Harold Varmus as Director of the NIH, concluding that funding research that uses hESCs not derived with federal funds would not violate the Dickey Amendment (Rabb, 1999; NIH, 1999).

54 The Bush policy was met with negative reactions from both the right and left of the political spectrum (Wertz, 2002) and substantial disappointment within the scientific community (Clark, 2001; McGinley and Regalado, 2002). Proponents of hESC research argued that limitations on federal funding would inhibit scientific advances and retard medical improvements (Wertz, 2002).

55 From "Harvard Stem Cell institute Annual Report 2005, page 20.

"underfunded" by the Federal government. A few exceptions to this pattern are clearly evident. First, the massive inflow of funding into malaria research by the Gates Foundation suggests that in some areas data on broad funding trends (such as life science funding) fail to capture micro-level trends at do illustrate funding gaps – tropical medicine as a case in point (see Gaule and Murray 2012).

The clear evidence on growing concentration of Federal and philanthropic funding on a few leading research universities poses a key challenge, particularly for science philanthropy. Growing economic evidence argues quite counter to this trend suggesting that the potential for a diversity of ideas and a plurality of participation is critical to the stability and creativity of innovation economies. Economic historian Joel Mokyr has, for example, argued that the demise of science in China was led by the increasingly narrow approach to science and innovation taken by a small number of people, leaving little room for alternative approaches to important questions. Likewise, the rise of the enlightenment and later Industrial Revolution in Britian can be traced, at least in part, to the diversity of participants and unusually rich network of connections among them. Recent economic theory emphasizes the need for diversity of approaches particularly in the earliest stages of research (Aghion et al.; Acemoglu 2012). An interesting and notably exception to the trend towards concentration in philanthropy is the Gates Foundation Exploration Grand Challenge grants that uses a form of "lean review" to select small-scale research proposals based on very limited information and with no identification of affiliation with elite schools or track records. To the extent that philanthropists shun such diversity in their choice of elite universities it is essential to consider whether their mode of funding can impose some diversity. , diversity of approaches to selection including. – may get "unusual suspects"

One critical aspect of science philanthropy that has been overlooked in mapping out broad funding flows is the extent to which philanthropy, while reemphasizing the overall rate and direction of Federal government funding has the opportunity to do so in a different way. Specifically, philanthropists can emphasize alternative mechanisms by which to allocation research funding or by which to manage the organization of research or its outputs (see Gans and Murray 2012 for a more detailed analysis of these issues in a general context). The freedom to experiment with different organizational approaches comes at least in part because contemporary science philanthropists give money driven by a complex set of motives and with a rich mix of control and freedom unusual for modern times. It is also afforded them by virtue of the freedom allowed their foundations (which are not under the same type of scrutiny that the Federal government confronts in its grant making process) and the degree of latitude that can be expressed in gift agreements. As philanthropist J. Roderick MacArthur, son of John D. MacArthur and a trustee of the John D. And Catherine D. MacArthur Foundation emphasized, as "the only institution in our society that does not have constituencies....Foundations should be striving to do the things that government cannot do."

High levels of autonomy are particularly well suited to science at the earliest stages of research and development, where freedom to select direction are highly valued by scientists (Aghion, Dewatripont and Stein 2007). And overall, such autonomy to challenge researchers to organize differently will be particularly salient for philanthropists whose patronage adds to areas with high existing levels of government support. In order for their support to have the impact they desire, they have to be convinced that they are serving a problem in the selection, organization or disclosure of research projects. In the case of Howard Hughes for fundamental research in biology – a field extremely well funded by Federal sources – the premise is that by providing long-term funding without the need for repeated and short grant-making cycles, researchers will be unfettered from low-risk projects and able to undertake bolder, risky projects. Recent evaluation suggests this to be true for Howard Hughes supported faculty (who are typically at highly prestigious schools with very high baseline levels of funding for fundamental biology) who show both higher impact in their projects and high rates of "failure" than a similar control group of scientists. For Milken, focused on translational research, the mechanism relates less to funding selection and more to the organization of research: Their aim is to stimulate more innovative collaborations and more effective engagement of patients in translational research to meet medical goals. Their approach also emphasizes sharing of research materials through novel collaborations and incentives that recognize the importance of material access in research productivity (see Murray et al., 2010, Furman and Stern 2009 for more systematic analysis of these trends).

Policy Questions

The significant role of science philanthropy is an overlooked but critical aspect of the funding landscape for leading U.S. research universities. While much attention has been paid to the impact of rising industry funding, philanthropists constitute a much bigger contributor to fundamental and translational research taking place in academia. Consequently, both the rate and direction of research are, at least in part, shaped by the desires of a relatively small number of individuals whose approach to resource allocation at the scientific frontier is entirely different from the archetypal Federal funding agency. If we also consider the contributions made by patrons of science to the construction of new laboratory facilities and the places of science, then the role of philanthropy on campus is even more substantial. Indeed both the physical and intellectual space of many of our leading research universities have been transformed by philanthropic generosity. It is not surprising then to find that universities have developed a complex and sophisticated infrastructure – generally referred to as the Office of Development - through which to solicit gifts and to engage with foundations. This little examined part of university institutionalization is clearly as important as the more frequently analyzed Offices of Technology Transfer when it comes to shaping the nature and direction of campus research. What then are the policy implications of extensive science philanthropy?

The most obvious question relates to the proposed changes in tax deductions for charitable contributions. Last changed in 2002/2003, the proposals would reduce deductions only for the wealthiest contributors. While a variety of general analyses have been done to estimate the impact of such changes, the composition and scale of individual giving to research universities is quite distinctive to other types of giving – being highly skewed towards larger gifts. Thus it would be timely to more carefully analyze the distribution of research gifts by size and to examine their sensitivity to changes in tax rules.

