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# Philanthropic supported innovation: trends, areas, and impact

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## Abstract

Philanthropy provides substantial support for science and research—does it do the same for technology and invention? We match patenting outcomes in the United States with philanthropic organizations as listed in the Candid database and find that at least 0.2% of U.S. patenting since 1976 received philanthropic support. After matching philanthropic patents to non-philanthropic patents based on technology, time, and the number of inventors, we find that philanthropic invention is more likely to be done by smaller teams and U.S. based inventors and less likely to rely on science research and non-U.S. prior art. Renewal rates are not significantly different from non-philanthropic patents and philanthropic patents are not more likely to be in underserved areas of technology. Philanthropic supported patents receive significantly fewer future prior art citations, thus implying that philanthropy supported patents are not exceptionally valuable.

**Keywords** Philanthropy · Research · Innovation · Patenting

**JEL Classification** O34 · O35 · O39

## Introduction

While their relative influence and impact have changed over time, governments and industry have historically been the main source of support for technology and science research. Recent research has highlighted another source, however, and illustrated how philanthropic support of science rivals that of government and industry (Michelson, 2020, p. 5; Shekhtman et al., 2021). While other work has linked and quantified the importance of

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government support for patenting (Fleming et al., 2019), little work has investigated how philanthropy influences patenting (Dodgson & Gann, 2020).

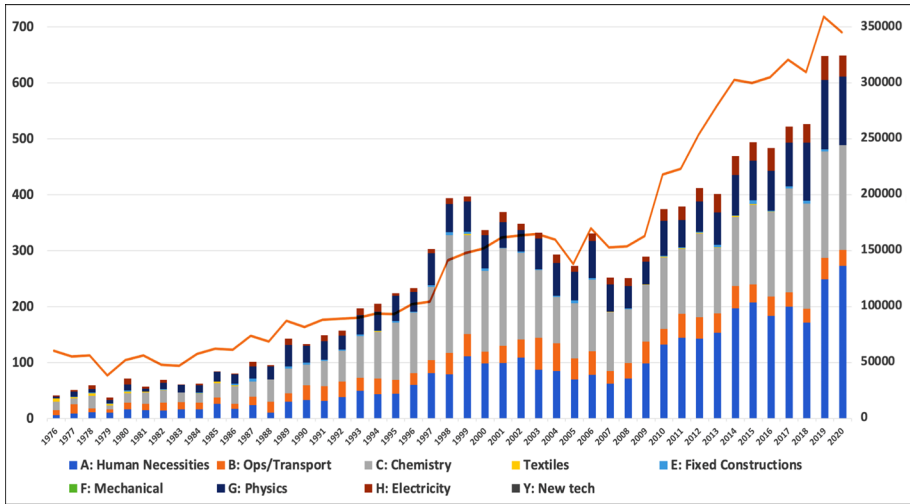
Linking philanthropic organizations to U.S. patents through acknowledgments of funding support or assigned ownership, and removing university and academic patents, we describe how philanthropies support a very small but consistent fraction of U.S. patenting. Based on matching philanthropic to non-philanthropic patents, philanthropic patents appear less valuable on average, particularly because they are cited less by future patents. Philanthropies also support “orphan” patents in technologies where no other patents are being issued, identified as patents for which there is no other patent in similar classifications, in the year preceding and year following the philanthropic patent, however, they do not do so at a greater rate than non-philanthropic patents. Philanthropic patents are no more likely to be renewed at any point in their lifetime. Matched philanthropic patents are also invented by smaller, more U.S. based teams, less likely to draw upon the scientific literature, and are similar in gender composition to non-philanthropic patents.

We define a philanthropy by its inclusion in the Candid database of non-profit organizations in the United States, which includes all non-profit organizations in the United States by tax status. We then identify potential links from 7,600,467 patents to 596,707 philanthropies, including (1) Private Operating Foundations, (2) Non-Private Operating Foundations, and (3) Public Charities, by matching the organization’s Candid name with an acknowledgement of support in a patent, or by ownership of the patent. While these criteria keep many obvious (and often medical) philanthropies, they also retain organizations more typically associated with industry and contract research laboratories, for example, Battelle Memorial Institute and The Gas Technology Institute. Given different and subjective definitions of philanthropy, and the heterogeneity of these organizations’ research portfolios (in particular, both contract and philanthropic research), we keep all links identified in the Candid database but remove academic organizations. Data are available on the Harvard Dataverse Network for use and further refinement.

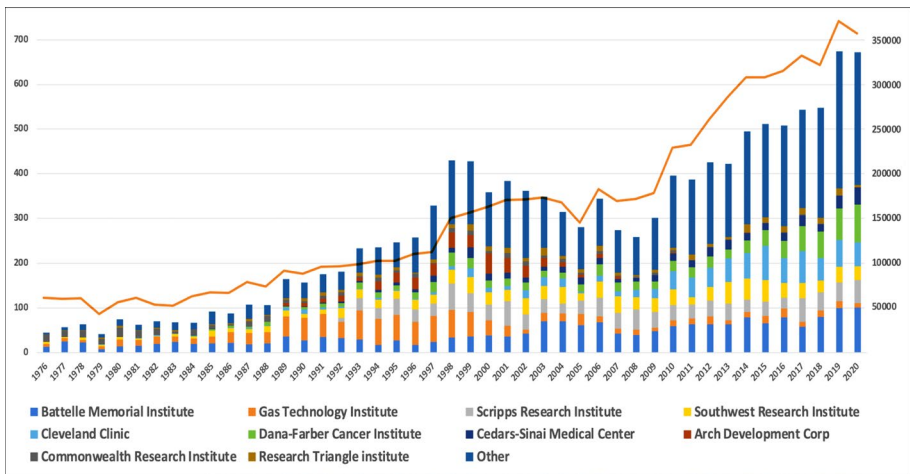
## Philanthropic support of U.S. patenting, 1976–2020

