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EVALUATING THE ROLE OF SCIENCE PHILANTHROPY IN AMERICAN RESEARCH UNIVERSITIES

Fiona E. Murray

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1050 Massachusetts Avenue
Cambridge, MA 02138
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ABSTRACT

Philanthropy plays a major role in university-based scientific, engineering and medical research in the United States contributing over $4Billion annually to operations, endowment and buildings devoted to research. When combined with endowment income, university research funding from science philanthropy is $7Billion a year. This major contribution to U.S. scientific competitiveness comes from private foundations as well as gifts from wealthy individuals. From the researcher's perspective, analysis in this paper demonstrates that science philanthropy provides almost 30% of the annual research funds of those in leading universities. And yet science philanthropy 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 directly to useful products. In contrast, philanthropy's contribution to overall levels of scientific funding, and, more importantly, the distribution of philanthropy across different types of research is poorly understood. To fill this gap, we provide the first empirical evaluation of the role of science philanthropy in American research universities. The documented extent of science philanthropy and its strong emphasis on translational medical research raises important questions for Federal policymakers. In determining their own funding strategies, they must no longer assume that their funding is the only source in shaping some fields of research, while recognizing that philanthropy may ignore other important fields.

Fiona E. Murray
MIT Sloan School of Management
100 Main Street, e62-470
Cambridge, MA 02142
fmurray@mit.edu

I. Introduction

This paper examines the place occupied by philanthropy in the funding of science in American universities. My practical goal is to illuminate this largely ignored but important source of funding for leading edge research – in science, engineering and medicine – and its growing importance to 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 <u>level</u> of philanthropic funding and its <u>distribution</u> – across fields, across universities, and across the spectrum of fundamental-to-translational research.

The multi-billion dollar fund-raising campaigns launched by research-oriented universities highlight the central importance of philanthropy to higher education, particularly how universities depend on philanthropy for forging new research lines, new models of knowledge production, and new research collaborations. The role of science philanthropy -- gifts from wealthy individuals, grants from private foundations to scientific research, and endowment income earmarked for research -- is an under-appreciated aspect of philanthropy in higher education whose importance becomes clear by examining trends in funding university research. Over the period 2005-2010, Federal funding to university research has grown less than 1%, and State funding has declined.[1] Industry contributions (usually regarded as the alternative funding stream for university research) amount to less than 6% of university research funding. In striking contrast, **science philanthropy makes up almost 30% of university research funding** and has been growing at almost 5% annually.[2]

Conceptually, science philanthropy presents a puzzle for scholars interested in the economics of science and innovation and for innovation policymakers. Broadly speaking, the two canonical funders – public sector government funding and private sector funds – have clear (but distinctive) incentives for contributing to university research that are well understood and (often) complementary (David, Hall, O'Toole 1998). In a simple economic framework, governments fund the earliest stages of research and industry supports the later, more applied stages (Nelson 1959, Arrow 1962, Aghion, Dewatripont and Stein 2008). In contrast, the

[1] See NSF Science and Engineering Statistics Report 2010 Chapter 5, p 10.
[2] 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.

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 patronage, science philanthropy is shaped by the legal arrangements that encompass charitable giving (Fleishman 2007). It is also driven by negotiations between the "client-savant" (as scientists were known in the Renaissance) and the funder (see David 2008, Gans, Murray and Stern 2010, Gans and Murray 2012), which become doubly complex when patrons sit down with today's university administrators.[3] Thus, few clear predictions exist regarding the distribution of science philanthropy.

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 and industrial) funders.

Between 2002 and 2010, Paul Allen, co-founder of Microsoft, and Nathan Myhrvold (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. A partnership between UC Berkeley's Radio Astronomy Laboratory and the private SETI Institute[4], its research purpose was to advance SETI – the Search for Extra-Terrestrial intelligence – by looking for signals from civilizations elsewhere in the galaxy.[5] Controversial from the start, the project had always suffered from difficulties in gaining robust, long-term government support. Myrhvold contrasted his philanthropy to government funding, making the 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

[3] The extensive analysis of science patronage in the Renaissance and beyond by Paul David is one of the only pieces of scholarly work in the economics of innovation literature dealing with philanthropy (P.A. David, 2008, The historical origins of open sciences: An essay on patronage, reputation and common agency contracting in the scientific revolution, *Capitalism and Society*, Vol 3(2): Article 5.

4 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.

[5] 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".

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 augmented the costs of observatory operations traditionally supported from two other 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).[6] In 2008, when California state budget deficits reduced funding to the Radio Astronomy Lab and Federal funding for the ATA was cut (citing ATA's failure to reach its expected level of performance and its lower than expected levels of sensitivity), Allen stepped into the gap to provide additional patronage.

In 2007, MIT announced a gift of $100M from David H. Koch, an alumnus with degrees in chemical engineering.[7] 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). The remainder of the money was pledged to support research projects. While building on existing strengths at MIT in understanding the basic processes of cancer biology, the aims of the Koch Institute gift followed the impetus of the National Institutes of Health (NIH) towards supporting 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 it was not funding 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 was underpinned by considerable government funding; its designation as a National Cancer Institute (NCI) cancer center entitled it to core funding from NCI for shared laboratory facilities, and it received other long-term NCI Grants. Faculty in the Koch Institute also had support from over 100 grants from the NIH and NCI and a number of foundations, including the Howard Hughes Medical Institute. While closely following shifting Federal priorities in terms of the type and direction of research activities, David Koch's funding enabled the creation of a novel organizational design on campus: the Institute housed both biology and engineering faculty – 40 labs in total -- to facilitate interdisciplinary research.

The core thesis of this essay is that science's modern day patrons play a unique, significant and under-appreciated role in U.S. scientific competitiveness. Compared to

[6] See http://www.nature.com/news/2011/110727/full/475442a.html
[7] 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

government funding, however, whose purpose is broadly understood, and industrial funding sources, which usually drives near term applications, the distribution of today's philanthropic funding cannot easily be theorized. While the historic role of science patronage in the U.S. established (rather than followed) the norms and institutions for funding basic research at a time when government only supported applied research (e.g. geological and coastal surveys etc.), science philanthropists today make a richer set of choices about their funding. The two gifts described above exemplify the different ways in which philanthropy supports U.S. science, engineering and medicine today: the Allen/ Myhrvold gift focused on fundamental (and controversial) research where government funds are limited and no industry support is likely to be forthcoming, while the Koch gift funded an area with extremely high levels of government and industry support and an established track record of research excellence. This suggests that philanthropic dollars can be 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).

To support this framework and fill the lacuna of systematic data, this 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, and we address three unanswered questions: what is the level of science philanthropy (relative to other funding sources), 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? Using the framework as an organizing approach, the paper then examines the patterns of philanthropy along <u>two</u> dimensions: Relative to Federal funding by university and field and across the fundamental to translational continuum.

The empirical evidence of significant science philanthropy, particularly its high concentration in areas of applied medical research and in a small number of schools, provides the basis for a discussion of how **Federal innovation policy could and should respond to modern science philanthropy**. By exploring the level and distribution of philanthropic funding, it is possible to better understand whether Federal funding choices should be made in the shadow of philanthropy. Should the availability of philanthropic capital in particular areas of research or particular schools lead the Federal government to reallocate resources? These are choices that must concern policymakers as they seek to optimize the allocative efficiency of Federal funding. Moreover, the ultra-wealthy have the potential for influencing the path of U.S. scientific, engineering and medical innovation and shaping agendas that were traditionally considered to be the purview of government or scientists themselves. This challenges policymakers as they consider how to balance the direction of research for the nation as a whole compared to directions spurred by a few wealthy individuals, whose research preferences may be highly idiosyncratic or not well matched with broader social goals.

The remainder of the essay proceeds as follows: Section II outlines the conceptual framework within which to consider science philanthropy. Section III places contemporary science philanthropy within its historical context by providing a brief overview of the traditions of U.S. science patronage. It then outlines the modern legal context, emphasizing the (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 rules within universities regarding how philanthropic interests are be matched to research. Section IV provides detailed empirical analysis of modern science philanthropy, while Section V concludes with a discussion of policy implications.

