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Evaluating the Role of Science Philanthropy in American Research Universities

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Executive Summary

Philanthropy plays a major role in university-based scientific, engineering, and medical research in the United States, contributing over $4 billion annually to operations, endowment, and buildings devoted to research. When combined with endowment income, university research funding from science philanthropy is $7 billion a year. This major contribution to US scientific competitiveness comes from private foundations as well as gifts from 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 measurable: 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 are poorly understood. To fill this gap, I 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 policy makers. 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.

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

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the direction of scientific progress are 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.

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 underappreciated aspect of philanthropy in higher education whose importance becomes clear by examining trends in funding university research. Over the period 2005–10, federal funding to university research has grown less than 1%, and state funding has declined (see National Science Board 2010, chap. 5, p. 10). 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.[1]

Conceptually, science philanthropy presents a puzzle for scholars interested in the economics of science and innovation and for innovation policy makers. 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, and Toole 2000). 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 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.[2] 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, cofounder of Microsoft, and Nathan Myhrvold, former chief technology officer of Microsoft, donated over $30 million to support a new telescope (to be referred to as the Allen Telescope Array [ATA]) at the Hat Creek Observatory in California. A partnership between the University of California, Berkeley's, Radio Astronomy Laboratory and the private SETI Institute,[3] its research purpose was to advance SETI—the search for extraterrestrial intelligence—by looking for signals from civilizations elsewhere in the galaxy.[4] Controversial from the start, the project had always suffered from difficulties in gaining robust, long-term government support. Myhrvold contrasted his philanthropy to government funding, making 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" (http://berkeley.edu/news/features/2000/08/01_seti.html). The philanthropic funding of over $60 million 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 (NSF) and the State of California's funding of Berkeley's Radio Astronomy Lab (Waldrop 2011). 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, Massachusetts Institute of Technology announced a gift of $100 million from David H. Koch, an alumnus with degrees in chemical engineering.[5] 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) toward supporting more applied, interdisciplinary 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 underappreciated role in US scientific competitiveness. Compared to government funding, however, whose purpose is broadly understood, and industrial funding sources, which usually drive near-term applications, the distribution of today's philanthropic funding cannot easily be theorized. While the historic role of science patronage in the United States established (rather than followed) the norms and institutions for funding basic research at a time when government supported only applied research (e.g., geological and coastal surveys), 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 US science, engineering, and medicine today: the Allen/Myhrvold gift focused on fundamental (and controversial) research for which 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, for 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 US research universities. The data come from four sources: the NSF's Science and Engineering Statistics, the Council for Aid to Education's Voluntary Support of Education survey on gifts to universities, the Foundation Center's grant makers 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 one can gain insights into the overall levels of science philanthropy, and I 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 two 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 can 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 policy makers as they seek to optimize the allocative efficiency of federal funding. Moreover, the ultrawealthy have the potential for influencing the path of US scientific, engineering, and medical innovation and shaping agendas that were traditionally considered to be the purview of government or scientists themselves. This challenges policy makers 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 US science patronage. It then outlines the modern legal context, emphasizing the (US-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 fig. 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 (1997) highlights the fact that much research considers both dimensions, 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 toward proof of concept and translation (see Aghion et al. 2008). A second dimension salient to this analysis is the degree to which philanthropic

		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

Fig. 1. Typology of approaches to science philanthropy

funding of research follows (or lags behind) high levels of nonphilanthropic support, or whether it serves to lead and highlight funding gaps; in other words, to what extent 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.

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 et al. [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 to fund the most fundamental research projects (within universities) on the basis that industry will likely fund more applied, immediately useful, and translational projects in which 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" (2008, 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 inquiry 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 Michael 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 2011). 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 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, provide 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–World War II 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

A. *Historical Origins*[8]

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 lie with princely Renaissance patrons, whose client-savants pursued their interests in scientific progress in return for useful and ornamental service to the courts (Feingold 1984; Westfall 1985; Biagioli 1989; David 2008). For scientists in the United States, external funding of any kind developed only 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" (Bache 1844; cited in Miller 1970); they often returned from training in Europe, only to be discouraged by the lack of equipment and research support.

