Professors Want to Share: Preliminary Survey Results on Establishing Open Source Endowed Professorships

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Abstract

This study proposes a novel policy to provide incentives for open science: to offer open source (OS) endowed professorships. To hold an *open source endowed chair*, in addition to demonstrated excellence in their field, professors would need to agree to: 1) ensuring all of their writing is distributed via open access in some way, and 2) releasing all of their intellectual property in the public domain or under appropriate open source licenses. The results of this survey study of university professors in the U.S. show that a super majority (86.7%) of faculty respondents indicated willingness to accept an OS endowed professorship, while only 13.3% of respondents would *not* be willing to accept the terms of an OS endowed professorship. The terms of accepting an OS endowed professorship that were the most popular among respondents were increased salary, annual discretionary budget, as a term of tenure and annual RA or TA lines. Although it should be pointed out that more than a quarter of respondents would require no additional compensation. The results demonstrate a clear willingness of academics to expand open access to science, which would hasten scientific progress while also making science more just and inclusive. It is clear that science funders have a large opportunity to move towards open science by offering open source endowed chairs.

1. Introduction

One of the foundational institutional norms of science is the idea that scientific knowledge is commonly owned (Sismondo 2010: 24). Contemporary scientific progress, however, is being held back by lack of sharing, specifically through three mechanisms: i) paywalls restricting access to copyrighted scientific literature (Gibbons, 1994; Heise & Pearce, 2020), ii) proprietary and expensive software (Damato, 2005; May, 2006) and iii) proprietary and expensive scientific equipment (Pearce, 2014; Gibney, 2016; Torrisi et al., 2016) that divides scientists into the “haves and have nots” (Chagas, 2018). All of these issues can be addressed by applying free and open source principles to the production and dissemination of scientific knowledge. While these principles are increasingly being applied to published academic literature, software, and hardware, linking these opportunities to contribute to open sharing of science with the professional expectations of university researchers is a novel and understudied approach.

There is a growing expectation for “unlimited access to the entire scientific journal literature” (Budapest Open Access Initiative, 2002), greater transparency in the scientific knowledge process (European Commission, 2015), and increased efficiency and effectiveness of science (Partha & David, 1994). Shifting regulations from federal funding agencies are increasingly requiring open access for publicly funded research (Suber, 2012). Simply being able to read the literature is a pre-requisite for being able to participate in cutting-edge science and the open access movement has matured considerably in the last several years to improve options for everyone (Johnston, 2008; Joseph, 2013). The Registry of Open Access Repository Mandates and Policies (ROARM) (2021) now lists 86 major funders, from national organizations to private foundations, such as the Academy of Finland, the Bill & Melinda Gates Foundation, the European Research Council (ERC), the Natural Sciences & Engineering Research Council of Canada (NSERC), and the Research Councils UK, as well as 57 funder and research organizations such as National Institutes of Health as well as the U.S. Departments of Agriculture, Commerce, Defense, Education, Energy, Interior, Health & Human Services, Homeland Security, State, and Transportation (DOT). In addition, over 800 universities and research organizations have mandated open access sharing (ROARM, 2021). Open access has become pervasive enough that Google Scholar now highlights the compliance of individual academics with open access mandates.

There is also growing utilization of free and open source software (FOSS) (Von Krogh & Spaeth, 2007; Fortunato & Galassi, 2021). Anyone is freely licensed to use, copy, study, and change FOSS in any way, and the source code is openly shared so that people are encouraged to voluntarily improve the design of the software. FOSS generally has a viral component that actually demands sharing of improvements. It is a well-documented fact that FOSS development leads to superior code (Raymond, 1999; Zeitlyn, 2003; Harroff et al, 2003; Von Krogh, et al., 2003; Bonaccorsi & Rossi, 2003; Lakhani & Von Hippel, 2004; Weber, 2004; Osterloh & Rota, 2007; Comino et al., 2007; Lee et al., 2009; Tozzi, 2017). The majority of large companies are now contributing to open source software projects and it has become the dominant form of technical development in this sector (LeClair, 2016); for example, 100% of supercomputers (Vaughan-Nichols, 2018) and 90% of cloud servers run open source operating systems (i.e. Every click on Facebook, Twitter, Wikipedia, YouTube or Amazon uses a machine running FOSS) (Hiteshdawda, 2020). FOSS is used by 90% of the Fortune Global 500 (Parloff, 2013), over 84% of the global smartphone market (IDC, 2020), and more than 80% of the “internet of things” devices (Eclipse, 2019). Academic researchers utilize both FOSS targeted at general computer and internet users, but also a rapidly growing list of scientific specific FOSS published in repositories (i.e. Source Forge lists over 17,900 free and open source programs for science and engineering (2021)). Increasingly, journals like *SoftwareX* and the *Journal of Open Source Software* are supported by organizations that understand the value of complete access to code for doing science (Chan Zuckerberg Initiative, 2019).