II. A Framework for Modern Science Philanthropy

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 for understanding science philanthropy it is appropriate to posit 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 (see Aghion, Dewatripont and Stein 2008). A second dimension salient to this analysis is the degree to which philanthropic funding of research follows (or lags behind) high levels of non-philanthropic support, or whether it serves 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 step in to fill funding 'gaps' in particular disciplines 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 funding is a complement that drives the contribution of *additional* money (for a thorough review see David, Hall and Toole 2000) - a question notoriously difficult to assess effectively. Nonetheless, at least since Vannevar Bush's 1945 "endless frontier" philosophy it has been seen as 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 is 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 other “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 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.[8] **Myhrvold's** approach is clearly stated when he argues that “Giving to the usual suspects has little impact”.[9] 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. However, 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

[8] It is worth noting that Medici and other Renaissance philanthropists also asked those under their patronage to engage in more useful activities including military technology, navigation devices, irrigation methods and maps.
9 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 is also an active researcher: 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.

best exemplified by the extensive **Gates** Foundation funding provided in the area of malaria research. While governments and other sources had provided low levels of funds, the Gates funding explicitly and dramatically transformed the overall level of support in malaria research; it clearly emphasized impact-oriented, translational research that would identify and fill knowledge gaps in order to rapidly advance 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.

In the contemporary university, funding supports opportunities across the fundamental-translational continuum. To generalize, industry-derived funds support translational projects, while (in the post-WWII era) scientists rely on the Federal government for fundamental research support. Current science philanthropy, as outlined in the framework, provides support across the research spectrum, although at levels significantly lower than overall Federal funding. Patrons fill gaps where other sources are limited or alternatively contribute additional funds in already well "provisioned" areas. The modern contours of philanthropy are shaped by historical traditions of science philanthropy in the United States starting as early as 1850 and by the contemporary legal context that structures giving to not-for-profit organizations including research universities.

III. Context for Science Philanthropy

Historical Origins

Researchers have historically relied on charitable private patronage to a much greater extent and with greater focus on fundamental research than today. The origins of science philanthropy lies with princely Renaissance patrons, whose "client-savants" pursued their interests in scientific progress in return for useful and ornamental service to the courts (David 2008, Biagioli 1989, Westfall 1985, Feingold 1984). For scientists in the United States, external funding of any kind only developed in the mid 1800s. Compared to their European counterparts, who by this time had strong and stable state – national - patronage), American scholars lacked "a bounty for research"[10] ; they often returned from training in Europe, only to be discouraged by the lack of equipment and research support.[11]

Initial funding for U.S. researchers did not come from state patronage. Instead, they were reliant upon the patronage of the commercial-industrial elite. In approaching their prospective patrons, scientists hoped to persuade them that to subsidize science was to undertake an act of patriotism enabling the U.S. to overtake their European counterparts in science at a time when legislators had little interest in supporting new discoveries. [12] They also linked to emerging American traditions of fundraising, which was remarked upon by de Tocqueville. Conceptually, therefore, the early U.S. patrons served as nineteenth century Medici, funding fundamental studies in astronomy, chemistry and biology. The government reserved its funds for translational research of immediate 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"[13]. John Quincy Adams (in a move that would closely reflect the norm for many bequests and foundations a century later) proposed that the capital remain intact, with 6% of the income used for operations. He was also a strong proponent of using the money for original investigations, conceiving the "Smithsonian" as a research institution. In 1846, Joseph Henry (a professor of physical sciences at Princeton) became the secretary, supporting research in areas from the physical sciences to anthropology and regularly voicing his views over the importance of fundamental enquiries. He also recognized a few critical gaps in the government's support of applied activities, funding an extensive system for meteorological observations.

Science patronage in the U.S. expanded as scientists became 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

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[10] Alexander Dallas Bache "On the Condition of Science in Europe and the United States", available in the Smithsonian Institution Archives, cited in Miller, ibid.
[11] 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.
[12] Miller, Howard S. *Dollars for Research: Science and Its Patrons in Nineteenth-Century America*. Seattle: University of Washington Press, 1970. Print.
[13] Taken from J. Rhees, ed., The Smithsonian Institution, Documents Relative to its Origin and History, 1835-1899.

not surprising that much of the early patronage in the United States came through the support of telescopes and observatories. 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, sparking a public meeting to “consider the felt want in this community of a Telescope”. While observatories remained popular philanthropic objects, Medici-like support also went to research artefacts in other areas of fundamental scholarship, including a place to maintain the specimens used by the charismatic and prominent palaeontologist and geologist, Louis Agassiz. Agassiz was lured to Harvard from Europe with a guarantee of his salary -- not from Harvard but from industrialist Abbott Lawrence.

By the 1880s, scientists realized the need for more stable support of research. Edward Pickering, director of Harvard’s Observatory, sought to build an endowment whose income might support ongoing research. At first, few patrons were interested in such a scheme; lacking in ornamental promise or even clear practical application. Instead, wealthy self-made men of commerce preferred to build more and greater observatories. (A few wealthy patrons did show “Gates-like” sympathies, emphasizing the practical utility of astronomy in navigation and insurance premiums). By the end of the century, with the support of an elite circle of wealthy manufacturers and industrialists, endowments slowly grew sizable enough to provide annual grants 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; however, it remained small in scale, while government continued to be focused only on translational projects.

Deeper funding support arrived at the start of the twentieth century with an organizational shift that shapes science philanthropy to this day: the emergence of the professionally managed “foundation” devoted to funding science (among other activities). For example, the Carnegie Institute of Washington’s $22M endowment funded the “exceptional men” of science with the goal, as Andrew Carnegie put it, to “change our position among Nations” in science .[14] In doing so, the Institute selected fundamental research areas with little or no government funding: geophysics, geomagnetism, plant biology and embryology as well as support for several observatories.[15] By 1925, at least a dozen large foundations sponsored

[14] Andrew Carnegie was a Scottish-American industrialist, businessman, and entrepreneur who led the enormous expansion of the American steel industry in the late 19th century.
[15] Nielsen, Waldemar A. *The Golden Donors*. New York: Truman Talley Books, 1985. Print.

academic research on a large scale: between 1918 and 1925, the Rockefeller Foundation via the General Education Board invested $20 million in astronomy, physics, chemistry, and biology.[16]

Growing philanthropic largess was not adequate for university scientists to build consistent, broad-based support for fundamental science.[17] However, it was only with the incursions of government into science during the First and Second World Wars that more stable, Federal funds for U.S. science became a reality. Leading scientists used the aftermath of WWII to put government funding on a large and more stable footing with a fundamental orientation. In 1945 Dr. L.C. Dunn, Professor of Zoology at Columbia University argued:

> *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 a good deal of fluid wealth.*[18]

Vannevar Bush sounded a similar note when he presented his call for government support of fundamental research in *Science, The Endless Frontier*, his report to the President.[19] These sentiments laid the groundwork for a funding landscape that creates the funding context today's scientists and for modern science philanthropists. 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," government funding was established to support fundamental research. In addition, other specialized agencies with a remit to support translational research had budget growth including the National Institutes of Health (medical research), the U.S. Atomic Energy Commission (nuclear and particle physics) and the Defense Advanced Research Projects Agency

[16] Ibid (Kohler)
[17] 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.
[18] Organization and Support of Science in the United States. Dunn. *Science* 30 November 1945: 548-554. DOI:10.1126/science.102.2657.548
[19] 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.

(DARPA). Together these agencies provide the strong Federal support for university research across the fundamental to practical continuum that continues today (see Gans and Murray 2012).

It is against the historic backdrop of science philanthropy in the U.S. and the contemporary Federal funding for research that science patrons provide their support to U.S. research universities in the twenty first century. While U.S. philanthropic traditions in science patronage emphasized fundamental enquiries in astronomy and biology, the complex interests of patrons in both fundamental and translational issues suggest that scientists can (and do) find patrons willing to fund projects across the research continuum. Moreover, with the expansion of governmental support, even patrons following in the footsteps of Medici or Smithson find it difficult to support only philanthropic projects in areas with explicit and obvious gaps; thus they also move into areas crowded with other funding sources.

Legal Context

The precise ways in which patrons fund university researchers are structured by the modern legal context of philanthropy broadly and by the ways in which universities have structured their own internal response to philanthropic research contributions. 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 science philanthropy.