The second set of policy issues relate to how Federal funding agencies might react to and engage with science philanthropists – an issue of particular importance in the light of dramatic proposed budget cuts for Federal research spending. With regard to the relationship between Federal and philanthropic funding, there is no comprehensive evidence that science patrons fill the gap left by Federal funding cuts. While a century ago patrons did support fundamental science filling the lacuna left by government, patronage today could not fill the extensive role of the government would. This is underscored by two key facts about philanthropy – philanthropists are more concentrated in their giving to specific universities and in giving to specific (translational) fields than the government, suggesting that with few exceptions – such a Nathan Myrvold's desire to support "stuff other people don't" as evinced by his funding for palaeontology - patrons add support to already well funded wealthy fields not fill gaps. In addition, the lack of allocative efficiency and coordination among patrons makes more comprehensive funding strategies impossible and leaves researchers at the whims of particular individuals. How should these insights influence today's Federal giving? The data presented above suggest that current Federal trends towards funding concentration in leading centers should be attenuated given the high concentration of philanthropy. In addition, the skew towards translational research by the patrons of science reemphasizes the need for the Federal government (and patrons themselves) to assess their commitment to fundamental research. Overall, this conversation would be most effectively supported by a deeper understanding of the relationship between Federal funding and philanthropic dollars by university and by field.

While the interaction between funding sources is crucial, the most important role of philanthropy is as a critical locus of learning for Federal agencies; philanthropists who experiment with new modes of selecting, organizing, and structuring research provide important insights for the management of research. A case in point is the MIT Deshpande Center for Technological Innovation - funded through a gift by entrepreneur Desh Deshpande and used for "proof of concept" faculty funding grants – that provides some of the inspiration for the Department of Commerce i6 Challenge. More generally, such philanthropic experiments should be more systematically analyzed by government agencies and may provide a path towards the more effective allocation of funding to enable both high-risk/high-return projects but also projects more likely to effectively contribute to economic growth and prosperity. Alternatively it may be that philanthropists could fill that high risk/reward gap, leaving the Federal government to allocate their research portfolio across a broader range of universities and fields.

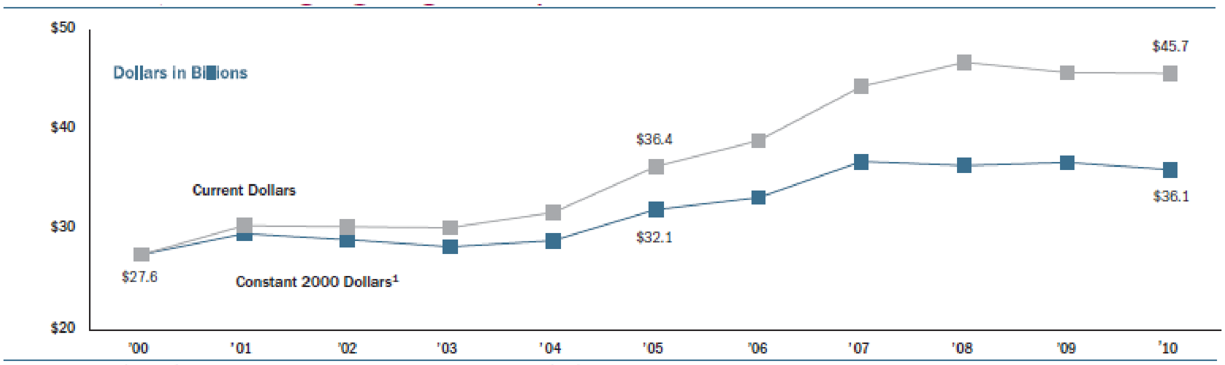
Two other critical actors in the science philanthropy nexus – patrons and universities – might also pause for reflection when considering the broad landscape of philanthropic funding for science, engineering and medicine. For philanthropists the provision of significant gifts to universities to strengthen the science is clearly of profound importance for national competitiveness. And yet there are clearly opportunities to have a greater impact on campus through carefully considered programs and modes of engagement – particularly through an analysis of prior modes of giving and their effectiveness. Of course with the desire to more precisely specify areas of interest or modes of engagement with the university comes a tension between allowing the university its traditional autonomy to pursue faculty-driven goals of long-term interest and donor-specified activities.

For university leadership considering these questions of autonomy, it is critical to reflect on the degree to which research directions on campus are set by faculty, by the Federal government through their definition of priorities or by a small number of influential and wealthy patrons – at this point we have only a limited sense of the concentration of patronage (i.e. the number of patrons shaping research) on campus. Moreover, faculty might consider once again the analyses presented by Useem in "The Inner Circle"[56] in which he laid out the networks of influence between large corporate boards, policy makers, foundations and universities. Today, it is worthwhile examining the inter-connected networks that continue to exist between the scientific and the commercial elites: Many of the leading donors to the research universities examined in this essay also chair their governing bodies and lead visiting committees that examine the health of the university. While their extensive business experience may lead them to be well suited to this role, this may not always be the case. It certainly raises the issue of whether these committees are constituted in such a way as to clearly and independently evaluate the appropriate long-term goals of the university. These issues are particularly salient in the light of the growing restrictions places on gifts to the university by donors.