Free and open source hardware (FOSH) uses the same sharing philosophy (Powell, 2012; Gibb, 2014) as FOSS. FOSH is hardware whose design is shared so that anyone can study, modify, distribute, make, and sell the design or hardware (OSHWA, 2021). FOSH provides the “source code” for physical hardware including the bill of materials, schematics, computer aided designs (CAD), and other information such as detailed instructions needed to recreate a physical item. As well established in FOSS development, FOSH has now demonstrated improved product innovation (Dosemagen et al., 2017; Yip & Forsslund, 2017). FOSH is growing rapidly but trails behind FOSS by about 15 years in the academic literature (Pearce, 2018). Many studies document enormous economic savings with FOSH (Fisher & Gould, 2012; Pearce 2012; 2014; 2017; Murillo and Wenzel, 2017; Damase et al., 2015) and encouragement across a wide range of disciplines for open source science (Willinsky, 2005; Hope, 2009; Robertson et al., 2014; Friesike et al., 2015; Heikkinen, et al. 2020). Compared to equivalent or lesser proprietary tools, the cost savings of FOSH range from 87% in general to 94% for those that utilize open source electronics and distributed manufacturing (i.e. 3-D printing) technologies (Pearce, 2020). In addition to cost savings and making science more accessible, calibrating FOSH scientific tools using open standards has the potential to assist in reigning in the replication crisis and reducing measurement error (Loken & Gelman, 2017). It is clear that FOSH offers the opportunity to radically improve access to instrumentation, while improving the quality and diversity of tools by leveraging recent advances in distributed digital manufacturing technologies (Baden et al., 2015; Gibney, 2016). Under a scalable open source approach that takes advantage of the downloaded substitution value (Pearce, 2015) of FOSH, scientific funding is primarily invested for the development of FOSH for science rather than spent to directly purchase equipment. A return on this investment (ROI) is then enjoyed by science investors by direct digital replication of scientific devices for research and education at only the costs of materials (Pearce, 2016). New academic journals like *HardwareX* and the *Journal of Open Hardware*, are dedicated to methods and open hardware for sharing high-quality hardware documentation and nascent international community networks are being established (Dosemagen, Liboiron & Molloy, 2017).

It is clear that open science is part of a larger social shift characterized by open production methodologies and decentralized, distributed models of collaboration (von Hippel, 2016). Despite the growing successes of the free and open source paradigm in sciences, there is still significant work to be done. The majority of the literature is still inaccessible to nearly all researchers behind paywalls. Most academics are still dependent on a raft of proprietary software. In addition, there are currently very few institutional programs such as the US NIH's 3D Print Exchange (Coakley, et al., 2014) and CERN's open hardware repository (ohwr.org) and licenses (Ayass & Serrano, J., 2012) contributing to a culture of hardware sharing among scientists (AAAS, 2014). The vast majority of scientific equipment is still extremely expensive and proprietary. In addition, science is sometimes threatened externally in regions by political or special interest groups (Hoppe, 1999; Weingart, Engels, & Pansegrau, 2000) and also weakened internally by what has been described as a 'reproducibility crisis' (Baker, 2016).