The legal foundations of American philanthropy can be traced to the English Statute of Charitable Uses, enacted in 1601 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.[20] Certain charitable beneficiaries were favored and others disadvantaged to promote and focus private sector resources for public problems, an approach ultimately adopted in the United States through individual tax incentives to philanthropists.[21]

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[20] http://digitalcommons.pace.edu/cgi/viewcontent.cgi?article=1486

[21] 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

For the purposes of this essay it is useful to understand the legal context for U.S. science 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 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 arrangements shaping the tax treatment of *patron* -- the wealthy with money to contribute to charitable client -- were defined in 1917, only four years after Federal income tax was first imposed. With the Federal rate raised to 77%, the individual income tax deduction for charitable donations was intended to encourage taxpayers' donations to charitable (tax-exempt) entities (Wallace and Fisher 1977).[22][23] In 1936, the federal government further expanded the universe of possible patrons by permitting corporations to deduct charitable donations from income. The legal framework for the "*client*" has a longer history and focuses 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.[24] These client organizations (typically referred to as charities) are defined in the U.S. code as organizations with charitable, religious, or educational purposes as exempt from Federal income tax.[25] Research-based organizations including universities are included at clients least in part because contributions to science are assumed to have a public purpose: increasing the level of knowledge and the speed of technological progress.

In 1969, the government turned its attention to another organization engaged in charitable giving: the private foundations: organizations first established by the first great

[22] It is use to outline the 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 price to less than a dollar. For example, if 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.

[23] Types of deductible contributions include cash, financial assets, and other noncash property such as real estate, clothing, and artwork. http://www.taxpolicycenter.org/taxtopics/encyclopedia/Charitable-Deductions.cfm

[24] In 1874 the Massachusetts charities statute extended property tax exemptions to any "educational, charitable, benevolent or religious purpose" including "any antiquarian, historical, literary, scientific, medical, artistic, monumental or musical" purpose; to "any missionary enterprise."

[25] 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." (i.e. 501(c)3).

American industrialists to formalize their philanthropy. As Rockefeller described, they were intended to "make it a life work to manage, with our cooperation, this business of benevolence properly and effectively." [26][27] Rather than act directly as "client" carrying out charitable activities, today they are tax-exempt, non-operating vehicles that give to other organizations consistent with the foundation's charitable mission, while their tax exempt status allows patrons to transfer assets on a tax deductable basis.

Until the mid-1960s, U.S. foundations had operated on an *ad hoc* basis but their public standing was reaching a low point; far from altruistic change agents, it appeared that wealthy families often formed foundations only to avoid paying taxes. 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.[28] The 1969 Tax Reform Act established elaborate rules including 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 all private foundation activities.[29] Their status is derived Section 501(c)3 defining tax exempt organizations, but with a clear understanding that by not soliciting the public for funds they are private foundations rather than public charities (who generally derive their funding primarily from the general public, receiving grants from individuals, government, and private foundations and few undertake grant making activities (although in science philanthropy public charities such as the Juvenile Diabetes Research Foundation does give grants (and is a charity inspire of its name!).[30] Importantly, while all

[26] Cite speech to University of Chicago 1899

[27] In a 1909 decision, the $100M Rockefeller Foundation became one of the first formal tax-exempt foundations in the U.S., granted a (New York) state charter for activities combining grant making & charitable involvement.

[28] 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.

[29] 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.

[30] A private foundation is a nonprofit organization having a principal fund managed by its own trustees. 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 that it falls into another category. A private foundation usually derives its principal fund from a single source - individual, family, or corporation. http://www.grantspace.org/Tools/Knowledge-Base/Funding-Resources/Foundations/Private-foundations-vs-public-charities

charitable organizations are expected to permanently dedicate their assets to charitable purposes, private foundations must distribute 4% of the foundation's income annually.

Against this legal backdrop, a patron of science hoping to contribute to research undertaken in a university has two well-defined of paths to using their funds for science philanthropy: The first is to make a direct, tax deductable contribution to the university, the second is to make a tax deductable contribution to a private (individual or family foundation) and then have the foundation contribute to the university. While similar in outcome, these two paths are traced separately by universities themselves, listed differently in tax documentation (foundation contributions are listed in their 990 tax filings), and thus must be accessed through distinctive data sources. As the client acting on behalf of individual researchers, the university also has significant leeway to shape the ways in which gifts for research are controlled and structured. Over time, a variety of distinctive channels have arisen for contributions:

1. Contributions to capital in the form of buildings; these can be expressly designed and designated for research; for example, much of the Koch Institute gift was earmarked for building new laboratories.
2. Contributions to capital in the form of endowment; the most widespread mode of giving to many universities, endowment gifts build the underlying wealth of the university and generally only the income on the endowment is spent. These contributions can be designated for research via funding of faculty (i.e. Endowed chairs), for research grants or for broad departmental support.
3. Contributions to so called "current operations," which generally flow to supporting yearly activities on campus. These can be designated for research, either for specific projects or for the use of particular faculty in the form of research projects or more unrestricted gifts.

While individuals are free to make use of all three categories, they most commonly support research through the first two types of giving. For example in 2002, successful entrepreneur "Desh" Deshpande gave MIT gift to create a center that would enhance translational research opportunities for MIT faculty. Structured to support the running of the center as well as so-called "proof of concept" research grants (that might otherwise not receive government funding – being too applied in nature), much of the gift provided (designated) endowment. Other more traditional individual approaches to science philanthropy include endowed chairs in particular research fields. In pursuing either approach, individuals can contribute directly or use their private foundation as the vehicle for the gift. This has a number of advantages; the foundation allows the patron time to make decisions regarding charitable contributions and can employ staff to assist the patron in selecting particular scientific areas and defining the landscape of possible funding opportunities. It is more common for large-scale foundations (particularly those with a professional staff engaged in grant making) to use the third approach and structure their philanthropy in the form of research grants made to current operations. Such grant-making activity 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.

Taking into consideration the different ways in which science patronage can come into the university from the patron, for internal purposes universities as clients often distinguish between gifts and grants (see Table 1). This often has important implications for the internal control over the funds and the broader organizational context in which the money is solicited: Gifts are generally managed through so-called Resource Development offices who work to cultivate the interests and altruism of wealth individuals. Grants from professional foundations are often managed through similar channels as government or industry grants, although universities have increasingly put in place mechanisms to manage foundation relationships.

Insert Table 1 about here

In fact, no legal designation between gifts and grants exists within the tax code. From the perspective of universities, philanthropy must be received so as not imperil their charitable status. This means providing clarity over the degree of control and oversight – specifically the lack thereof – allowed the patron. In general, gifts offer little control for the patron 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 explicit scientific outputs in return for the grant.

Favourable tax structures for philanthropy, together with a tradition of philanthropy providing of public goods with private wealth, have led the United States to boast the most robust charitable sector in the world. Researchers in universities have benefitted from this context more than any other nation, and can turn to science philanthropy for projects, equipment and infrastructure across the fundamental to translational spectrum of projects and in well funded and somewhat overlooked field. Casual empiricism on campus suggests that this philanthropic landscape is more robust than ever and has grown in significant in the past several decades. To the extent that such observations are grounded in systematic empirical evidence, they suggest that public policymakers should seriously assess the magnitude and distribution of philanthropic funds as they make their own funding allocation decisions. In what follows, this paper provides the first systematic evidence of science philanthropy as a set towards informing policy decision-making.

IV. Evaluating Trends in Science Philanthropy

Giving to tax-exempt organizations totalled almost $290 billion in 2010, with over 1.6 million tax-exempt organizations as the recipients (of which 1 million are public charities, including universities and colleges.[31] The greatest portion of charitable giving, $211.77 billion, was given by individuals -- 73 percent of all contributed dollars (charitable bequests make up another 8 percent and corporate giving another 5%). After individual giving, private foundations are the next largest contributors, giving over $40 billion annually on an asset vase of about $620Billion (see Figures 1a & 1b for details on levels of Foundation giving and assets over the past decade).[32] Around $45Billion of the $290 Billion in philanthropy went to educational purposes in 2010, of which about $32B went to higher education. The Top 50 research-oriented PhD granting universities received about $11Billion of this total each year to support both research and educational missions.