Figure 1 illustrates two data series from 1976 through 2020, both from U.S. patents (note that a U.S. patent can be owned or invented by a non-U.S. entity or individual). The orange line indicates the total number of U.S. patents issued each year and corresponds to the right axis. The bars illustrate the total number of philanthropy supported patents (of private and non-private operating foundations, and public charities) and corresponds to the left axis. Note that the two measures loosely track each other, in other words, philanthropic patenting has increased at about the same rate as overall U.S. patenting since 1976. The bars in Fig. 1 are broken out into the 9 high level CPCs (Cooperative Patent Classifications). Most philanthropic patenting historically has been in class C of Chemistry and Metallurgy, which probably reflects the industry research institutes. Class A, Human necessities, includes biotech, pharmaceuticals, and medical technologies, and has increased to be approximately as popular as the chemistry class recently. Support for class Y, which includes yet to be classified novel technologies (such as green tech), has also increased recently.

Figure 2 illustrates the same data as Fig. 1, however the stacked bars now illustrate the organizations with the most philanthropically supported patents over the same time period. Battelle Memorial Institute patented the most consistently from 1976 through 2020. Likewise, the Southwest Research and Gas Technology Institutes also patent a great



**Fig. 1** Orange line and right vertical axis represents total U.S. patenting from 1976 through 2020. Bars represent yearly philanthropic supported patenting in United States, broken out by CPC class



**Fig. 2** Orange line and right vertical axis represents total U.S. patenting from 1976 through 2020. Bars represent yearly philanthropic supported patenting in United States, broken out by the top ten organizations and all others

deal, though the latter has decreased its patenting in the 2000s.<sup>1</sup> More conventional philanthropies that have consistently patented include the Dana Farber Cancer Institute, Scripps

<sup>1</sup> While these research institutes accept private industry contracts, they also do philanthropic research. For example, the Gas Technology Institute now pursues philanthropically supported research on de-carbonizing the atmosphere. Hence it is difficult to accurately define these as non-philanthropic patentees (due to their industry research), and they are kept in the analysis sample.

Research, Cleveland Clinic Foundation, and Cedars Sinai Medical Center. These ten organizations have typically accounted for a bit more than half the non-profit patenting in the U.S.

## Which philanthropies support which technologies?

Figure 3 provides a Sankey diagram for the top ten philanthropic patenting organizations in 2020, with philanthropies on the left and CPC subclasses on the right. Battelle Memorial Institute is first, following by mainly medical research philanthropies, such as Dana-Farber and Memorial Sloan-Kettering. Consistent with Figs. 1 and 2 and the longer time span, most patents fall into classes A (Human Necessities) and C (Chemistry and Metallurgy, although the recent increase in category G, Physics, is more easily noticed than from Fig. 1. The increase in physics appears to be driven by all the philanthropies, and not just the non-medical research laboratories, such as Battelle Memorial or Southwest Research.

As an example of one philanthropy's patents over the years, Fig. 4 illustrates Scripps Research Institute patents, from 1996 through 2020. The left side quantifies the number of patents each year and the right side quantifies the amount of patenting in each technology area since 1996 (the illustration is exhaustive of all Scripps patents found in our database linkages). The right side is roughly prioritized top to bottom by time (areas at the top right were early areas of patenting by Scripps, areas of the bottom right are more recent areas).

A number of inferences can be drawn from Fig. 4. First, Scripps has patented fairly consistently over the years, as illustrated by the fairly uniform distribution of sizes of the left hand boxes. Most of Scripps' patenting is in the C class of Chemistry and Metallurgy, and the three highest sub-fields are *C07K: Peptides*, *A61K: Preparations for Medical, Dental, or Toilet Purposes*, and *C07H: Heterocyclic compounds*. Scripps' recent patenting (as indicated by areas towards the lower right) include *G06F: Electrical Digital Data Processing*, *G16B: Bioinformatics*, and *A61P: Specific Therapeutic Activity of Chemical Compounds or Medicinal Preparations*. The thin blue line from 2008 to *C07: Peptides* illustrates a patent invented by the 2021 Nobel Laureate in Medicine, Dr. Ardem Patapoutian. The patent covered genes and peptides that influence the perception of pain, which probably builds upon the science that earned Dr. Patapoutian the Prize.