Increasing open source sharing in academia is a practical approach to contribute solutions for all of the problems caused by restrictions on information sharing. Incentives are needed in addition to the many open science resolutions (Friesike & Schildhauer, 2015). This study proposes a novel method to provide incentives for open science: to offer open source endowed professorships. Endowed chairs are a well-known form of encouraging academic excellence and bring prestige to professors, their institutions, and the donors that fund them (Schaeffer & Papalia, 1966). To hold an *open source endowed chair* (also referred to here as an endowed professorship), in addition to demonstrated excellence in their field, professors would need to agree to: 1) ensure that all of their writing is distributed via open access, either by publishing in open access journals or posting legal preprints of all academic work, as well as ensuring their books are made available on open access platforms in some way, and 2) releasing all of their intellectual property in the public domain or under appropriate open source licenses. To assess the potential of this method for improving the application of open source principles throughout the scientific process in academia, a survey was conducted on a broad swath of U.S. academic faculty to determine willingness to accept an open source endowed professorship and identify what forms of compensation would increase the appeal of such a position. The survey was deployed online and was designed to gauge attitudes towards and preferred terms of an open source endowed professorship among academics. The findings contribute to the development of a practical method for effective information sharing and scientific progress.

2. Methodology

Survey method was used to assess willingness to accept an open source endowed professorship and to identify the preferred terms among academic faculty in the U.S. Survey method effectively measures preferences and attitudes of individuals in a target population, which can logically inform generalizations about populations too large to observe directly (Babbie, 2010). Given the purpose of this research, this study utilized survey method to understand attitudes towards and preferred terms of an open source endowed professorship among academic faculty in the U.S.

2.1 Procedure

Upon Institutional Review Board approval, the survey was launched online in April 2021 and remained open through June 2021. Participants were engaged via email and prompted to follow a link for online survey completion. Responses were recorded using Qualtrics software (Qualtrics, 2005) and then exported to IBM SPSS Statistics (version 26) (IBM Corp., 2019) to facilitate analysis. In pursuit of equal probability of selection among U.S. academic faculty, a random sample frame was constructed by systematically scanning academic institution websites to compile a list of potential participants. Specifically, 188 U.S. institutional websites with as diverse a background as possible were scraped for faculty email addresses based on the top ten percent from each category listed in the U.S. News Best Colleges in March of 2021 (U.S. News, 2021). The web scraper searches for any lines containing “@” and “email” on the selected departmental faculty websites. The application adds the matching email addresses to a database. This scraping included:

- 18 community colleges
- 39 national universities
- 23 national liberal arts colleges
- 8 black colleges and universities
- 18 regional north universities
- 17 regional south universities
- 16 regional midwest universities
- 13 regional west universities
- 5 regional colleges in the north
- 12 regional colleges in the south
- 9 regional colleges in the midwest
- 10 regional colleges in the west

2.2 Sample

This study aimed to achieve a sample representative of academic faculty in the U.S. The sampling technique previously described resulted in a sample frame of 59,869 individuals. Of the 59,869 surveys distributed, a total of 867 opened the survey, 803 partially completed the survey, and 638 completed in full (1% response rate). After elimination of incomplete responses, the effective sample size is 638 participants. Table 1 presents the key characteristics of the sample on selected variables relevant to representing the target population of academic faculty in the U.S.

Table 1
Key characteristics of survey respondents.

Professor Type	**Percent of Sample**
Professor of Practice	2.7
Adjunct Professor	11.4
Assistant Professor	16.4
Associate Professor	26.3
Full Professor	25
Endowed Professor	5.2
Other	10
Educational Institution Type	
Community, Junior, or Technical College	5.3
Four-year College or University	71.4
Research University	21.3
Other	1.9
Tenure Status	
Tenured	53.5
Not tenured	44
Prefer not to answer	2.3
Academic Discipline	
Humanities	18
Social Science	15.6
Natural Science	14.7
Formal Science (Mathematics and Computer Science)	8.5
Agriculture	1.1
Architecture and Design	0.6
Business	7.7
Education	7.2
Engineering and Technology	8.9
Environmental Studies and Forestry	0.6

Professor Type	Percent of Sample
Law	1.1
Library and Museum Studies	2.8
Medicine	2.7
Other	10.3

Table 1 indicates diversity among survey respondents in terms of professor and college type as well as academic discipline. While equal representation of these selected variables was not achieved, responses from this sample are still applicable for developing an understanding about academic faculty attitudes towards and preferred terms of an open source endowed professorship because they provide insight into a diverse range of perspectives of academic professionals of different status and subject area expertise. Despite the small response rate, this sample can support valid conclusions about preferences for the terms of an open source endowed professorship because the goal of this analysis is to explore academic faculty attitudes, rather than to detect statistical effects between key characteristics and willingness to accept an open source endowed professorship and the preferred terms.