Taken together, the analysis of science philanthropy presented in this paper argues for much greater attention to the role of science patronage on campus. Prior scholarship has explored the role of philanthropy as a critical and distinctive element of the U.S. culture and institutions (going back as far as the observations of de Tocqueville) and has examined the impact of philanthropy in higher education broadly. However, the influence of science philanthropy in sustaining leading U.S. research universities has not been well documented. To fill this gap, this paper presents an initial approach to combining data sources, presenting some provocative descriptive statistics and laying out a series of policy issues. Together they suggest the need for a robust research program combining economic and sociological perspectives and grounded in quantitative and qualitative analyses of the role of philanthropy in the laboratory.

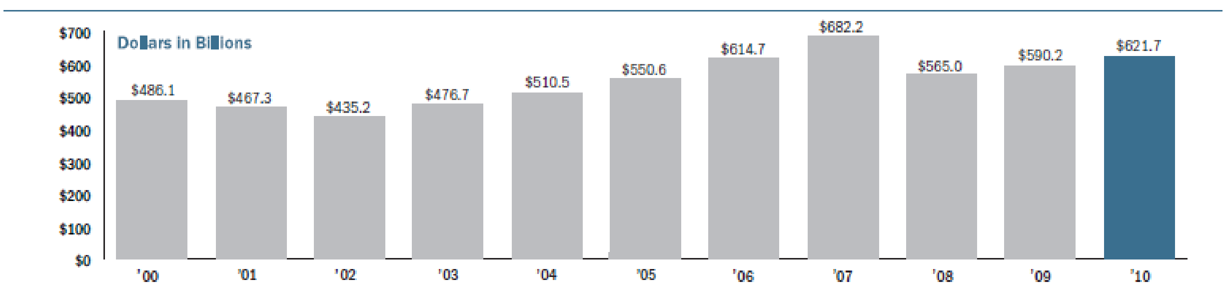
[56] See Useem (1996) for a thorough analysis of the inter-connected networks of large corporate boards, political campaigns and policy advising, foundations and universities.

Figure 1a:
Trends in Philanthropy – Foundation Giving 2000-2010 [57]



Source: The Foundation Center, *Foundation Growth and Giving Estimates*, 2011. Figures estimated for 2010.
[1]Percent change in constant 2000 dollars based on annual average Consumer Price Index, all urban consumers (Source: U.S. Department of Labor, Bureau of Labor Statistics, as of March 2011).

Figure 1b:
Trends in Philanthropy – Foundation Assets 2000-2010 [58]



Source: The Foundation Center, *Foundation Growth and Giving Estimates*, 2011. All figures based on unadjusted dollars. Figure estimated for 2010.

[57] Figure taken from the Foundation Center: Trends in Foundation Giving 2011 report available from http://foundationcenter.org/gainknowledge/research/pdf/fgge11.pdf
[58] Figure taken from the Foundation Center: Trends in Foundation Giving 2011 report available from http://foundationcenter.org/gainknowledge/research/pdf/fgge11.pdf

Figure 2:
Average Total R&D Expenditures for Different Groups of US Universities

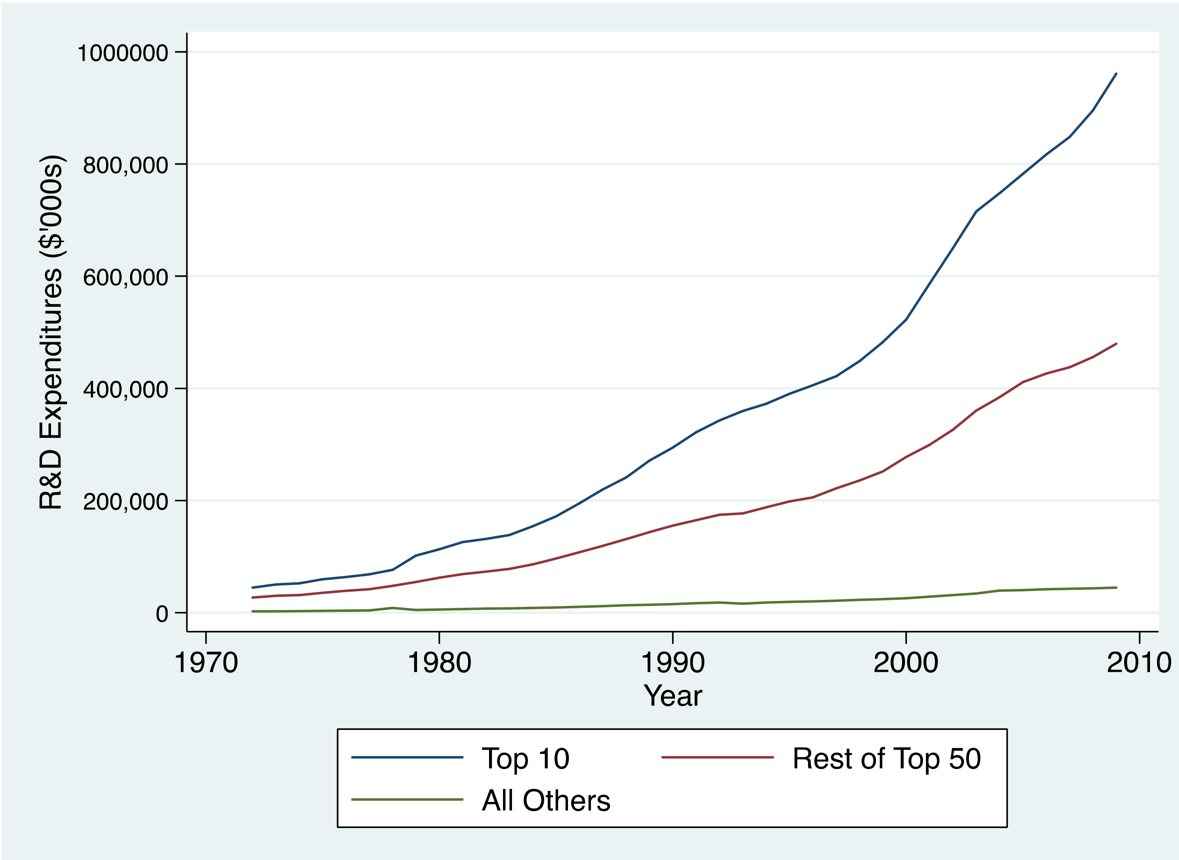


Figure 3a:
Trends in composition of R&D Funding by type of Source for Top10 research universities (Federal + State, Industry, “Other” and Institution) from 1970 – 2009 in $000s.