## Philanthropic support of less popular technologies

While most philanthropic patenting occurs in areas also pursued by private firms and universities, 327 (2.6% of the identified total) philanthropic patents can be described as "orphan" patents, defined as a patent that is classified in an area with no other patents in the year prior or hence; technically, in whose 6 digit CPC subclasses there are no other patents, in the year prior and year after the orphan patent issues. Note that this is a strict definition and implies that *none* of the listed subclasses on a patent had a patent in the year before or after. Figure 5 illustrates a Sankey diagram of the orphan patents with philanthropies on the left and classes on the right. The high level distribution of CPC classes is similar to the non "orphan" patents, with the bulk of philanthropy support in classes A (Human Necessities), C (Chemistry and Metallurgy), and G (Physics), though not surprisingly, the distribution of CPC subclasses is more granular. The top organizations are somewhat similar though also more granular, and

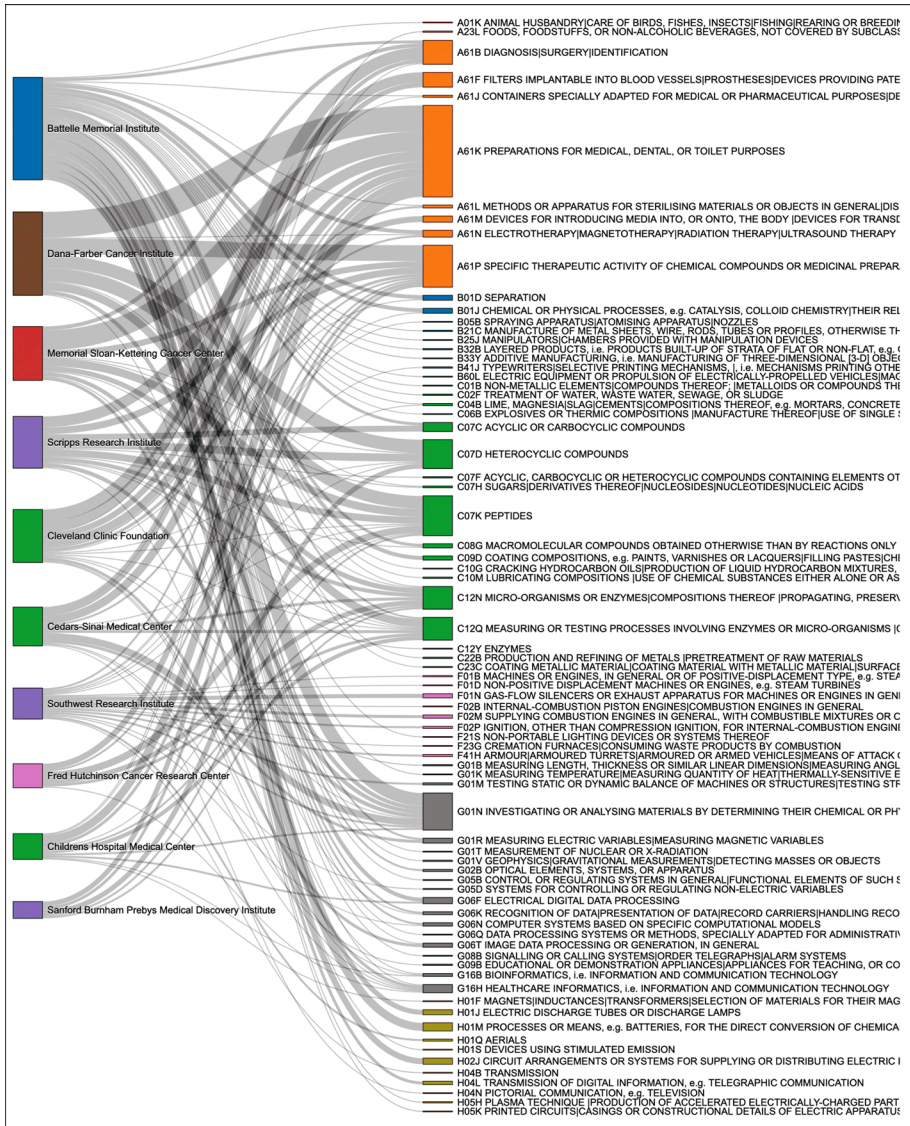
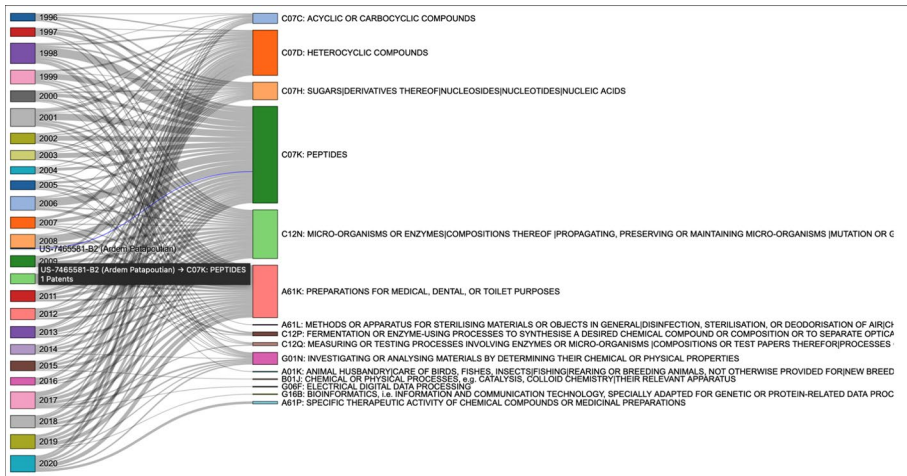


Fig. 3 Top 10 U.S. philanthropies and their patenting subclasses in 2020

include the contract research labs. In order to assess whether philanthropies are more likely to support orphan patents, we drew a random sample of 1000 U.S. patents and determined that 4.8% of them had no subclass overlaps within a year before and after granting. Hence, it does not appear that philanthropies are more likely to invent orphan technologies.