2.3 Survey Design

Survey items were intended to measure the diversity among study participants, identify the preferred terms of an open source endowed professorship, and to generally gauge attitudes towards the concept. Both closed and open-ended responses were solicited from participants, which streamlined survey completion and provided respondents the opportunity to elaborate and voice their opinions. All survey items were designed to be exhaustive by allowing open-ended responses.

The main variables of interest in this study are willingness to accept an open source endowed professorship and the preferred terms, which were captured in a single survey item. Participants were first presented with information about open source endowed professorships to provide context and clarity for the subsequent multiple-choice question that prompted an answer to the following statement: “I would be willing to accept the terms of an open source endowed professorship for the following compensation: (Please select ALL that apply). Five terms: (i) increased salary, ii) annual discretionary budget, iii) as a term of tenure, iv) annual research assistant (RA) or teaching assistant (TA) lines or v) no additional compensation, were presented along with an open-ended option to describe other preferred terms, as well as a choice to denote they would not be willing to accept the terms. This survey item provides direct insight into attitudes towards and preferences for an open source endowed professorship among academic faculty in the U.S.

The various independent variables included were focused on measuring the demographic diversity among academic faculty who participated in the survey. Respondents were prompted to indicate what type of professor they are, what type of college or university employs them, their tenure status, and discipline of study. Table 1 displays the list of options presented to participants with regard to these key demographic variables.

2.4 Analysis

All data were analyzed with IBM SPSS Statistics (version 26) (IBM Corp., 2019). A small effective sample size relative to the target population reduced the statistical power of these data and rendered the results most suitable for descriptive statistical tests rather than inferential analyses. The results are discussed in terms of frequency of responses for willingness to accept an open source endowed professorship and the preferred terms among U.S. academic faculty, which serves the purpose of this exploratory study.

3. Results & Discussion

3.1 Establishing the Tenants of an Open Source Endowed Professorship

The results of this study reveal that only 13.3% of respondents would *not* be willing to accept the terms of an open source (OS) endowed professorship. All other respondents, representing a super majority (86.7%), indicated willingness to accept an OS endowed professorship by selecting which of the listed types of compensation they would prefer. This is rather remarkable considering that most research active universities have a technology transfer office that focuses exclusively on locking down intellectual property (IP) and licensing it rather than openly sharing knowledge generated by the institutions. Only a few universities, like MIT (Millar-Nicholson, 2017) and the University of Massachusetts (UM, 2021), make a point to discuss OS in their technology transfer plans. Yet the vast majority of faculty who participated in this study appear willing to divest of all IP for an endowed chair, based on their selection of compensation they seek in return.

An endowed chair of any kind is generally supported by income from an endowment fund established by a gift (or many gifts) from private sources, including individuals or industry, and is made available to a distinguished faculty member in support of his/her teaching, research, and service activities. Normally endowed chairs, which are highly sought after and held in high esteem in academia, are associated with some form of additional compensation and a discretionary spending budget drawn from the interest of the endowment (e.g. 4-7%/year). These traditional rewards for endowed chairs were the two most favored by respondents for OS endowed chairs. Of the listed types of compensation, an increased salary (41.2%) and an annual discretionary budget (38.8%) were most frequently selected by respondents as their preferred terms. The former simply increases a faculty member’s take home pay, but the latter creates a positive feedback for research excellence. Discretionary funds are generally the most valuable for research and often the hardest to obtain. Real scientific research cannot be fully planned and thus often diverges from pre-planned budgets submitted to conventional funders. University systems often attempt to provide researchers with some flexibility by providing a percent of return to researchers from overhead. An OS endowed chair with known discretionary research funds that would continue every year could enable professors to take more risks and develop preliminary data that could then be leveraged for more funding. Initial experiments are often expected to lead to far more funding from government or industry sources *after* the important part was already proven using seed funding from the discretionary endowed funds. Further, 21.6% of participants selected preference for increased research or teaching assistant lines, with presumably the former directly helping to accelerate scientific research and the latter freeing up the professor's time to spend more effort focusing on research and thus helping accelerate progress indirectly.