<Insert Figures 1a and 1b about here>

Science philanthropy is only a small fraction of all charitable giving and is not explicitly tracked by any of the philanthropy-oriented data sources. This analysis provides the first serious estimate of the philanthropic contribution to major U.S. research universities, focusing specifically on the top 50 universities (by overall R&D expenditures). In total, the data suggest that **science patrons actively contribute around $4Billion each year for current**

[31] 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.

[32] Figure derived from Giving USA.

research, endowment or buildings devoted to science, engineering and medicine (to the Top 50 universities). In other words, 36% of the $11Bn in philanthropy to these top research organizations is restricted specifically for research!! In magnitude, this is a lower bound estimate as it excludes all universities below the Top 50, as well as giving for research, endowment and buildings at advanced medical centers, whose research is reported separately from the affiliated university (i.e. Harvard Medical School is included in the data but the Massachusetts General Hospital is not). As previewed by the discussion of the legal context, giving comes from two sources – private foundations' grant making and individual giving.

According to data compiled for this project from the Foundation Center, private foundations contribute around $2Billion of the $4B through grant-making to the Top 50 U.S. research universities (although this data fluctuates with endowment earnings – see Figure 2).

<Insert Figure 2 about here>

This accords with an estimate in *Science* magazine that 5% of grant volume from the nation's private foundations goes to science and engineering (in other words around $2 Billion in 2010), although some put this figure closer to 10% - with the rise in very large foundations such as the Gates Foundation, which have a strong orientation towards medicine). Although large in magnitude, a 1999 survey of the 8,000 foundations in the Foundation Directory suggests that foundations giving to science and engineering are highly concentrated – only about 300 have a primary interest in science and engineering.[33] Considering grants of more than $50Million, ten of the top 50 (in the past decade) were directed to building the research capabilities of specific universities. Others also contributed (indirectly) to universities e.g., grants to the Global Health Initiative and the Medicines for Malaria Venture.[34]

Individual contributions to research at leading U.S. universities made up the remaining $2Billion per year over the past decade (see Figure 2). Although data is less systematic, analysis of major gifts (over $1M) listed by the Chronicle of Philanthropy suggests that gifts to Top 50 universities amounted to more than $23BN in the period 2005 to 2011 i.e. $3Billion a year. Of this amount, gifts to university science, engineering and medicine constituted about 50% - approximately $1.5-$2Billion per year (see Figure 2b for data over the decade).[35]

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

[34] This data is from The Foundation Center Statistics Information Service table on Grants of > $50M (1973-2010).

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

Science Patrons' Funding in the University Context

Science philanthropy is a simple concept to describe and appreciate, but tracing its flow from its sources into the university and then into laboratory expenditures requires more careful accounting and the triangulation of data from a variety of sources. The overall flows are illustrated in Figure 3.

<Insert Figure 3 about here>

In the first stage, as noted above, science philanthropy comes from individuals in the form of gifts and private foundations (typically in the form of grants) – data that can only be gleaned from tax statements or press announcements.

The second stage is to account for the funds as they enter the university. From the perspective of a major research university, according to the Council on Aid to Education (CAE) [36] Voluntary Support of Education (VSE) Survey, philanthropic giving is allocated in terms of contributions to three categories - current operations, capital for endowment and capital for buildings.[37] For the purposes of this analysis, I define science philanthropy as philanthropic giving whose purpose is explicitly restricted to research i.e. dedicated to pursuing the knowledge frontier. Again, three elements are considered: current operations funding restricted to research (which is dominated by foundation giving), endowment funding restricted to science (e.g. restricted to support academic divisions, faculty and research) and building support (of which I assume that 50% goes to research buildings -- an estimate guided by CoP data).

CAE data suggest that annual science philanthropy amounts to $85M per Top 50 university (broken down into $45 M for current research operations, around $20 M in capital to research-related buildings and at least $20 M in annual contributions to research endowment - expanding the research-restricted endowment at about 2% annually). However, this varies across universities. The Top10 receive a much higher fraction of their philanthropic gifts in the form of science patronage. For them, over 40% is **science philanthropy** explicitly directed towards research related activities. As they receive more than $269M annually in philanthropy, this provides them with over $108M annually in science philanthropy alone.

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[36] The Council for Aid to Education (CAE) is a nonprofit established in 1952 for policy research on higher education. It is a key source of data on private giving to education through the Voluntary Support of Education (VSE) survey.
[37] While the VSE does not explicitly categorize research-restricted giving over all, it has various measures that I use to isolate *science philanthropy* from more general philanthropic support of higher education.

The third stage for tracing movement of philanthropic capital into research is to examine how it flows into research funding. In addition to determining how it contributes to developing the research infrastructure and buildings that characterize the modern American university campus today, science philanthropy can be traced to documented annual research expenditures by examining two clear categories tracked by the National Science Foundation:

- “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 that this in part derives from individual gifts for current operations coming into the university from 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 (around $4Billion a year).
- “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. It can be thought of as grants largely made through Foundations for specific research projects (as described above) (around $2Billion a year).

In aggregate, **contributions to university R&D from science philanthropy constitute $6Billion of the costs of annual research expenditures** for the Top 50 research universities when considered to be the sum of NSF designated categories – Institutional funds and Other funds. Of the $6B total, around $2Billion is passed through directly from private foundation giving to universities designated for current research operations (and defined as “Other” by the NSF) while the additional $4Billion is the amount that universities contribute to research from their own funds (either from individual gifts or income from restricted endowment etc). Thus, when combined with the additional $1Billion contributed towards buildings, science philanthropy contributes over $7Billion each year to U.S. research in science engineering and medicine (outside the academic medical centers).

Science Philanthropy versus Federal Funding

How important is science philanthropy relative to the large amount of government funding for university science and engineering research and compared to the much-discussed contributions from industry? To address this question we have compiled statistics on the contribution of philanthropy to scientific research at leading U.S. universities in the past decade, focusing on the top 50 research universities in the United States (henceforth referred to as *Top50* or as *Top10* and *Top10-50* respectively when universities ranked in the top 10 or 10 to 50 only are analyzed separately) - as defined by the National Science Foundation on the basis of their total annual level of science and engineering R&D spending.

In the past decade, the combined R&D expenditures of U.S. universities grew to over $50Billion a year in 2009 (in 2009 dollars). In real terms this means about a fourfold increase from 1972 (when spending was only $2Billion in total), with a particularly sharp increase in the late 1990s to the end of 2009. From the perspective of an individual research university, the decade 2000-2009 saw dramatic growth in university R&D expenditures from average R&D expenditures of $47M in 2000 to $79M per university in 2009.[38] The average statistics mask a striking feature of this increase -- the divergence in resource levels for the top 50 university recipients of R&D funding compared to all others (i.e. the remaining 900 of so universities). Among the Top10[39] S&E universities, average spending per university has increased to almost a billion dollars a year for science and engineering R&D. (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!) The Top10-50 spend $480M, while the remaining universities have seen almost no increase in real terms with expenditures of only $45M annually in 2009 (see Figure 4 for a breakdown by different university type from 1970 to 2009).

<Insert Figure 4 about here>

R&D Expenditures in universities come from a wide range of sources. The National Science Foundation considers five of these sources in its statistics: Federal, State, Industry, Institutional and "Other". Federal, together with State/Local funding, constitute traditional *public* support of research. (State/Local funding responds to local research needs and to the desire to support local, especially public universities, as examplied by the State of California's funding for the SETI telescope efforts). Industry funding is generally understood to be the dominant *private* source that funds research in order to reap corporate benefits, while the relationship between public and industry (private) funding is the focus on attention among

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[38] *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.

[39] 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.

observers of university research funding. The two final categories -- Institutional and Other -- have not been closely examined. As noted above, they provide a useful lower bound estimate of the contribution of science philanthropy to S&E research expenditures.

Taken together, Other and Institutional *philanthropic* funds provide almost 30% of annual science and engineering expenditures in the nation's leading universities. The breakdown for the Top10-50 (Top10) in 2009 shows that after Federal funding at 59% (63%), Institutional funds and Other (foundation) sources constitute 18% (17%) and 9% (10%) (see Figures 5a and 5b). In aggregate terms this amounts to 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. It should also be noted that according to CAE data, corporate funding in the form of (tax-exempt) giving has grown in significance. This is an under-examined aspect of industry giving (as captured by the NSF categorization), suggesting that current notions of industry funding as reflecting private benefits may overlook the countervailing tax treatment of gifts and philanthropic contributions in kind.