Initial funding for US researchers did not come from state patronage. Instead, they were reliant on 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 United States to overtake their European counterparts in science at a time when legislators had little interest in supporting new discoveries (Miller 1970). They also linked to emerging American traditions of fund-raising, which was remarked on by de Tocqueville, with early American patrons 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" (Smithson's will dated October 23, 1826; quoted in Rhees 1901). 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 inquiries. 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 United States 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 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" (quoted in Miller 1970, 36). While observatories remained popular philanthropic objects, Medici-like support also went to research artifacts in other areas of fundamental scholarship, including a place to maintain the specimens used by the charismatic and prominent paleontologist 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 20th 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 $22 million endowment funded the "exceptional men" of science with the goal, as Andrew Carnegie put it, to "change our position among Nations" in science (quoted in Miller 1970, 173).[9] 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 (Nielsen 1985). By 1925, at least a dozen large foundations sponsored 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 (Kohler 1985).

Growing philanthropic largess was not adequate for university scientists to build consistent, broad-based support for fundamental science (Kohler 1985). However, it was only with the incursions of government into science during the First and Second World Wars that more stable, federal funds for US science became a reality. Leading scientists used the aftermath of World War II to put government funding on a large and more stable footing with a fundamental orientation. In 1945 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. (1945, 548)

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 (1945). These sentiments laid the groundwork for a funding landscape that creates the funding context for 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 NIH (medical research), the US Atomic Energy Commission (nuclear and particle physics), and the Defense Advanced Research Projects Agency. 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 United States and the contemporary federal funding for research that science patrons provide their support to US research universities in the 21st century. While US philanthropic traditions in science patronage emphasized fundamental inquiries 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.

B. 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. 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 (Fishman 2008). 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 (Givens 2004).

For the purposes of this essay it is useful to understand the legal context for US science philanthropy as providing rules both for the "patron," that is, the donor of wealth, and for the "client organization," that is, 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 clients—were defined in 1917, only 4 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).[10] 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 allows them, under a provision in the 1894 Revenue Act (later formally ratified in the Sixteenth Amendment to the US Constitution in 1913), to be tax-exempt.[11] These client organizations (typically referred to as charities) are defined in the US Code as organizations with charitable, religious, or educational purposes as exempt from federal income tax.[12] Research-based organizations including universities are included as clients at 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 American industrialists to formalize their philanthropy. As Rockefeller described in 1899 in a speech at the University of Chicago, they were intended to "make it a life work to manage, with our cooperation, this business of benevolence properly and effectively."[13] Rather than act directly as clients carrying out charitable activities, today they are tax-exempt, nonoperating 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-deductible basis.

Until the mid-1960s, US 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 Private Philanthropy and Public Needs Records, 1964–80). Government intervention followed: US Congressman Wright Patman instigated a Senate Finance Committee hearing.[14] 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 and Government Entities Division of the Internal Revenue Service authority to police all private foundation activities (Nielson 1985). Their status is derived from 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. In contrast, public charities generally derive their funding primarily from the general public, receiving grants from individuals, government, and private foundations, and undertake few grant-making activities. (It should be noted that in the area of science philanthropy, some public charities do give grants.)[15] Importantly, while all charitable organizations are expected to permanently dedicate their assets to charitable purposes, private foundations must distribute 5% 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 paths to using funds for science philanthropy: The first is to make a direct, tax-deductible contribution to the university; the second is to make a tax-deductible 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 a 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 that work to cultivate the interests and altruism of wealthy 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.

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 to imperil their charitable status. This means providing

Table 1
University Designation of Gifts versus Grants

Indicator	Indicative of a Gift	Indicative of a Grant
Source	Individuals, nonprofit 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), nonprofit organizations, corporations, corporate foundations
Description	"Contribution" (unconditional transfer of cash that is voluntary and nonreciprocal)	"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; benefits derived from donor club status are immaterial	Particular value to provider, may include reports, intellectual property rights, publication rights, data, etc.
Timing of cash inflow	Money received up-front	
Paperwork	Gift agreement	Award letter grant agreement
Overhead charged	None	US Dept. of Health and 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 reports of unused funds
Use timing	NA	Specified time period of use
Uses	NA	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	NA	May be required to return to sponsor
Penalties	NA	Penalties may exist for failure to reach milestones or use funds
Synonyms	Unrestricted, donation	Awards, sponsorship

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; that is, 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.