For untenured faculty members that accept an OS endowed chair, should the terms of an OS professorship be a requirement for tenure? Over a quarter of respondents (27.2%) felt it was appropriate for the requirement for tenure. Of the additional forms of compensation, this would have the lowest costs to implement (e.g. there would be no direct cost). In this case, first, as a requirement of tenure, all publications must be made available on legal open access repositories like the preprint servers often housed within university libraries. This seems like an easy and straight forward policy to institute for academic journal articles and there is substantial evidence this will only benefit the academic with an increased citation rate (Niyazov, et al., 2016), but may be more challenging for scholars that are expected to write books, as publishers are just beginning to experiment with open access book publishing. Second, the software and hardware developed should be posted in the public domain or made available with open source licenses. This does not have a direct cost other than the time to document and post, but there may a perception of opportunity costs from loss of IP revenue. The tech industry has certainly found ways to profit from open source development, so this may be a red herring, but future work is needed in these areas specifically focusing on universities.

Perhaps even more noteworthy, more than a quarter (27.5%) of responding professors declared that no additional compensation would be needed for them to accept the terms of an OS endowed professorship. This suggests that there is widespread shared sentiment in favor of knowledge sharing among some academics, which is supported by previous research on scientists (Ensign & Herbert, 2004; Ensign, 2008; Oliveira, 2019) as well as the burgeoning open access movement (Johnston, 2008; Suber, 2009; Liesegang, 2013).

Table 2 summarizes these findings and ranks the preferred terms based on survey results. Respondents who described "Other" types of compensation they would be willing to accept in an open-ended response (8.6%) most commonly discussed wanting all open-access publication costs covered (36%) or a course release to allow more time for research (15%).

Table 2
Ranking of preferred terms of an open source endowed professorship.

Terms of OS Endowed Professorship	Percentage
Increased salary	41.2
Annual discretionary budget	38.8
No additional compensation	27.5
As a term of tenure	27.2
Annual RA or TA lines	21.6
Other	8.6

Open-ended responses about willingness to accept the terms of an OS endowed professorship indicate that faculty members had different interpretations of the areas of sharing that most impacted them from open access publishing, publishing teaching materials freely, and publishing patentable intellectual property.

The majority believed that their primary barrier was the fees associated with open access (e.g. article processing charges (APCs)) and they wanted funds to cover these fees. There were a notable number of inaccurate opinions revolving around open access posting of academic work, which indicates future work is needed in open access awareness. A few faculty members thought that posting preprints was not permitted, they were not peer reviewed, that it would starkly limit where they could publish, and one faculty member believed, for example, that because of the complexities of American and international copyright law, such a professorship would require a dedicated assistant to navigate the legal quagmire. These beliefs, however, are simply not true. Nearly all academic publishers allow for preprint posting and have clear published policies to that effect (e.g. Springer (2021), Taylor and Francis (2021), Elsevier (2021), Wiley (2021), and Sage (2018)). Posting preprints is free (zero financial cost), there are many non-profit pre-print servers (e.g. arXiv, HAL, OSF, Zenodo, etc.) or hosted by publishers (e.g. SSRN owned by Elsevier and preprints.org by MDPI), and many universities house their own servers for their own faculty and students. As some respondents pointed out posting preprints in arXiv in some disciplines like physics is already standard procedure. Open access journals that state it, are, in fact peer reviewed and in the case of hybrid journals the peer review process is literally identical to traditional journals.

There was a notable concern among respondents that because publication in high-impact journals is an important component of demonstrating expertise for grants, tenure, etc. and many open access journals because they are in general newer carry lower impact scores that requiring open access would be onerous. Others felt there were no journals in their field of study. These issues can be overcome by either preprint posting in traditional journals and/or paying open access fees to hybrid journals (e.g. those that normally publish on the subscription model, but allow authors to pay to have their specific article made open access). The number of journals offering some means of open access is substantial as the

Directory of Open Access Journals (2021) currently lists over 16,000 journals of which over 11,000 have no APCs. It is true that for many open access journals and hybrid journals that charge a fee for open access release that APCs can be prohibitively expensive (e.g. *Nature Communications* currently charges $5,560, which is enough to fund a $10/hour summer research assistant). This explains why over 40% of the faculty wanted a predictable discretionary budget covered by the OS endowed chair funds that could be used to offset concerns about the additional costs of publishing in open access journals.