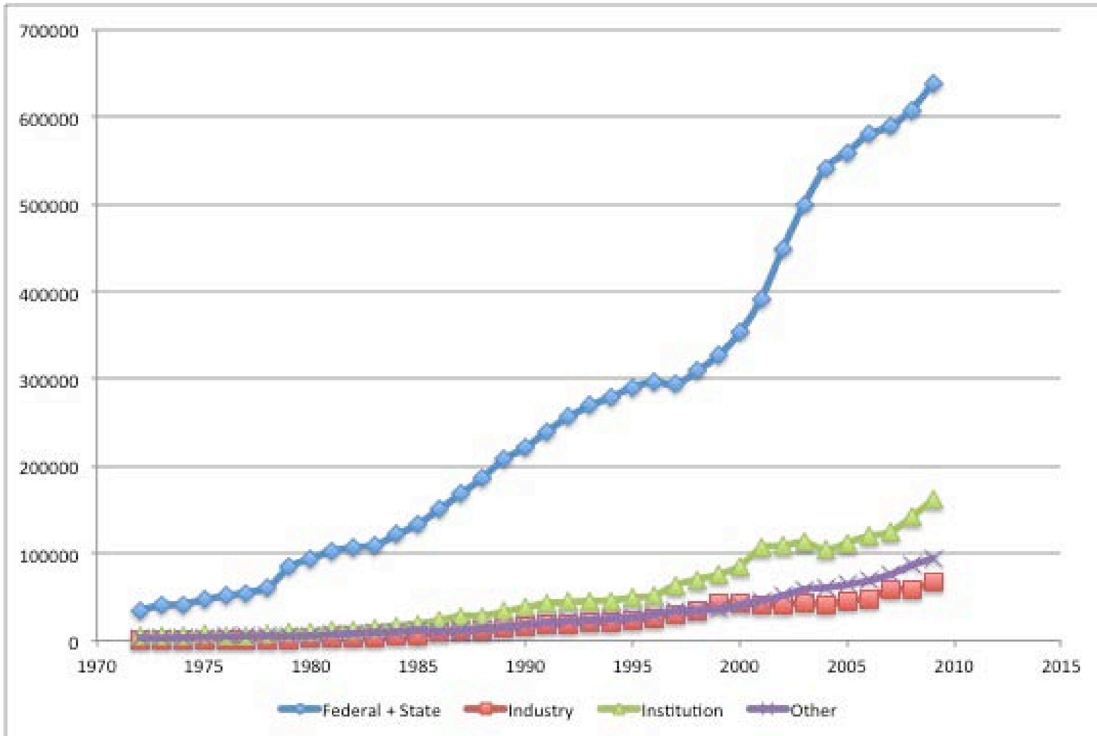


Figure 3b:
Trends in composition of R&D Funding by type of Source for Top10-50 research universities (Federal + State, Industry, “Other” and Institution) from 1970 – 2009 in $000s.