**Fig. 4** Scripps Research Institute patents, 1996–2020. The blue line from 2008 to C07 Peptides indicates patent number 7,465,581, “Transient receptor potential channel TRPM8 and its use,” by the 2021 Nobel Laureate in Medicine, Dr. Ardem Patapoutian. The patent covered genes and peptides that influence the perception of pain

### The worldwide distribution of inventors of U.S. philanthropic patents

Figure 6 provides a worldwide choropleth indicating the number of non-domestic co-authors of US philanthropic patents. Inventors from Canada, Japan, Australia, the United Kingdom, France, and Germany are most prominent. Some of these collaborations represent local innovation, for example, Theonest K Mutabingwa from Muheza, Tanzania, co-invented a Malaria vaccine patent, US 8,012,493. While this choropleth would imply that philanthropic invention in the U.S. is very global, the matched sample analysis below will show that philanthropic patent teams have on average a higher proportion of U.S. inventors, relative to a matched sample.

### Are philanthropic patents more or less important?

Given that government supported patents are typically more “important” than privately supported patents, with importance defined by conventional and readily available bibliometric measures (Fleming et al., 2019), here we investigate whether philanthropic patents are similarly more important. Since these measures can vary by field of technology, we match philanthropy patents with non-philanthropy patents by their degree of Cooperative Patent Class (CPC) subclass overlap, as described in detail in Fleming et al. (2019). The approach takes the philanthropy patent and matches it to the most similar control patent, based on the number of six digit CPC subclass overlaps that are applied for within the year before or after the philanthropy patent. The approach also matches on patents with a similar number of inventors, binning patents into inventors with 1, 2 or 3, or 4 or more inventors. Bibliometric measures take the pertinent date for each patent (for example, future prior art



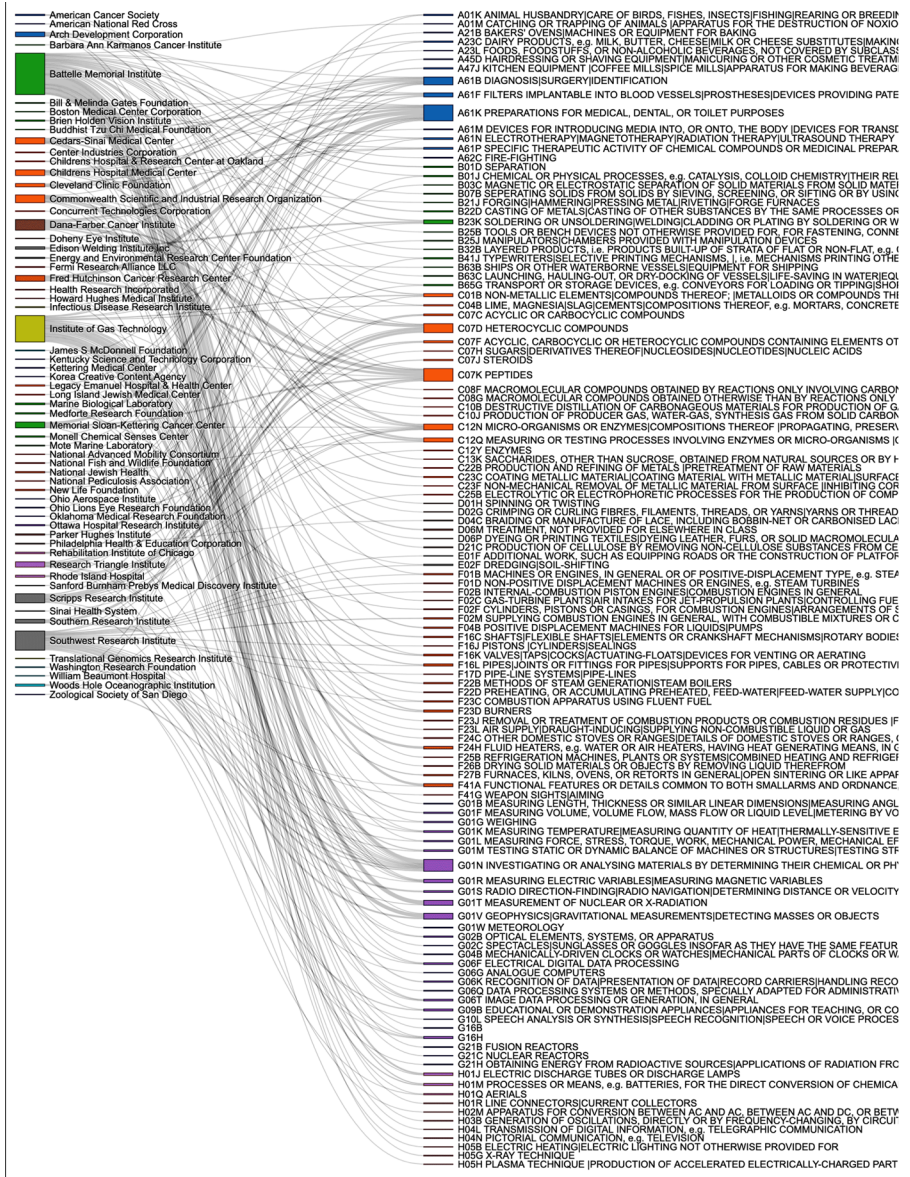
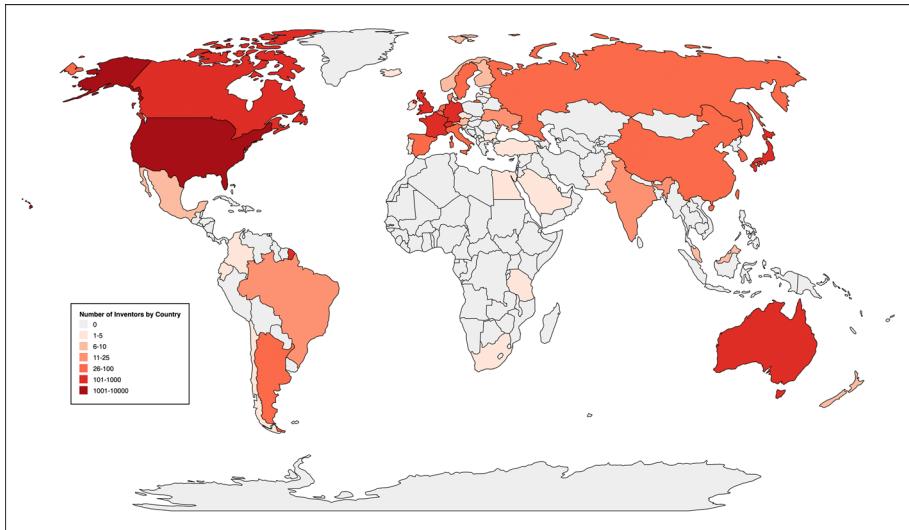