Open access books publishing, as pointed out by the respondents, is more challenging. Some felt writing open access books with a traditional publisher with traditional copyright is impossible. Although this is not strictly true as high impact (e.g. high sales) authors can leverage open access into contracts, for most academics the option involves paying for open access publishing. Many academic publishers are already moving in this direction. Springer Nature, for example, offers several open access book publishing methods (2021). Many open access academic book publishing contracts involve APCs, which again shows a need for the OS endowed chair discretionary funds. Another option pointed out by respondents is to have robust public investment and ownership of academic publishing so everything would be open access.

Many respondents pointed out that appropriate open scholarship involves more work (e.g. depending on the field open scholarship requires making components that are normally not shared 'presentable', submitting preregistrations, commenting and making code available, cleaning data sets, publishing full BOMs, ensuring CAD is shared in a format accessible top open source software, etc.). These respondents tended to favor additional funding for RA/TA support to help lighten the additional work load.

Following the path of conventional endowed chairs, many respondents indicated they wanted an increased salary. This was for many different reasons. Some used the same argument about additional work as was discussed for the need for extra RA/TA support. Some were also concerned that without it, the title would lack credibility; which is a concern that funders may want to consider if funding OS endowed chairs. Others felt that many university teachers are living for poverty or below-poverty wages because of the proliferations of adjunct instructors. They worried that loss of royalty income would hamper some faculty that were barely making ends meet. Those faculty members felt that to guarantee an instructor a living wage and job security was appropriate in exchange for making their intellectual and creative work open source. This issue of job security was a common concern. Many, for example were only willing to consider an OS endowed chair after they had already received tenure. In the responses, there was also an expressed worry that tenure had been weakened as administrator continue to increase in number and relative power in comparison to faculty, echoing many of the points raised by Ginsberg in *The Fall of the Faculty* (2011).

Some respondents focused primarily on how open source endowed chair requirements would impact their teaching. Although most respondents that commented this way thought that having greater access to academic work would provide them with better resources for teaching their students, others were worried that if they shared their teaching materials their job security could be put at risk (e.g. being replaced by low-paid adjuncts). Many pointed out that they often taught with materials that were not fully polished, but if all teaching materials were to be openly published substantial time investment would need to be made (e.g. to add full documentation like descriptions, notes, instructions, and other supplemental materials as well as ensuring images, graphs, etc. did not break copyright). Most respondents that expressed concerns about open sourcing teaching materials wanted additional compensation for the additional work although some wanted course release time to work on producing high-quality content.

Of the minority of responders that were not willing to accept an OS endowed chair, the primary issue was IP. In some cases, this was because the respondents believed this would hamper relationships with some industry partners. Others pointed out that at their institutions, patents count for tenure and promotion. The most common issue expressed by respondents, however, was that patent issues were governed by trustees, regents and university administrators and that open source would require modifications to the current faculty contracts. They believed that any work they created is the property of the university, having signed contracts that stated their institutions requires that they file records of inventions and provisional patents for “any potentially licensable IP.” All new science and technology is arguably potentially licensable IP, but there are no universities that have degraded academic freedom to a point that they prevent academics from freely publishing their ideas in the peer-reviewed literature. Such publication effectively becomes prior art, preventing the intellectual monopoly of the ideas by anyone with patents. Thus, if professors are personally willing to abstain from seeking an intellectual monopoly, they will not run afoul of faculty contracts that often require patented IP to be whole or in part turned over the university. Interestingly, the last group of respondents were concerned about IP for the opposite reason. They worried that private companies in the U.S. were already overly subsidized by government through direct subsidies, low-interest loans, bailouts, tax advantages, and SBIR/STTR programs and that openly sharing IP and thus being made even more easily available to them would further increase wealth concentration. Future work is needed to clarify and educate faculty about their rights to their own IP and the results of freely sharing it.

Lastly, a great number of respondents fell into a category of faculty that saw no disadvantage to the stipulations of an open source endowed professorship. In fact, many saw direct benefits such as reaching more people with their work through open access, having their work replicated and cited more by sharing open source software and hardware. For example, those working in computer science and software engineering pointed out that releasing research code with OS licenses can also be considered as a competitive advantage and an efficient way to increase impact. For these reasons, a large number of responding faculty already practiced full or partial open source methods in their work and one even had it as a requirement. Many respondents believe that open source is in alignment with most universities' missions and the notion, then, of intellectual proprietorship, is intrinsically alien to the academic enterprise. Several discussed OS in terms of the common good and used for example, the hoarding of COVID-19 vaccine patents as examples exemplifying why OS should be standard in academia and science should all be public. Others argued that open sourcing removes the monetary gain from academic work and thus allows the purest pursuit of knowledge for the good of humankind. Similarly, many respondents believed cooperation and collaboration is the way to advance the public interest and justice in society and that all research should be freely available to the public. Even though many faculty members felt that OS is the "right thing to do," they still would appreciate any additional benefits. Lastly, some respondents would want to be part of a cohort of open source endowed professors, which may be of interest to potential funders.