<Insert Figures 5a & 5b and Figure 6a & 6b about here>

Dynamic trends are also notable; while totally decoupled from the national debate on scientific competitiveness, and linked to individual rather than national views on the importance of science, philanthropic funds have kept pace with the rapid increase in government funding during the period from 2000 to 2009. (See Figure 6a & 6b). In particular, Institutional funds (largely derived from individual giving and endowment income) have increased steadily from 12% in 1972 to 19% in 1991. They have remained at roughly that fraction since then.

Science Philanthropy across research fields

In this final section of the analysis, we emphasize how science philanthropy is allocated across the two by two matrix outlined in the introductory sections of the paper. The horizontal dimension captures where funding is allocated *across* the research line from fundamental to translational. The vertical dimension captures allocations *relative* to Federal funding.

Science Philanthropy Across the Research Continuum: From an empirical perspective, systematic data on the *distribution* of science philanthropy across different types of research is more difficult to determine than overall levels of research support. To provide some insights into allocation across scholarly research fields we examined data from the Chronicle of

Philanthropy covering major gifts. This data captures gifts of over $1M to all charities from 2005 onwards. From the data we extracted gifts to universities and then coded all those focused on science according to the research field: fundamental fields included life sciences, computer science, physical sciences (including mathematics) and social sciences, while translational fields included medicine, engineering, and energy.   A final category was used for "interdisciplinary" gifts that covered research in a variety of fields. As noted earlier, between 2005 and 2011 total gifts over $1M to universities amounted to $23 Billion. Of this, over $19B was given in gifts over $10M that could be categorized. The $19M was broken down into $9B for non-research and 10B for science philanthropy (around $2Billion a year). (See Figure 7).

< Insert Figure 7 about here >

While annual ratios vary, an average of 70% is directed towards translational research in medicine, engineering and (to a much lesser extent) energy. This figure underscores the degree to which today's science patrons act in the Milken and Gates "quadrants", 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 each year. With regards to the 24% devoted to fundamental research, an average of 12% is given to 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. Interestingly, 2011 saw three of the largest gifts to higher education in US history – each one to support broad cross campus initiatives focused largely on bolstering the 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) in support of the College of Humanities and Social Sciences and College of Arts and Sciences, respectively. They are among the top 10 gifts to higher education in U.S. history. The third such gift was from David and Dana Dornsife: $200M to the University of Southern California – an unrestricted gift to the College of Arts, Letters and Sciences.

Like individual giving, private foundations seem to provide a larger fraction of their science patronage to translational research activities. To determine their allocation across the continuum, we reanalyze data from the Foundation Center on grants from major foundations to the Top 50 research universities. These data are gathered from the 990 Tax Filings of each of the foundations and generally can only be gathered by year at the dyadic foundation-university level; as a result, discipline-based coding is complex. To overcome this challenge, we rank the top 10 foundations by cumulative funding over the period 2000-2009 to the Top 50 universities – over $5Billion of the $20B total for the period. The leading foundations are listed in Table 2.

< Insert Table 2 about here >

As can be seen, while individual grants are likely to be for a wide range of activities, 7 of the 10 (including the Gates Foundation, which is the largest grant-maker to Top 50 universities at three times the size of the Robert Wood Johnson Foundation) focus on translational, mainly medically-oriented research. Of course, notable exceptions exist, including the Andrew W. Mellon and Annenberg Foundations, which focus on the arts, media and journalism.

Science Philanthropy Relative to Federal Funding: The distribution of philanthropic gifts (and grants) contrasts sharply with Federal funding allocations to different research areas. (See Table 3 for a detailed comparison of individual gifts versus Federal funding to Top 50 universities by research discipline).

< Insert Table 3 about here >

These comparative statistics (which only illustrate that part of science philanthropy devoted to major gifts over $10M designated to specific fields) emphasize the contemporary focus of philanthropy away from fundamental fields and towards translational fields, both in absolute terms and when compared to the Federal government – 73% versus 56%. In particular, the data suggest a deepening emphasis of science patronage on medicine – with over 57% of large individual gifts designated to medicine versus 35% for the distribution of Federal funding.   This number should be interpreted carefully because independent academic medical centers are not included in the data. 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, for example, Foundation grants), the relative allocation is more interesting than the fraction of overall funding provided by philanthropy compared to Federal funding. However, the data suggest that at least for fundamental research, philanthropists are not stepping in as modern Medici to fill gaps left by the Federal government in areas such as physics or chemistry. Instead, patrons follow and reemphasize patterns of translational funding that have come to increasingly dominate (non-defence) government research allocations at leading research universities.

V. 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, most of 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.[40] In August 2001, President Bush introduced his administration's policy:[41] 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."[42] They had already been supported by science philanthropy of over $40M, including a $5 million commitment to launch HSCI by

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40 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).

41 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).

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

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 <u>generally</u> 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. Secondly, philanthropy not only maps to Federal funding trends, but it also emphasizes them, particularly with regards to translational applied research: 73 cents in every dollar of science philanthropy goes 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 "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) fails to capture micro-level trends, such as when philanthropists try to fill funding gaps; tropical medicine is a case in point (see Gaule and Murray 2012).

Policy Questions

The analysis presented here confirms the starting hypothesis in this essay -- that 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 contemporary 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. It is also important for foreign governments seeking to emulate the U.S. science funding infrastructure to focus not only on Federal funding, but also on philanthropic funding and the tax incentives, which contribute to how science philanthropy has come to play such an important role in the university. The tax structure is certainly an important inducement for supporting the frontiers of knowledge in academia.

The second and most pressing set of policy issues relate to how Federal funding agencies must 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, their interaction is complex, and the missions, orientations and approaches of these sources are not always complementary. Moreover, the empirical evidence in this paper provides little support for the proposition that science patrons usually fill "gaps" left by Federal funding. While a century ago patrons did support fundamental science, filling the lacuna left by government, patronage cannot provide adequate funding to substitute for the extensive role of the government. In addition, few philanthropists appear to seek to identify such gaps. This fact is underscored by one key fact about philanthropy – philanthropists are more concentrated in their 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" in palaeontology -- patrons add support to already well funded wealthy fields instead of filling gaps. In addition, the lack of allocative efficiency and coordination among patrons makes comprehensive funding strategies impossible leaving 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 fields should be examined in the light of the high concentration of philanthropy in these same areas. 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. While provocative, this discussion must be supported by a deeper understanding of the relationship between Federal funding and philanthropic dollars by university, field and project.

While the interaction among funding sources is crucial, perhaps the most important role of philanthropy could be to serve as a 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. Andrew Carnegie (followed later by Hughes and the MacArthur Awards) led the way in funding individuals of genius and potential rather than specific projects. More recently, philanthropic gifts have emphasized different types of research funding. More generally, such philanthropic experiments should be more systematically analyzed by government agencies; they may provide a path towards the more effective allocation of funding to enable both high-risk/high-return projects and projects that are more likely to effectively contribute to economic growth and prosperity. Alternatively, perhaps 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.

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 challenges. Together they suggest the need for a robust research program grounded in both quantitative and qualitative analyses of the role of philanthropy in the laboratory.