Fig. 5 Orphan patents 1976–2020 (327 patents), their funders, and category of patenting

citations are calculated for consistent windows, starting from the date of grant of each patent). Of the full sample of 12,560 philanthropic patents, 12,233 patents can be matched. 327 patents could not be matched and are considered below as “orphan” patents (essentially, no other patent is invented in any of the patent’s subclasses, within a year prior and after to the grant of the orphan patent). Paired and two sided t-tests were run in STATA to compare the statistic for each measure. Results differed very slightly, depending on which





**Fig. 6** Choropleth of authors inventing philanthropically supported patents, 1976–2020. U.S. philanthropic patents tend to have more U.S. inventors, relative to a matched control group

matched patent was selected, in the case of an exact tie between matching patents on time, inventor, and technology.

Perhaps the easiest to calculate and surely the most widely used bibliometric measure of patent value is the number of future prior art patent citations (Trajtenberg, 1990). When an inventor applies for a patent, s/he must list similar technology and then establish their difference from such “prior art.” Patent examiners supplement this list (Alcácer & Gittleman, 2006) as well. Much work has relied on this measure and other research has established the positive financial value of prior art citations, for example, Hall et al. (2005) estimate that a patent increases in value of up to 3% for every citation (Hall et al., 2005). Kogan et al. (2017) estimates the value of a citation in the range between \$15,000 to \$500,000 (in 1982 prices), at the median of citations. We calculated windows of the time at risk of citation for three, five, 10, and all possible years. In every time period, philanthropic patents received significantly fewer future prior art citations. By the more conservative two sided and paired t-test, the difference in coefficients of future citations was  $-0.49$ ,  $-0.95$ ,  $-2.25$ , and  $-4.30$ , respectively (all significances  $p < 0.001$  or less in all reported analyses, unless specified otherwise), respectively.

Hence, by this simple and most popular measure, philanthropic patents are less important than non-philanthropic patents. This may surprise, given that government supported patents were shown to be more important by a similar matched approach, and that many philanthropic patents are also supported by government (indeed, philanthropic patents are also more likely to acknowledge government support relative to control patents, with a coefficient estimate of 0.16). Investigating this by bifurcating the sample into patents with and without government support, 7513 of the 12,560 patents are supported by both the U.S. government and by philanthropy; for these patents supported by government funding, the difference in future prior art citations is slightly less (for all possible years at risk of citation, the coefficient estimate is  $-3.35$ , for the 7,412 patents that are both government supported and can be matched to a control patent). For the 4,821 philanthropic patents

without U.S. government support, the difference is greater ( $-5.76$ ). All differences were individually significant, though they were not significantly different from one another.

Patent value can also be assessed by whether owner kept up the payment of maintenance fees to the USPTO; in order for a patent to remain valid, the owner must pay maintenance fees in its 4th, 8th, and 12th years. Firms may be better able to see the financial value of their patents, and more quickly stop paying fees on patents that they have decided are less valuable. One might also argue that philanthropies are less financially able to renew the patent, thus leading to a potentially negative bias. There is, however, no significant difference in the likelihood of renewal of philanthropic patents in any time period. Hence, by the metric of renewal, philanthropic patents are no more or less valuable.