Favorable 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 benefited from this context more than in any other nation and can turn to science philanthropy for projects, equipment, and infrastructure across the fundamental to translational spectrum of projects and in a well-funded and somewhat overlooked field. Casual empiricism on campus suggests that this philanthropic landscape is more robust than ever and has grown significantly in the past several decades. To the extent that such observations are grounded in systematic empirical evidence, they suggest that public policy makers 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 toward informing policy decision making.

IV. Evaluating Trends in Science Philanthropy

Giving to tax-exempt organizations totaled almost $290 billion in 2010, with over 1.6 million tax-exempt organizations serving as the recipients (of which 1 million are public charities, including universities and colleges). The greatest portion of charitable giving, $211.77 billion, was given by individuals—73% of all contributed dollars (charitable bequests make up another 8% and corporate giving another 5%). After individual giving, private foundations are the next-largest contributors, giving over $40 billion annually on an asset base of about $620 billion (see fig. 2 for details on levels of foundation giving and assets over the past decade).[16] Around $45 billion of the $290 billion in philanthropy went to educational purposes in 2010, of which about $32 billion went to higher education. The top 50 research-oriented PhD-granting universities received about $11 billion of this total each year to support both research and educational missions.

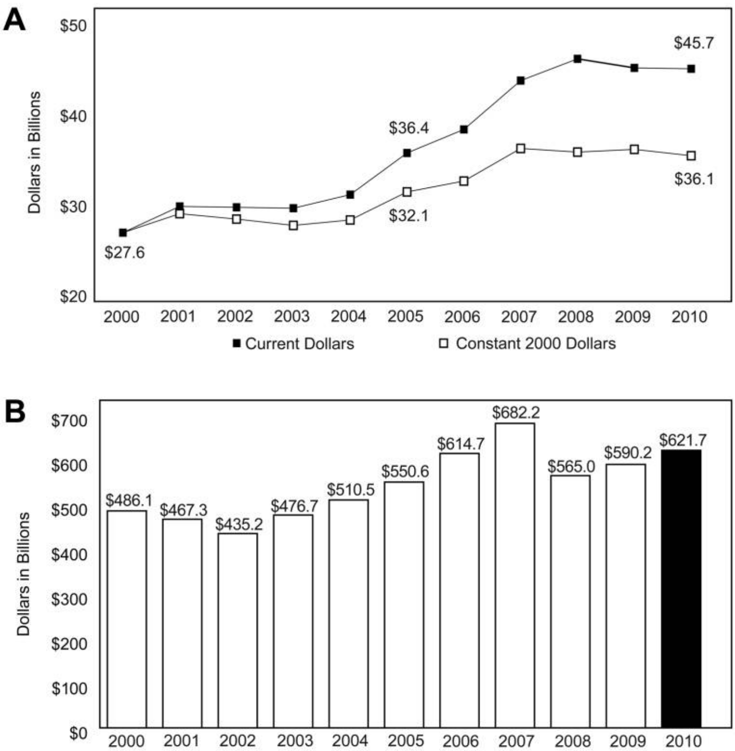

Fig. 2. Trends in philanthropy: *A*, foundation giving, 2000–2010; *B*, foundation assets, 2000–2010. In panel *A*, figures are estimated for 2010: percentage change in constant 2000 dollars is based on annual average consumer price index, all urban consumers (source: US Department of Labor, Bureau of Labor Statistics, as of March 2011). In panel *B*, all figures are based on unadjusted dollars. Figures are estimated for 2010. Source: Foundation Center (2011).