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Table 1:
University designation of Gifts vs. Grants

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

Table 2:

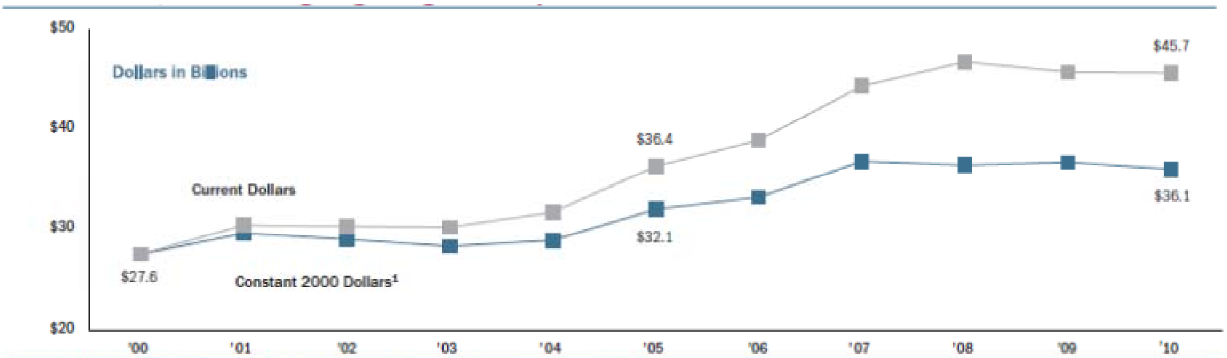
Top Ten Foundations Contributing to Top 50 Research Universities

	2003-2011 Grants Total to Top50	Focus Area
Bill & Melinda Gates Foundation	1,529,707,386	Translational - Life science
The Robert Wood Johnson Foundation	559,068,171	Translational - Public health
The Duke Endowment	527,574,253	Translational - Healthcare, environment, educational access
The Andrew W. Mellon Foundation	380,906,505	Other - Liberal arts
Lilly Endowment Inc.	361,008,584	Fundamental - Life sciences
The William and Flora Hewlett Foundation	280,369,859	Translational - Energy & environment, education, arts
The Annenberg Foundation	250,313,519	Other - Journalism, communication, arts
W. M. Keck Foundation	240,523,977	Translational - Medical, science and engineering
Gordon and Betty Moore Foundation	217,549,545	Translational – Environment & Fundamental sciences
The David & Lucile Packard Foundation	200,010,378	Translational -Conservation, reproductive health

Table 3: Comparison of 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)

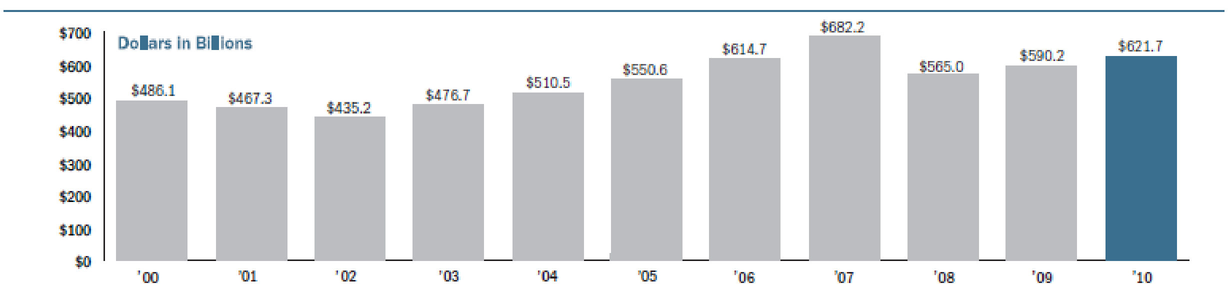
	Federal $M (2008)	Federal %	Philanthropy Big gifts $M (avg 2005-2011)	Philanthropy%
Life Science	7,907	26%	183	15%
Physical Sciences (+Math &CompSci)	4,215	14%	50	4%
Social Science	1,447	5%	98	8%
Engineering & Architecture	4,705	15%	152	12%
Energy & Environment	1,826	6%	51	4%
Medicine	10,757	35%	713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

Figure 1a:
Trends in Philanthropy – Foundation Giving 2000-2010 [43]



Source: The Foundation Center, *Foundation Growth and Giving Estimates*, 2011. Figures estimated for 2010.
¹Percent 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 [44]



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

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

Figure 2: Initial estimate of annual giving in US$ Millions to Top 50 Research Universities for Research-focused activities (Foundation data from Foundation Center, Individual Gifts estimated from Chronicle of Philanthropy)

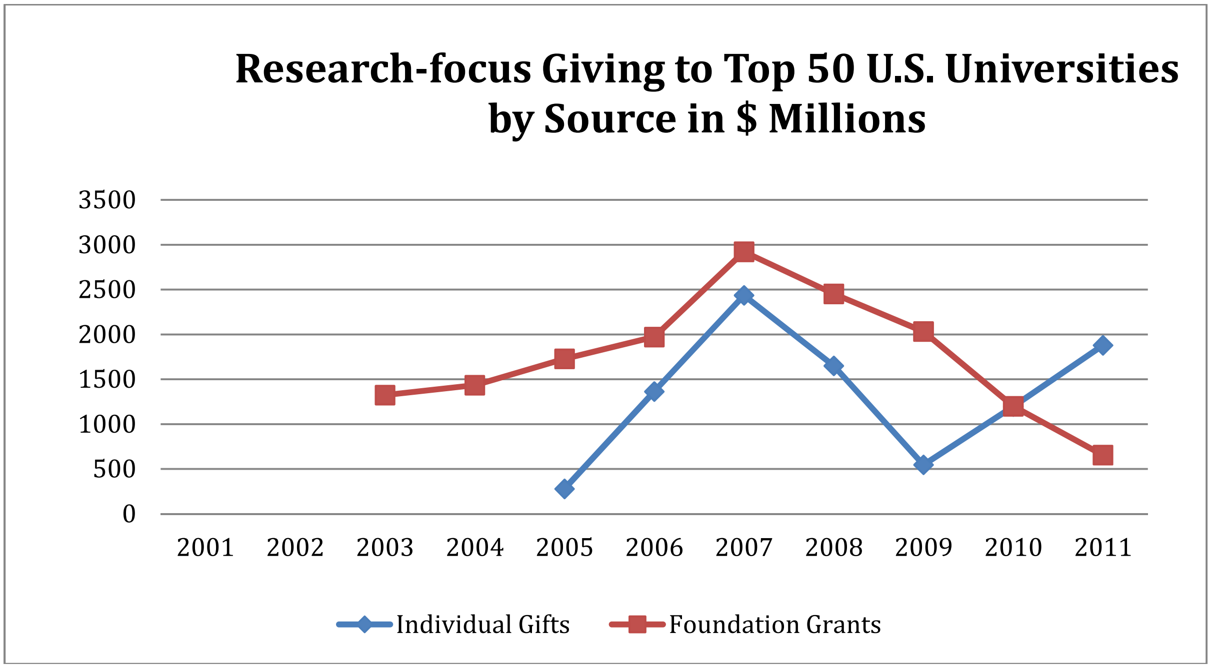


Figure 3: Schematic of Flows of Science Philanthropy from sources to the university and into science and engineering R&D Expenditures on campus (data for 2009)