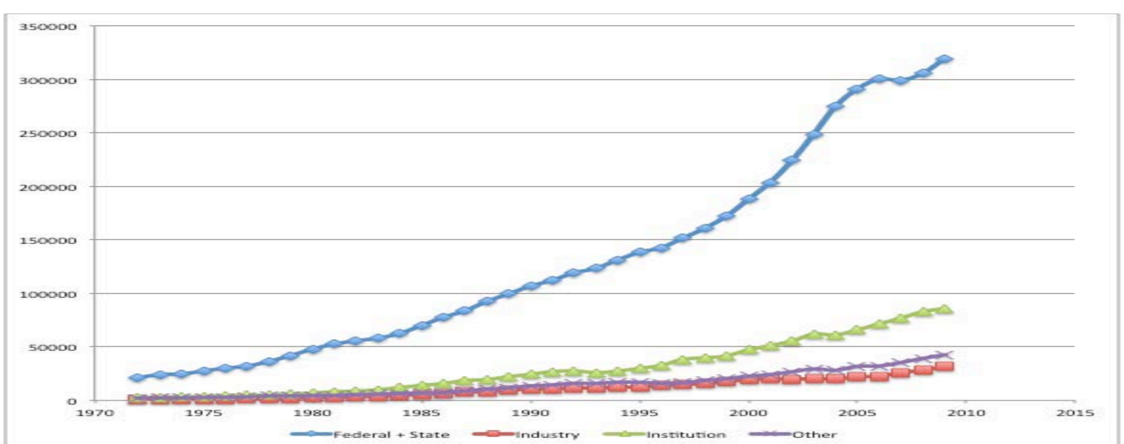
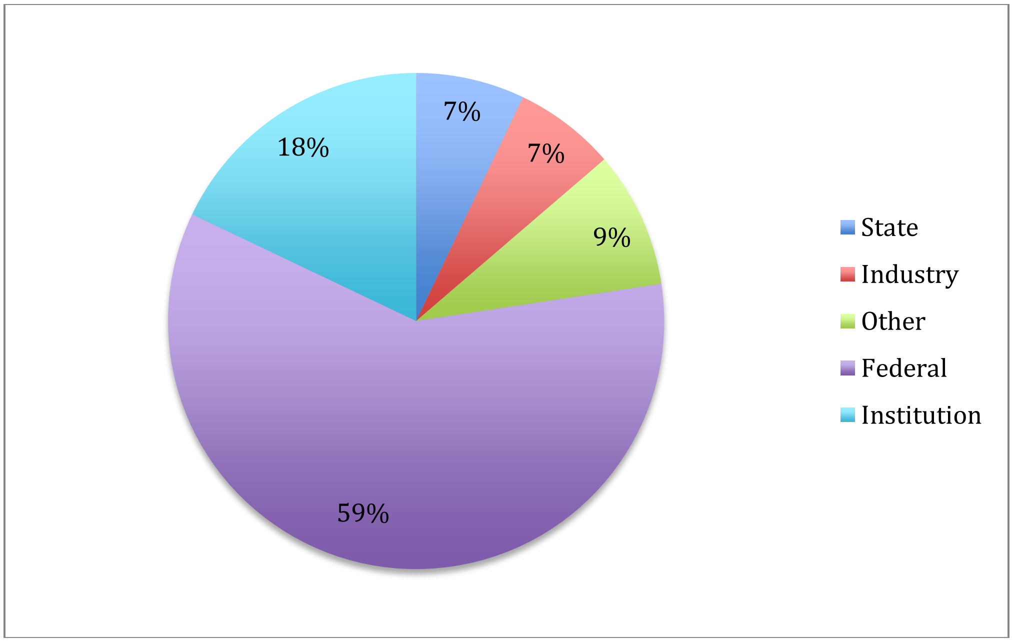
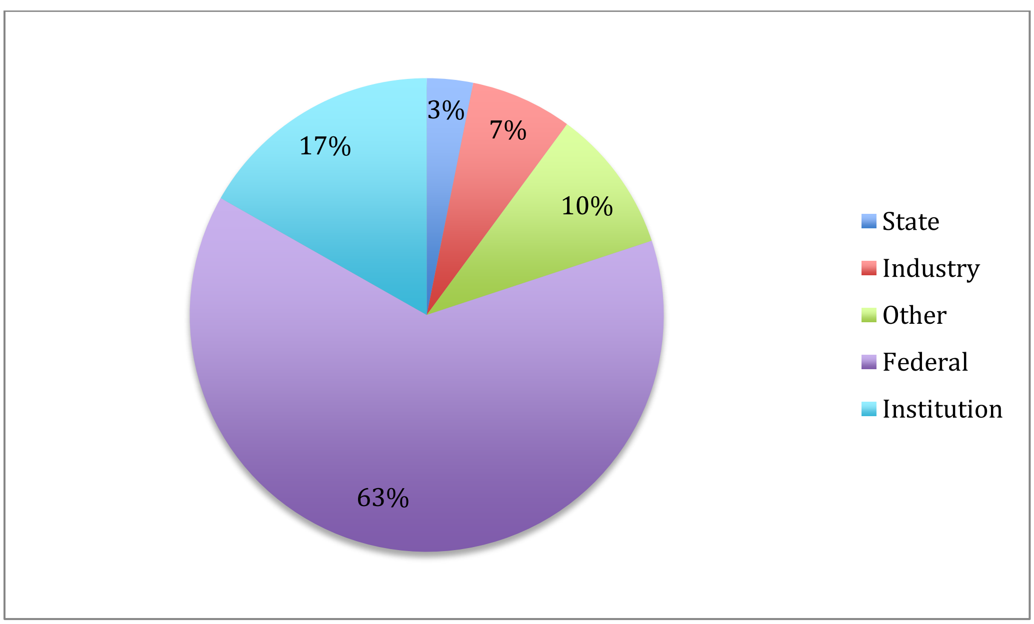


Figure 4a
Breakdown of R&D Expenditures by Source in year 2009 for Top10-50 Universities



Total Expenditure: $16.3BN
Average Expenditure per University: $479M

Figure 4b
Breakdown of R&D Expenditures by Source in year 2009 for Top10 Universities



Total Expenditure: $9.6BN
Average Expenditure per University: $961M

Figure 5
Histogram of Foundation Grants to Universities for 2003-2009 (taken from the Foundation Center Grantmakers data to Top50 research universities in the United States.