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 US 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 $4 billion each year for current research, endowment, or buildings devoted to science, engineering, and medicine (to the top 50 universities). In other words, 36% of the $11 billion 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

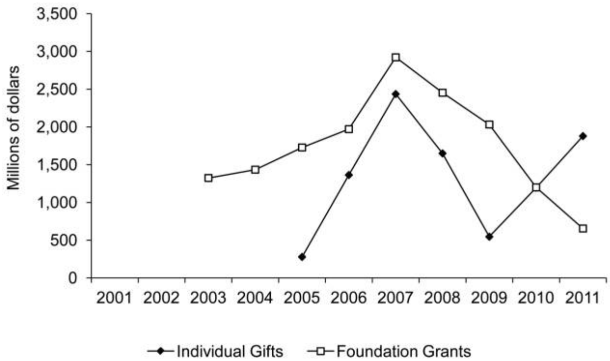

Fig. 3. Initial estimate of annual giving in US$ millions to top 50 research universities for research-focused activities (foundation data from the Foundation Center; individual gifts estimated from the Chronicle of Philanthropy).

medical centers, whose research is reported separately from that of 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 $2 billion of the $4 billion through grant making to the top 50 US research universities (although these data fluctuate with endowment earnings; see fig. 3).

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 toward 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 (http://www.philanthropyroundtable.org/topic/excellence_in_philanthropy/the_scale_of_private_support_for_science). Considering grants of more than $50 million, 10 of the top 50 (in the past decade) were directed to building the research capabilities of specific universities. Others also contributed (indirectly) to universities, for example, grants to the Global Health Initiative and the Medicines for Malaria Venture.[17]

Individual contributions to research at leading US universities made up the remaining $2 billion per year over the past decade (see fig. 3). Although data are less systematic, analysis of major gifts (over $1 million) listed by the Chronicle of Philanthropy suggests that gifts to top 50 universities amounted to more than $23 billion in the period 2005–11 (i.e., $3 billion a year). Of this amount, gifts to university science, engineering, and medicine constituted about 50%—approximately $1.5–$2 billion per year.[18]

A. *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 4.

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 be gleaned only 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) Voluntary Support of Education (VSE) survey,[19] philanthropic giving is allocated in terms of contributions to three categories: current operations, capital for endowment, and capital for buildings.[20] For the purposes of this analysis, I define science philanthropy as philanthropic giving whose purpose is explicitly restricted to research, that is, 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 Chronicle of Philanthropy data).

CAE data suggest that annual science philanthropy amounts to $85 million per top 50 university (broken down into $45 million for current research operations, around $20 million in capital to research-related buildings, and at least $20 million in annual contributions to research endowment—expanding the research-restricted endowment at about 2% annually). However, this varies across universities. The top 10 receive a much higher fraction of their philanthropic gifts in the form of science patronage. For them, over 40% is science philanthropy explicitly directed toward research-related activities. As they receive more than $269 million annually in philanthropy, this provides them with over $108 million annually in science philanthropy alone.

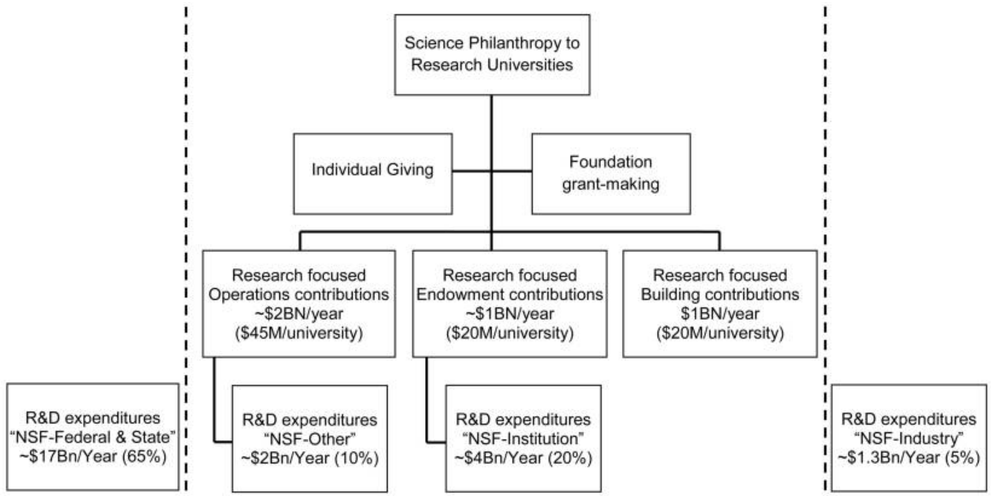

Fig. 4. Schematic of flows of science philanthropy from sources to the university and into science and engineering R&D expenditures on campus (data for 2009).