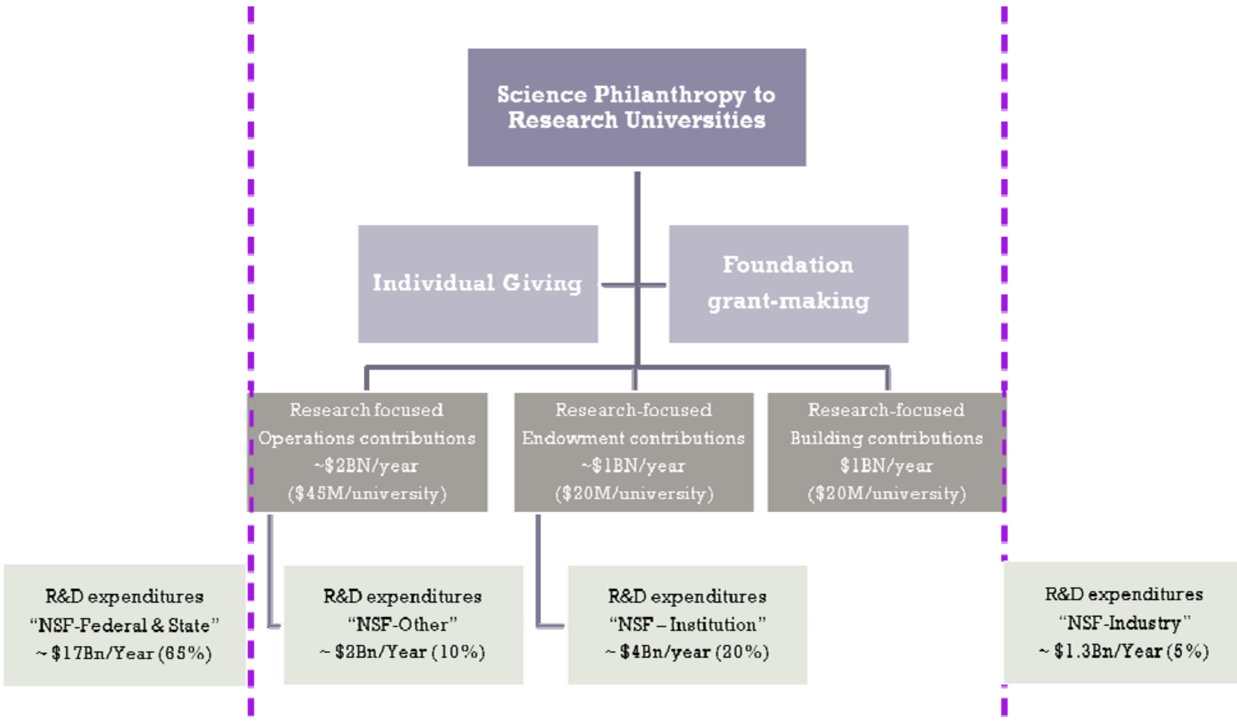


Figure 4:
Average Total R&D Expenditures for Different Groups of US Universities

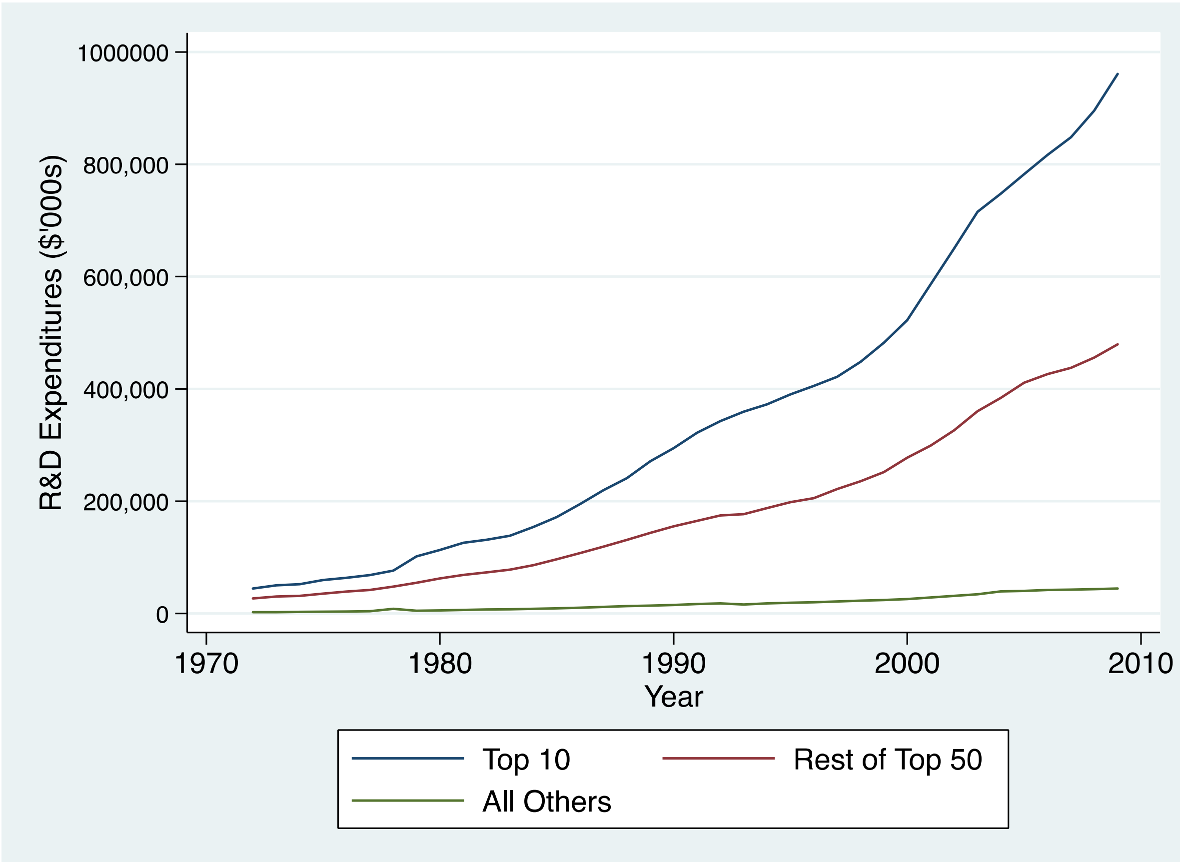
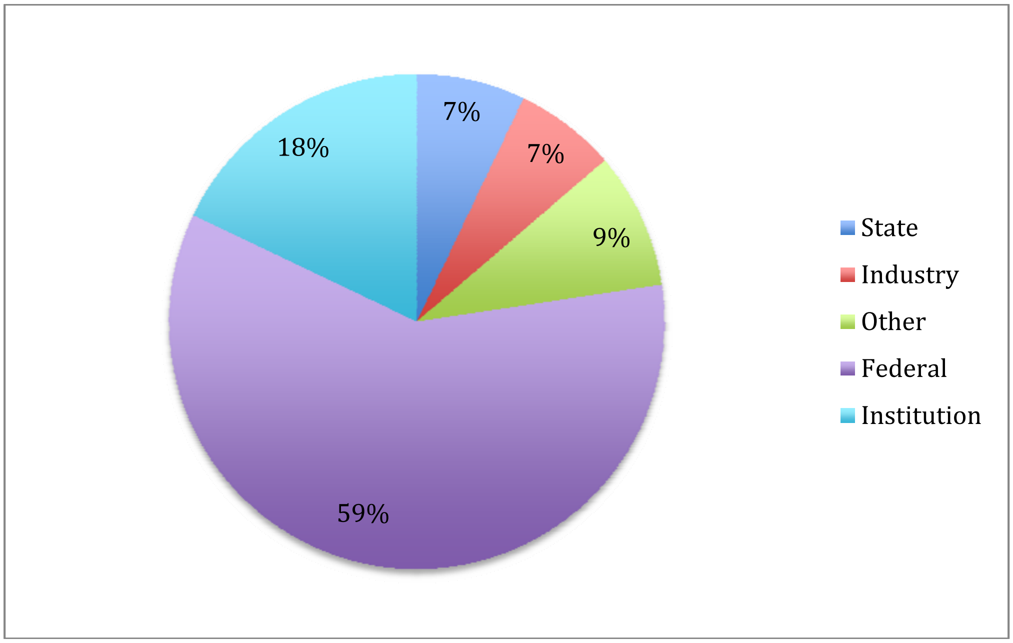
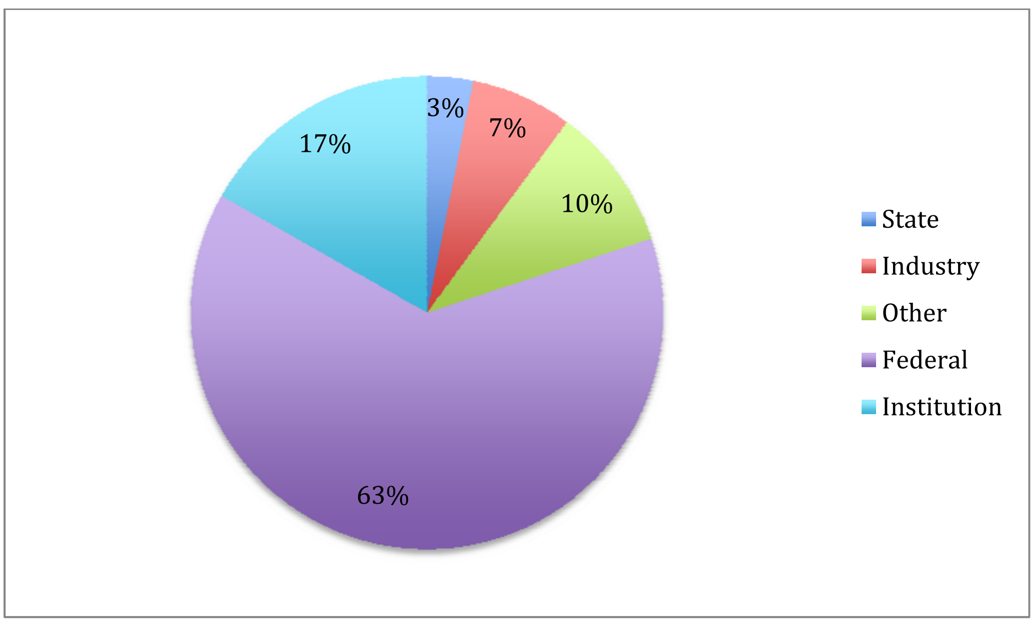


Figure 5a
Breakdown of R&D Expenditures by Source in year 2009 for Top10-50 Universities



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

Figure 5b
Breakdown of R&D Expenditures by Source in year 2009 for Top10 Universities



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

Figure 6a:
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.