One explanation for these results is an adverse selection of valuable philanthropic patents, such that higher value patents are retained by other, non-philanthropic organizations. Another explanation is that philanthropic patenting simply occurs in less popular areas; just as we identified a number of patents in classes that had no other patents (labelled as “orphan” patents), matched patents may be in areas that are simply less popular. Evidence for the latter hypothesis can be gained by considering the difference in a patent’s “backward” prior art citations; rather than considering how many future patents cite a particular patent, we can look at the particular patent, and see how many patents it cited as coming before it.

By this measure of the count of backward prior art citations, philanthropy supports patenting in less popular areas, with a large and highly significant mean difference of  $-14.17$ . One might also test whether philanthropic patents are more highly cited, conditional on occurring in less popular areas, by testing the ratio of future cites to backward cites, within a patent. This also appears not to be the case, with philanthropic patents being  $-0.18$  less than the ratio of control patents (though the difference is not statistically significant). In summary, it is difficult to argue that philanthropic patents are more important or valuable, relative to a matched sample of non-philanthropic patents, based on a broad variety of metrics. Indeed, by some measures, they are clearly less valuable than for-profit patents in similar areas of technology.

## Are philanthropic patents different?

The matching approach also enables a number of other comparisons of philanthropic and non-philanthropic patents, for example, to what extent do philanthropic patents rely on science? Given that philanthropy supports basic research (Dodgson & Gann, 2020; Shekhtman et al., 2021), and that many philanthropic patents are supported by medical charities, it might be the case that philanthropic patents rely more heavily upon science research. This can be assessed by comparing the number of citations to the non-patent literature, which are often to peer-reviewed research. This turns out not to be the case, however; philanthropic patents cite less non-patent literature, with the mean difference being  $-5.11$  references. Philanthropic patents also cite significantly less foreign prior art (estimate of  $-5.27$ ). They cite older prior art as well, though the difference is not significant.

Philanthropic teams are smaller on average, with a significant coefficient difference of  $-0.14$  inventors. The ratio of males to females is not significantly different between philanthropic and non-philanthropic patents (female inventors were identified by the Patents-View gender prediction algorithm, see Toole et al., 2020). U.S. philanthropic patents also

have more U.S. based inventors than the control group, with a coefficient of 0.79. The proportion of U.S. inventors to all inventors on a patent is also significantly higher for philanthropic patents, with an estimate of 0.30.

Although control patents are not available (by definition) for the “orphan patents”, population averages are typically similar relative to the control results, for example, the orphan patents are on average cited less than both philanthropic patents and control patents.

## Data

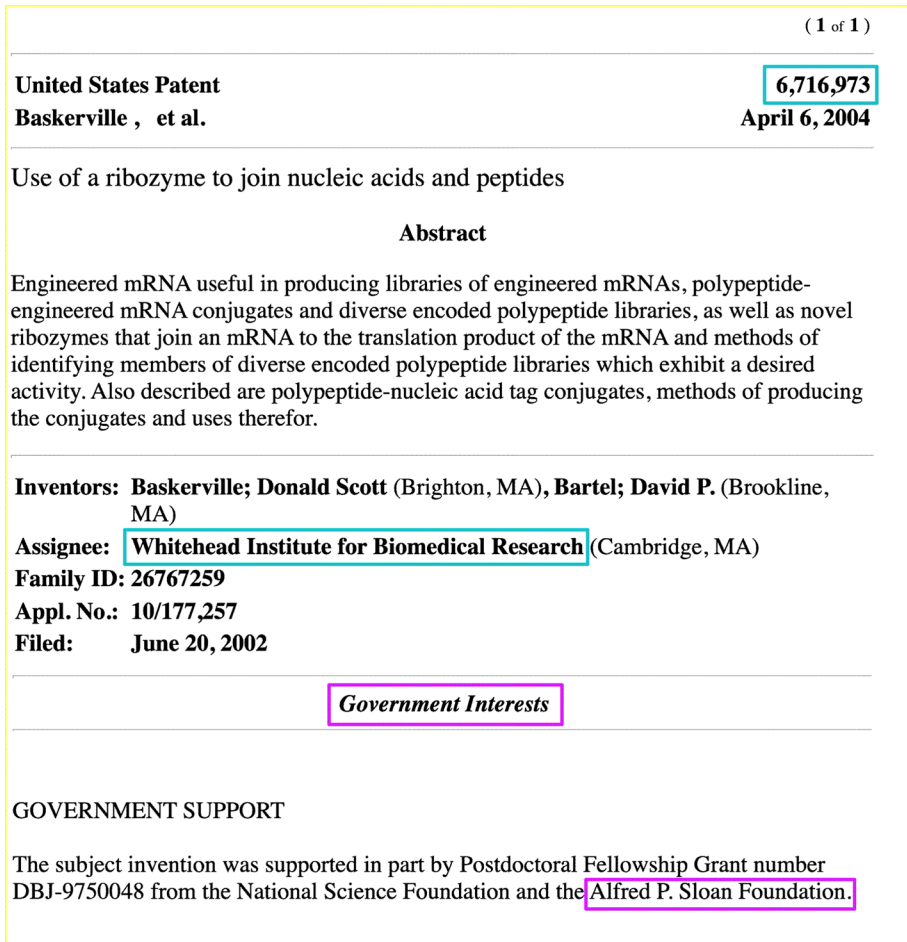
The primary data challenge in this research was to identify a patent either supported or owned by a philanthropy. We accomplished this by linking the 2011–2020 Candid database of philanthropic organizations, specified as those that file Form 990-N to the IRS [Tax Exempt, Non-Profit Organizations, all categorized as 501(c)(3)] to acknowledgements of support within or ownership of U.S. patents.<sup>2</sup> This database was built upon an earlier database by the Foundation Center, which merged with Guidestar, and is now marketed as Candid.