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 NSF:

- "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 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 $4 billion 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 $2 billion a year).

In aggregate, contributions to university R&D from science philanthropy constitute $6 billion 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 $6 billion total, around $2 billion 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 $4 billion is the amount that universities contribute to research from their own funds (from either individual gifts or income from restricted endowments etc.). Thus, when combined with the additional $1 billion contributed toward buildings, science philanthropy contributes over $7 billion each year to US research in science engineering and medicine (outside the academic medical centers).

B. *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 I have compiled statistics on the contribution of philanthropy to scientific research at leading US universities in the past decade, focusing on the top 50 research universities in the United States (henceforth referred to as *top 50* or as *top 10* and *top 10–50*, respectively, when universities ranked in the top 10 or 10–50 only are analyzed separately)—as defined by the NSF on the basis of its total annual level of science and engineering R&D spending.

In the past decade, the combined R&D expenditures of US universities grew to over $50 billion a year in 2009 (in 2009 dollars). In real terms this means about a fourfold increase from 1972 (when spending was only $2 billion 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 $47 million in 2000 to $79 million per university in 2009.[21] 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 or so universities). Among the top 10 science and engineering universities,[22] 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 $2 billion—for all university and research centers in the country!) The top 10–50 spend $480 million, while the remaining universities have seen almost no increase in real terms with expenditures of only $45 million annually in 2009 (see fig. 5 for a breakdown by different university type from 1970 to 2009).

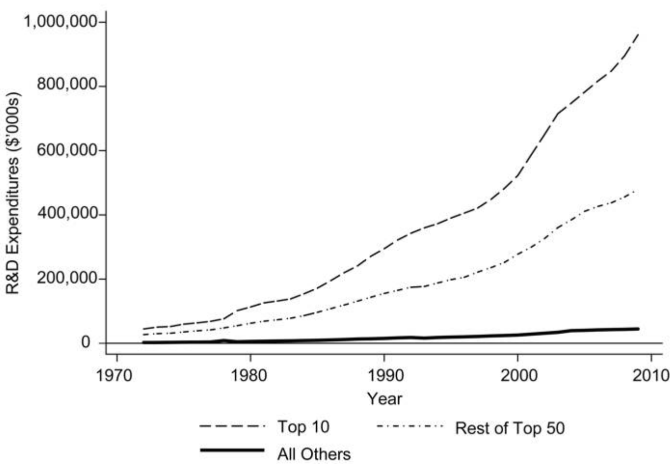

Fig. 5. Average total R&D expenditures for different groups of US universities

R&D expenditures in universities come from a wide range of sources. The NSF 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 exemplified 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 of attention among 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 science and engineering 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 top 10–50 (top 10) in 2009 shows that after federal funding at 59% (63%), institutional funds and other (foundation) sources constitute 18% (17%) and 9% (10%) (see fig. 6). In aggregate terms this amounts to total contributions to the top 50 of $15 billion from the federal government; institutional funds, $4.3 billion; other (foundation) funds, $2.4 billion; industry, $1.7 billion; and states, $1.5 billion. 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 underexamined 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.

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 fig. 7). 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.