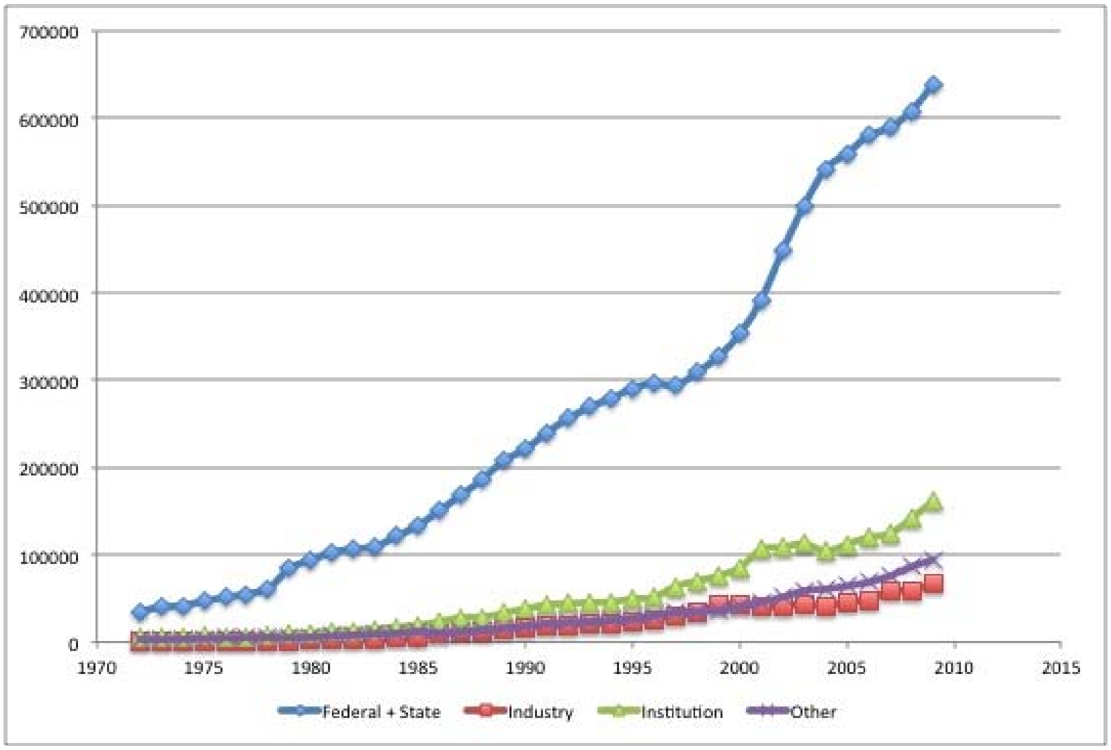


Figure 6b:
Trends in composition of R&D Funding by type of Source for Top10-50 research universities from 1970 – 2009 in $000s.

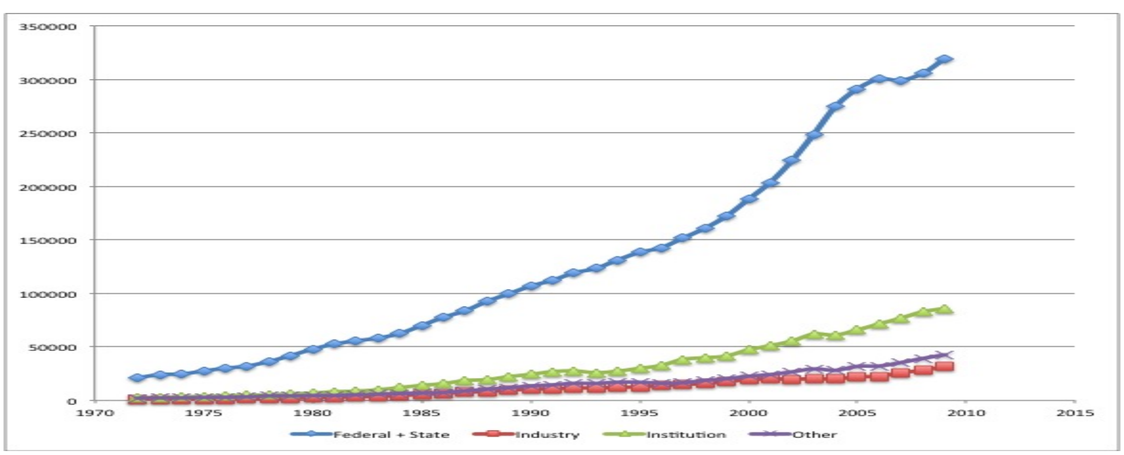
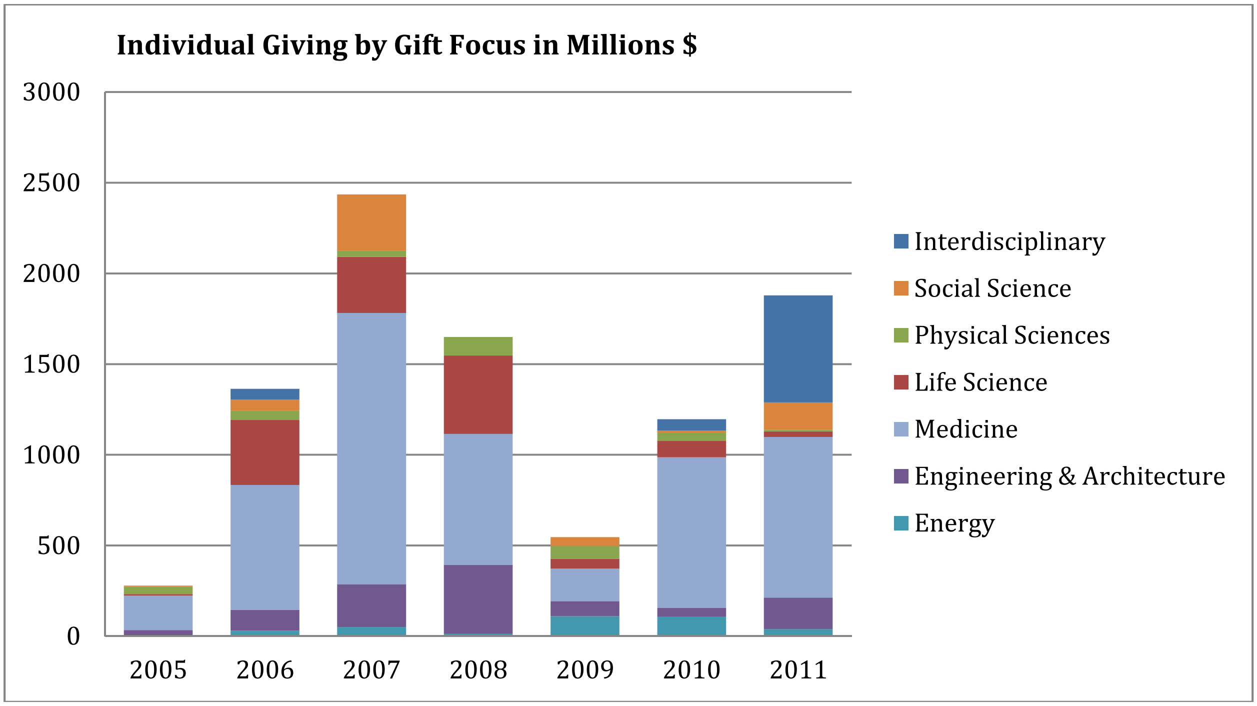


Figure 7:
Major Individual gifts to science philanthropy by subject in Millions $ (adapted from Chronicle of Philanthropy data)[45]



[45] 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.