Figure 7 illustrates how U.S. Patent 6,716,973 is owned (that is, “assigned” to) the Whitehead Institute for Biomedical Research) and was supported by the Alfred P. Sloan Foundation. Most of the identified patents did not acknowledge philanthropic support but instead were owned (that is, “assigned”) to philanthropic organizations. It is possible that inventors and/or their organizations did not acknowledge their philanthropic sponsorship, and if this happened, then this process would miss those patents and underestimate the sponsorship of innovation by philanthropies.

Figure 8 illustrates the data process flow that identified patents and Table 1 provides descriptive statistics of the analysis sample. The process began with the lists of philanthropies and patents. First, we applied an exact string match algorithm to the name of the philanthropy and a string in the acknowledgements or government interest (in Fig. 7, this would be the “Alfred P. Sloan Foundation”). Sometimes this exact match would flag a false positive, for example, “Energy Services Inc”, a Candid Foundation string, would match against “Halliburton Energy Services Inc.” To eliminate these false positives, we applied the Named Entity Recognition module in the Stanford NLP Java Library to check for erroneous prefixes and suffixes, which we removed. We removed academic patents in two redundant ways, first, by using the Candid Cause Area designation (which flags academic institutions from their tax status) and by the university string identification algorithm used in Fleming et al. (2019). Given that this approach would miss patents with a slight misspelling or different spelling (for example, “Alfred P. Sloan Foundation” vs. “Alfred Sloan Foundation,”) we then re-expanded the dataset by identifying the assignee number from the PatentsView dataset, and took all patents in that database with the same identification number. Assuming that one patent was available to look up the PatentsView assignee identification number, then all patents owned by that philanthropy should be included in the analysis sample. A final manual check was performed, and 26 patents removed. These patents typically had the exact same name as a Candid non-profit, yet were for profit firms that clearly

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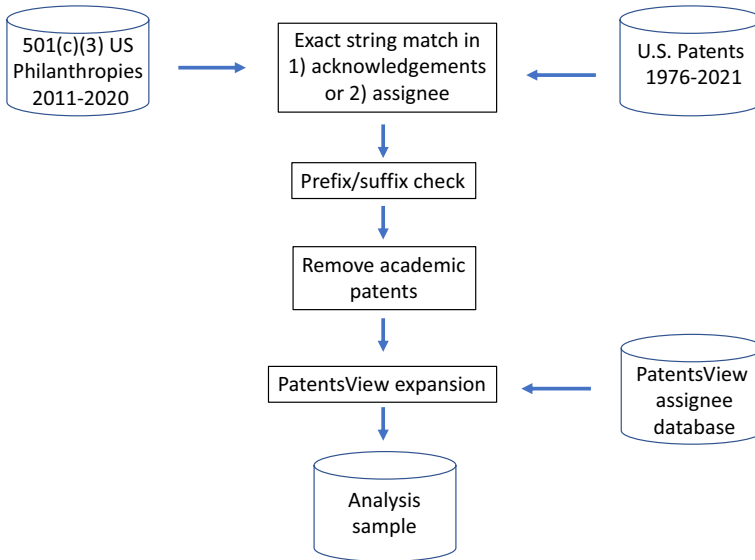
<sup>2</sup> This included IRS Subsection 501(c)(3) Private Operating Foundation (8,383 unique foundation name strings), 501(c)(3) Private Non-Operating Foundation (112,716 unique foundation name strings), and IRS Subsection 501(c)(3) Public Charity (475,608 unique foundation name strings).



**Fig. 7** Philanthropically supported U.S. Patent 6,716,973, owned by (that is, assigned to) The Whitehead Institute for Biomedical Research and supported by The Alfred P. Sloan Foundation

had nothing to do with the non-profit. Four patents were also removed that were clearly assigned to an academic institution.

Note that this approach still has many limitations. Strings may be inaccurate or contain different versions of the same organization, and this would introduce error in the matching processes (despite our strict string matching and re-expansion). The Candid database only extends back to 2011, hence older philanthropies that are no longer listed in the database will be missed. This might manifest as fewer identified patents in the earlier years of analysis and an underestimate of the total number of philanthropic patents. A patent may acknowledge support that is outside of conventional philanthropic support or organization, since our definition of philanthropy relies solely upon tax status. Such reliance could be questioned, for example, for industry research organizations which are funded by industry donations and do research for that industry. Such a definition surely includes more organizations than, "...non-profit, independent grantmaking institutions" (Michelson, 2020, p. 3). On the other hand, the matching correctly identified all members of the Science



**Fig. 8** The data flow

Philanthropy Alliance,<sup>3</sup> an association made up of philanthropies that support science and basic research. Ultimately, “It is difficult to identify the exact number of grantmaking foundations in the United States...” (Michelson, 2020, p. 9), particularly in an automated fashion, and this creates an unavoidable limitation to this research.