C. Science Philanthropy across Research Fields

In this final section of the analysis, I emphasize how science philanthropy is allocated across the 2 × 2 matrix outlined in the introductory sections of

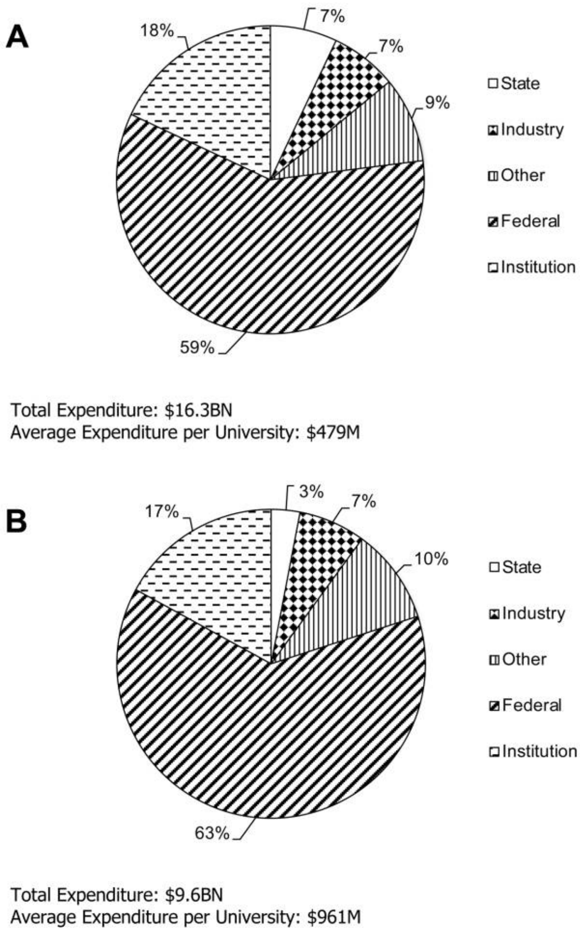

Fig. 6. Breakdown of R&D expenditures by source in year 2009: *A*, for top 10–50 universities; *B*, for top 10 universities.

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 are more difficult to determine than overall levels of research support. To provide some insights into allocation across scholarly research fields, I examined data from the Chronicle of Philanthropy covering major gifts. These data capture gifts of over $1 million to all charities from 2005 onward. From the data I extracted gifts to universities and then coded all those focused on science according

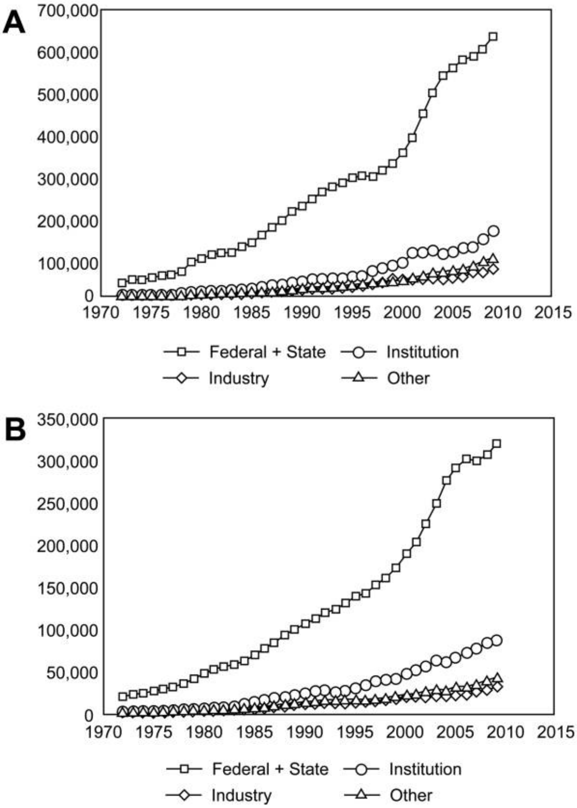

Fig. 7. Trends in composition of R&D funding by type of source for 1970–2009 in $ thousands: *A*, top 10 research universities (federal + state, industry, "other," and institution); *B*, top 10–50 research universities.

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 $1 million to universities amounted to $23 billion. Of this, over $19 billion was given in gifts over $10 million that could be categorized. The $19 billion was broken down into $9 billion for nonresearch and $10 billion for science philanthropy (around $2 billion a year; see fig. 8).