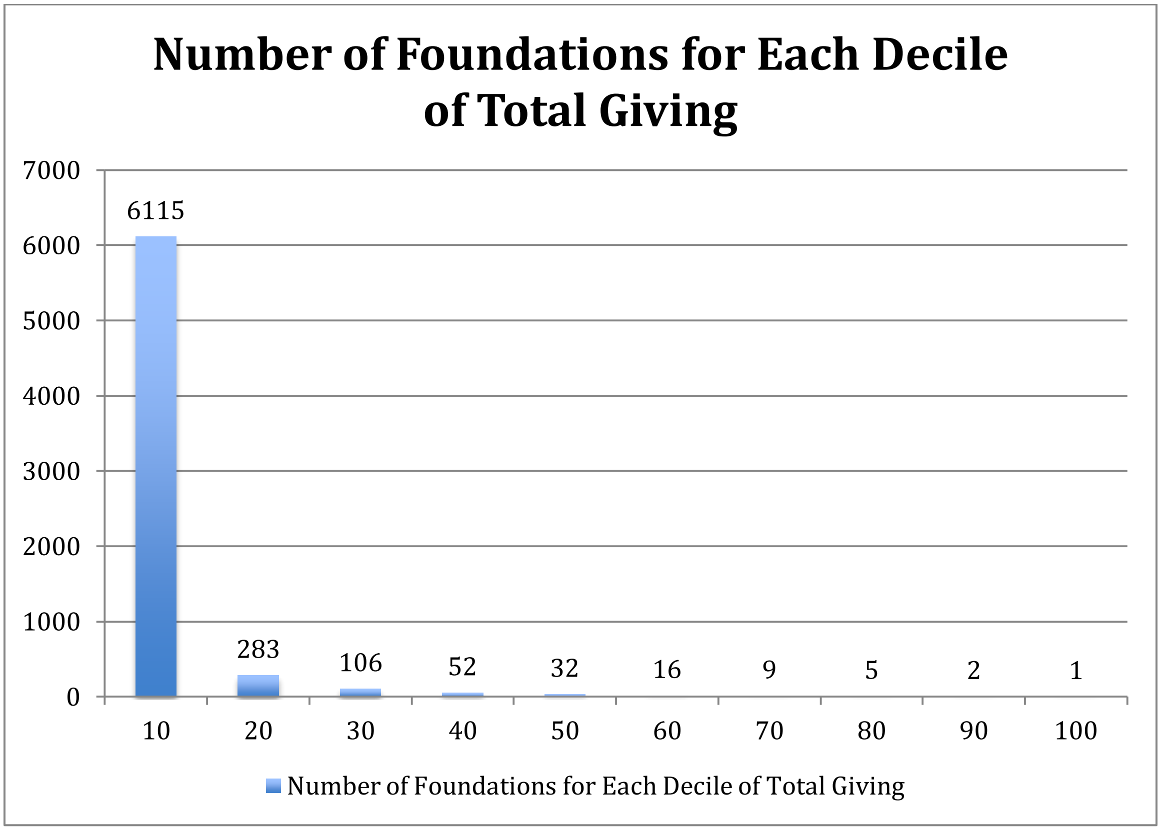


Figure 6:
The Relative Importance of Science Philanthropy in overall philanthropic support for higher education for Top10, Top50 and other research universities (Data from the Council on Aid to Education VSE)

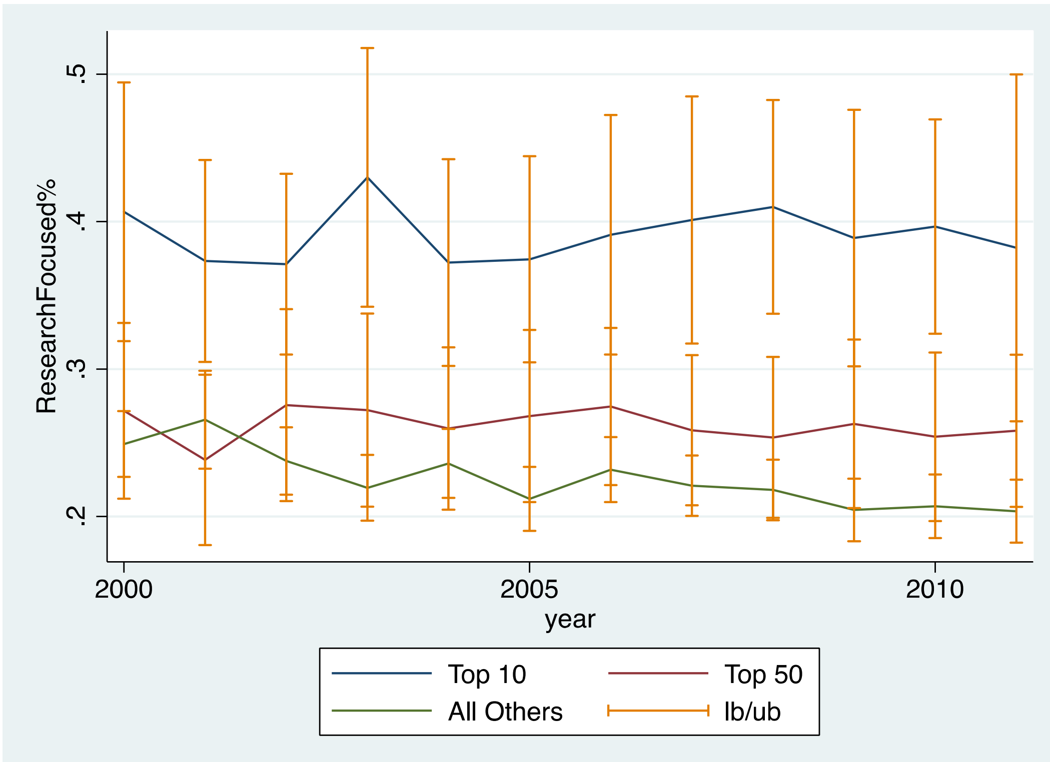


Figure 7a

Contributions to Current operations restricted to Research Funding from Individuals, Foundations and Industry for Top10 research universities (Data from Council on Aid to Education VSE).