## Discussion

This research has provided a first and high level overview (essentially a mapping between philanthropic organizations and the patents they support), and provides a dataset and empirical foundation for additional investigation. Given the limitations of a large sample and automated data analysis approach, future work should move towards qualitative and case-study methods, in order to elaborate and define the processes by which philanthropies support innovation.

As one possible research question, is patenting mostly a by-product of philanthropy’s support for fundamental science research? Or do philanthropies invest with the intent to create patents? Are philanthropic patents intended—in which case, what are the motivations—or simply an afterthought? Given that our understanding of how philanthropy influences science has only recently received serious qualitative attention (Michelson, 2020), these questions are probably best addressed with interview, qualitative, and inductive methods.

Many additional questions can be pursued simultaneously, for example, how often do philanthropies work with other organizations that might also claim the intellectual property, and is their a tendency for the for-profit partner to keep the more valuable patents? This might explain why philanthropic patents are less valuable, namely, the possibility

<sup>3</sup> Azrieli is not a U.S. philanthropy.



**Table 1** Descriptive statistics of the analysis sample

Variable	Observations	Mean	Std. Dev	Min	Max
Philanthropic count of CPC subclasses	12,560	7.07	6.73	1	72
Control count of CPC subclasses	12,233	14.07	14.33	1	187
Number of CPC 6 digit subclass overlaps	12,560	3.11	2.47	0	30
Philanthropic backward citations to non-patent references	12,560	26.78	61.15	0	1346
Control backward citations to non-patent references	12,233	31.97	85.69	0	1601
Philanthropic backward citations to prior art	12,560	17.50	38.15	0	724
Control backward citations to prior art	12,233	31.65	102.78	0	3751
Philanthropic backward citations average patent number	11,129	5543451	1297681	0	1.04E+07
Control backward citations average patent number	10,968	5553389	1264611	0	1.06E+07
Philanthropic backward citations to non-U.S. patents	12,560	4.87	15.19	0	280
Control backward citations to non-U.S. patents	12,233	10.12	32.28	0	1071
Philanthropic forward citations total	12,560	17.77	45.36	0	823
Control forward citations total	12,233	22.22	64.63	0	1619
Philanthropic forward citations 3 years	12,560	1.11	3.62	0	250
Control forward citations 3 years	12,233	1.62	8.26	0	519
Philanthropic forward citations 5 years	12,560	2.65	8.06	0	481
Control forward citations 5 years	12,233	3.64	13.70	0	661
Philanthropic forward citations 10 years	12,560	7.16	17.16	0	530
Control forward citations 10 years	12,233	9.49	30.28	0	1393
Philanthropic number of inventors	12,444	2.90	1.80	1	21
Control number of inventors	12,233	3.04	2.19	1	29
Philanthropic number of US inventors	12,560	2.66	1.79	0	21
Control number of US inventors	12,233	1.87	2.21	0	29
Philanthropic number of male inventors	12,444	2.35	1.55	0	18
Control number of U.S. inventors	12,233	1.87	2.21	0	29
Control number of male inventors	12,233	2.43	1.76	0	26
Philanthropic number of female inventors	12,444	0.36	0.67	0	7
Control number of female inventors	12,233	0.43	0.83	0	12
Philanthropic indicator of government support	12,560	0.60	0.49	0	1
Control indicator of government support	12,233	0.45	0.50	0	1
Philanthropic failure to renew at 4 years	12,560	0.09	0.29	0	1
Control failure to renew at 4 years	12,233	0.10	0.30	0	1
Philanthropic failure to renew at 8 years	12,560	0.12	0.32	0	1
Control failure to renew at 8 years	12,233	0.12	0.33	0	1
Philanthropic failure to renew at 12 years	12,560	0.10	0.30	0	1
Control failure to renew at 12 years	12,233	0.10	0.31	0	1
Control grant date difference	12,233	- 4.11	138.20	- 364	364
Absolute difference in days Philanthropic and Control	12,233	97.44	98.08	0	364

that for-profit actors consciously guide the more valuable philanthropic supported patents towards ownership by for-profit firms. It may not necessarily be bad if valuable patents are assigned to for-profit firms, as these firms would then have the incentives and freedom to operate to accomplish commercialization and the application of the technology for profit and social welfare.

## Conclusion

Philanthropy has a powerful role to play in solving society's problem through science research and innovation, and this potential is increasingly being realized in science research (Michelson, 2020; Shekhtman et al., 2021). It is less clear whether philanthropic innovation, at least as measured by patenting, is currently fulfilling a large role. Philanthropic patents appear to account for only a small percentage of overall U.S. patenting and be less valuable than matched private patents by a number of measures. Further (probably qualitative) research is needed to assess whether this is due to a selection of less important technological areas, or whether the most valuable innovations by philanthropies are being kept by for-profit firms.

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