While annual ratios vary, an average of 70% is directed toward 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

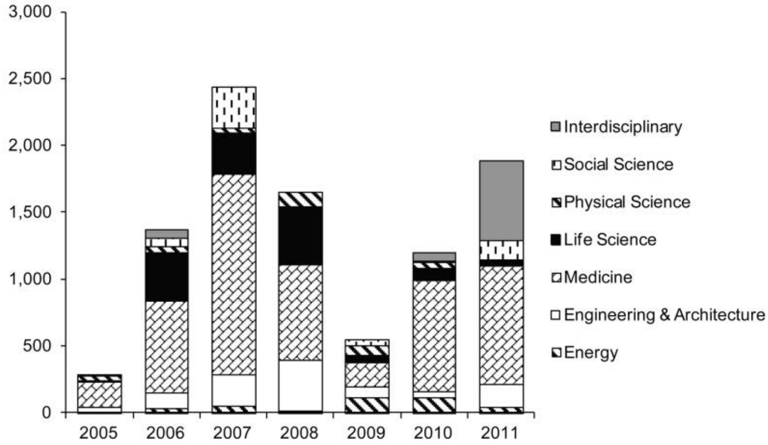

Fig. 8. Major individual gifts to science philanthropy by subject in $ millions (adapted from Chronicle of Philanthropy data). The subject analysis has been completed only for science philanthropy gifts over $10 million. These amount to $19 billion in individual gifts for the period 2005–11, of which $10 billion are categorized as science philanthropy. The category "interdisciplinary" is for gifts to support research across the entire campus.

personal interest. In particular, medicine gathers an average of 53% of the translational philanthropy each year. With regard 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 interdisciplinary 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 $225 million to Carnegie Mellon University and $125 million 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 US history. The third such gift was from David and Dana Dornsife: $200 million 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, I 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 be gathered by year only at the dyadic foundation-university level; as a result, discipline-based coding is complex. To overcome this challenge, I rank the top 10 foundations by cumulative funding over the period 2000–2009 to the top 50 universities—over $5 billion of the $20 billion total for the period. The leading foundations are listed in table 2.

As can be seen, while individual grants are likely to be for a wide range of activities, seven 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 vs. federal funding to top 50 universities by research discipline.)

These comparative statistics (which illustrate only that part of science philanthropy devoted to major gifts over $10 million designated to specific fields) emphasize the contemporary focus of philanthropy away from fundamental fields and toward translational fields, both in absolute terms and when compared to the federal government—73% versus 56%.

Table 2
Top 10 Foundations Contributing to Top 50 Research Universities

	2003–11 Grants Total to Top 50 ($)	Focus Area
Bill and Melinda Gates Foundation	1,529,707,386	Translational—life science
Robert Wood Johnson Foundation	559,068,171	Translational—public health
Duke Endowment	527,574,253	Translational—health care, environment, educational access
Andrew W. Mellon Foundation	380,906,505	Other—liberal arts
Lilly Endowment Inc.	361,008,584	Fundamental—life sciences
William and Flora Hewlett Foundation	280,369,859	Translational—energy and environment, education, arts
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 and fundamental sciences
David and 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 (>$10 Million) by Field (2005–11 Average) for the Period 1999–2009 in US$ Millions

	Federal ($ Millions) (2008)	Federal Percentage	Philanthropy Big Gifts ($ Millions)*	Philanthropy Percentage
Life science	7,907	26	183	15
Physical sciences (plus math and computer science)	4,215	14	50	4
Social science	1,447	5	98	8
Engineering and architecture	4,705	15	152	12
Energy and environment	1,826	6	51	4
Medicine	10,757	35	713	57
Fundamental	13,569	44	332	27
Translational	17,288	56	916	73

Source: National Science Board (2010).
*Average 2005–11.

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% vs. 14% for physical sciences and 15% vs. 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, e.g., 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 Medicis 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 (nondefense) government research allocations at leading research universities.