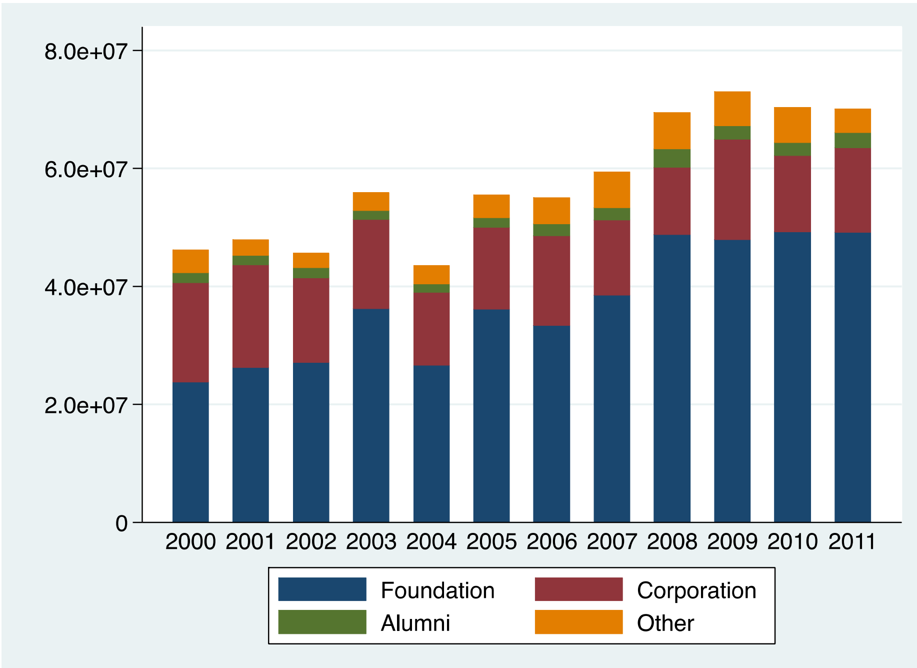


Figure 7b

Contributions to Current operations restricted to Research Funding from Individuals, Foundations and Industry for Top10-50 research universities (Data from Council on Aid to Education VSE).

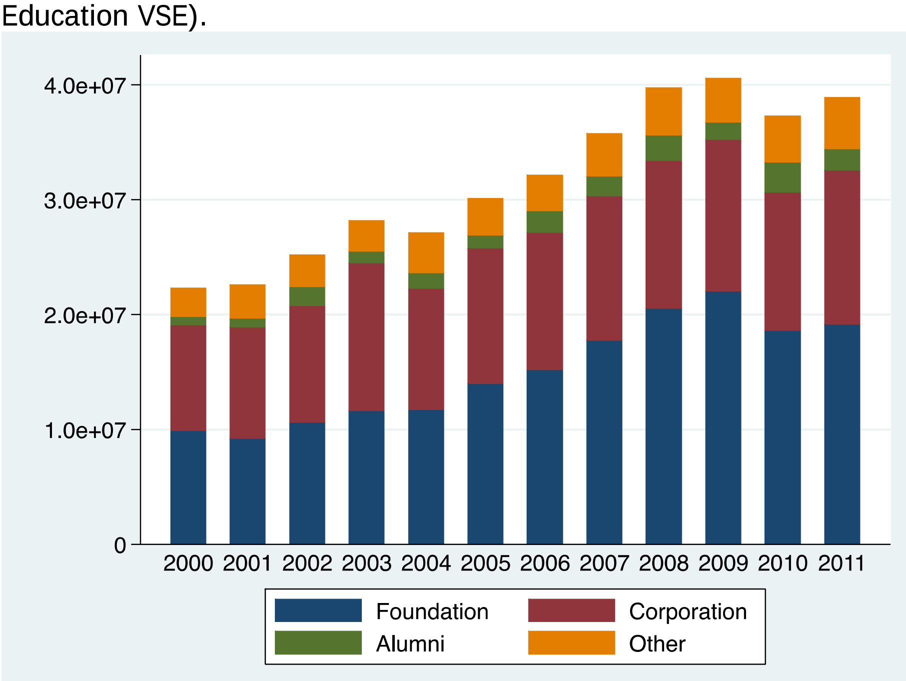


Figure 8:
Annual average levels of Current operations support for research and endowment restricted to research for Top10, Top10-50 and other research universities (2000-2011). (Data from the Council on Aid to Education VSE)

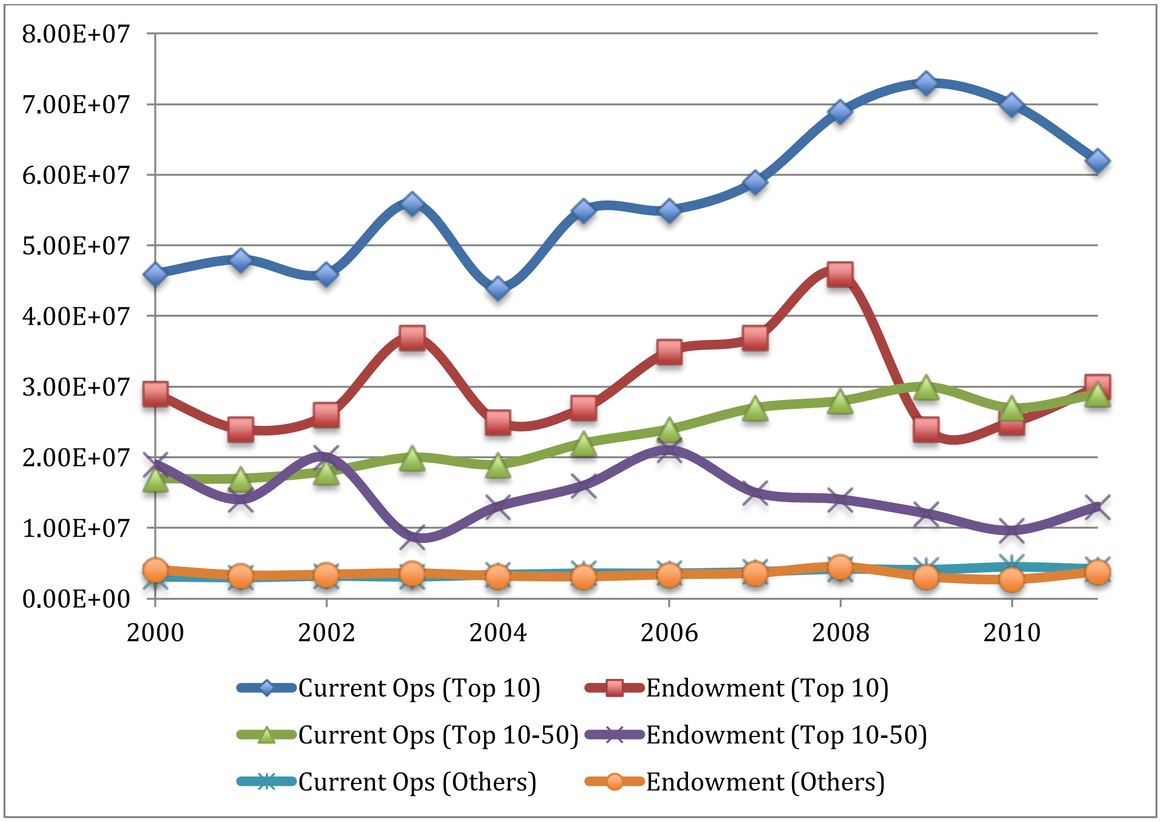
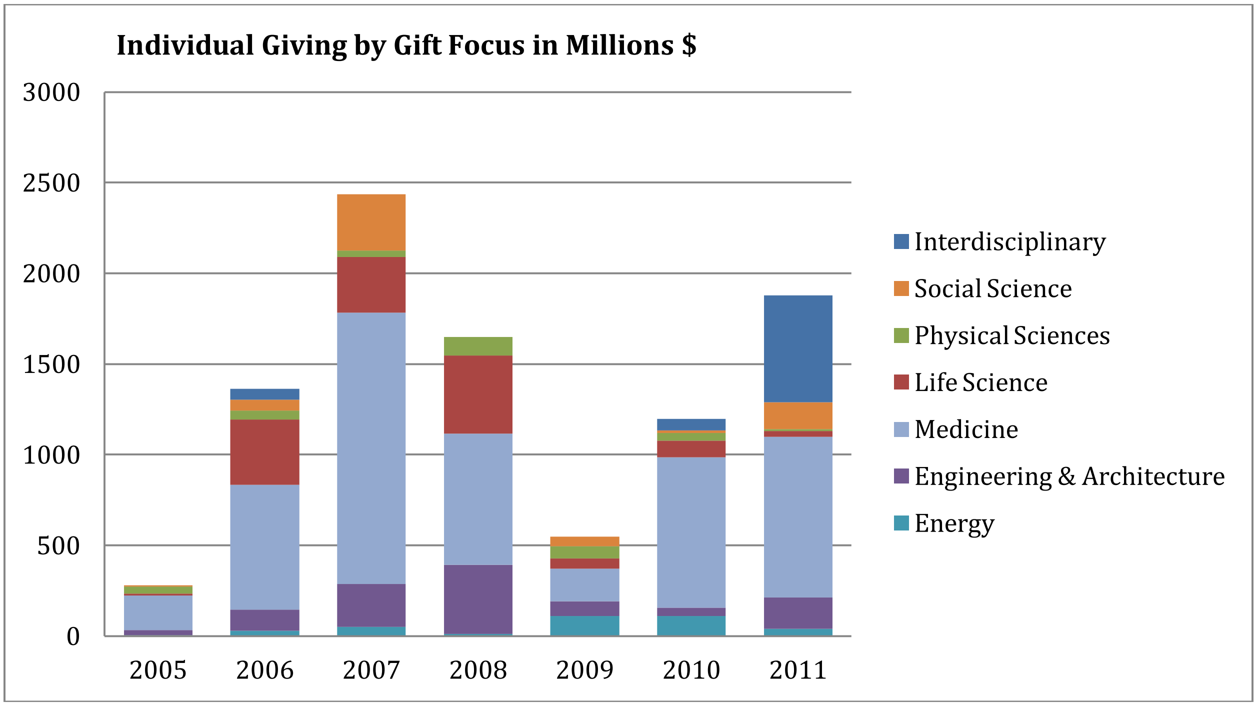


Figure 9:
Major Individual gifts to science philanthropy by subject in Millions $ (From Chronicle of Philanthropy)[59]



[59] The subject analysis has only been completed for science philanthropy gifts over $10M. These amount to $19BN in individual gifts for the period 2005-2011 of which $10B are categorized as science philanthropy. NOTE: the category "interdisciplinary" is for gifts to support research across the entire campus.

Figure 10: Comparing Federal funding obligations to academia by research field (2008) to Major Philanthropic gifts (>$10M) by field (2005-2011 average) for the period 1999-2009 in US$ millions (taken from the NSF Science and engineering Statistics 2012)

	Federal $M (2008)	Federal %	Philanthropy Big gifts $M (avg 2005-2011)	Philanthropy%
Life Science	7,907	26%	183	15%
Physical Sciences (+Math &CompSci)	4,215	14%	50	4%
Social Science	1,447	5%	98	8%
Engineering & Architecture	4,705	15%	152	12%
Energy & Environment	1,826	6%	51	4%
Medicine	10,757	35%	713	57%
Fundamental	13,569	44%	332	27%
Translational	17,288	56%	916	73%