V. Conclusions and Policy Implications

A. Conclusions—Challenges and 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 1800s, 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 in which 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, under the Clinton administration, human embryonic stem cell (hESC) proposals had been sought by the NIH (on the basis of a legal ruling on the legality of such projects);[23] in 2001, the Bush administration stopped the funding of these projects.[24] 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" (20). They had already been supported by science philanthropy of over $40 million, 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 2 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 regard to schools, philanthropy, particularly from individuals, is disproportionately garnered by the top 10 schools for their research activities and certainly by the top 50. Second, philanthropy not only maps to federal funding trends but also emphasizes them, particularly with regard to translational applied research: 73¢ in every dollar of science philanthropy goes to translational research, particularly medicine, compared to less than 55¢ 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) fail to capture micro-level trends, such as when philanthropists try to fill funding gaps; tropical medicine is a case in point (see Gaulé and Murray 2012).

B. 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 US 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 that of 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 2002/3, 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 are quite distinctive from other types of giving—being highly skewed toward 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 US 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 as Nathan Myhrvold's desire to support "stuff other people don't" in paleontology—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 toward 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 toward translational research by the patrons of science reemphasizes the need for the federal government (and patrons themselves) to assess its 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 toward 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 its 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 US culture and institutions and has examined the impact of philanthropy in higher education broadly. However, the influence of science philanthropy in sustaining leading US 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.

Endnotes

I would like to acknowledge the excellent research assistance provided by Sarah Wood and Kenny Ching on this project as well as undergraduates Brooke Johnson and Juan Valdez. For acknowledgments, sources of research support, and disclosure of the author's material financial relationships, if any, please see http://www.nber.org/chapters/c12716.ack.

1. If we consider that up to half of all industry funding is contributed via tax-deductible 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.

2. The extensive analysis of science patronage in the Renaissance and beyond by Paul David (2008) is one of the only pieces of scholarly work in the economics of innovation literature dealing with philanthropy.

3. The SETI Institute is a not-for-profit research organization founded in 1984 by scientists from the National Aeronautics and Space Administration's (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.

4. 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."

5. Much of this information is drawn from *MIT Reports to the President 2007–2008* of the David H. Koch Institute for Integrative Cancer Research at MIT (http://web.mit.edu/annualreports/pres08/2008.06.10.pdf).

6. 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.

7. It should be noted that Myhrvold is a highly unusual and active scientific patron: not only does he fund research into dinosaur paleontology but he is also an active researcher: In 2000 he and other colleagues had a paper published in *Nature* (Barsbold et al. 2000) on their codiscovery of a bird-like tail bone from a nonavian dinosaur in Mongolia.

8. This aspect of the historical analysis draws heavily on Miller (1970), one of the few comprehensive analyses on the support of science in this historical period.

9. 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.

10. The calculus of charitable giving under this regime is as follows: The deduction subsidizes giving by lowering the price that people must pay privately to support charitable organizations. A charitable contribution of $1 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%, a deductible $1 cash gift to charity will reduce the donor's taxes by 30¢, so the price of the gift to the donor will be only 70¢. 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).

11. 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."

12. 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" (26 USC sec. 501[c][3]).

13. In a 1909 decision, the $100 million Rockefeller Foundation became one of the first formal tax-exempt foundations in the United States granted a (New York) state charter for activities combining grant making and charitable involvement.

14. 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.

15. A private foundation is a nonprofit organization having a principal fund managed by its own trustees. Every US and foreign charity that qualifies under sec. 501(c)(3) of the IRS 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).

16. Figure derived from Giving USA.

17. These data are from the Foundation Center Statistics Information Service table on grants of > $50 million (1973–2010).

18. Statistics compiled from the Chronicle of Philanthropy database on major (over $1 million) individual gifts.

19. The 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 VSE survey.

20. While the VSE does not explicitly categorize research-restricted giving overall, it has various measures that I use to isolate science philanthropy from more general philanthropic support of higher education.

21. 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.

22. The top 10 include 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.

23. This shift from prior NIH funding policies was based on an opinion provided by Harriett Rabb, then general counsel at the Department of Health and Human Services, in a letter dated January 15, 1999, 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 (NIH 1999).

24. 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).

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