3.2 Assessing Differences Among Academics of Different Discipline

To assess if differences in preferred compensation types among academics of various disciplines exist, responses from faculty in engineering/technology and natural science were analyzed in isolation. These disciplines were of specific interest because they produce physical products, software, and discover IP, and are the most likely to protect or patent their research findings (Owen-Smith & Powell, 2001); therefore, understanding the nuances of their preferences and perceptions towards the concept is critical for advancing the state of OS knowledge. Results indicate that among engineers and natural scientists, an annual discretionary budget (42.1%; 43.6%) and increased salary (42.1%; 34%) remain the preferred compensation types. These forms of compensation are most common across all respondents, suggesting that irrespective of academic discipline, faculty would be most interested in financial support to facilitate information sharing.

3.3. Funding Open Source Endowed Chairs

It appears intuitively obvious that open source knowledge sharing is superior form of knowledge development, which is well supported in the literature (Von Krogh, Spaeth, & Lakhani, 2003). Based on the lack of opposition towards the concept of an OS endowed professor identified by this survey study, it is maintained that OS knowledge sharing is largely viewed to be beneficial. Therefore, supporting OS endowed chairs would appear worthwhile for increasing scientific output and the benefits associated with it. Funding for endowments to support OS chairs can come from several sources: 1) conventional donors and high net wealth individuals that are interested in maximizing the impacts of their donations, 2) governments interested in ensuring their funding is accessible to the tax payers while also maximizing research per dollar invested, and 3) corporations that may benefit from OS development in a sector that improves their business. The first two funders are straight forward and already exist; for example, funders are demanding that the results of their research are made openly accessible (e.g. the largest federal funder in the US, the NIH, does this). Based on this growing demand for access to knowledge and the sentiment among academic faculty revealed by this study, it is easy to anticipate that future funders would also demand that the results of the research be made freely accessible to all.

Businesses that would want to see OS development is less intuitive for those only familiar with conventional IP-scarcity driven business models. There are, however, many businesses that already benefit to an enormous degree from OS technologies, and such businesses would be well positioned to fund OS chair endowments. Business models that are successful for software are well established (Helander & Rissanen, 2005; Bonaccorsi, Giannangeli, & Rossi, 2006; Chang et al., 2007; Munga, Fogwill, &

Williams, 2009; Shahrivar, et al. 2018). Translating OS to hardware is more challenging (Beldiman, 2018). Li & Seering, however, found that establishing a community in FOSH can increase customer perceived value, decrease costs for product development and sales, shorten product go-to-market time, and incubate startups with knowledge, experience, and resources (2019). Pearce (2017) established several profitable FOSH business models for scientific hardware specifically, which include kit sales, specialty component sales, and calibration suppliers for scientific makers, in addition to FOSH hardware direct sales. FOSH advantages can compensate for risks associated with open strategies and can make OS design a viable strategy for hardware startups (Li & Seering, 2019), particularly if FOSH businesses target technically-sophisticated customers first and, as usability matures, target expanded markets of conventional scientific consumers (Pearce, 2017). Such FOSH businesses, as they grow, will be in positions to fund OS endowed chairs.

There are limitations to this study. First, the construction of the sample frame was challenged by some school's website design or anti-spamming features, which precluded a few institutions that were identified in the sampling frame (pulling top 10 across multiple ranked categories) from full study participation. Additionally, based on feedback from some participants, the recruitment email was often flagged as spam, which may have impacted response rate. To overcome these limitations, future studies could have emails sent from the individual university's vice president of research or internal equivalent rather than coming from external email, have the emails personalized to the individual professors, and offer a reward (e.g. gift certificate) for study participation. In addition, response bias is an inevitable artifact of survey research (Mathiyazhagan and Nandan, 2010). Faculty members with strong support for or opposition to OS are more likely to take the survey than someone who is indifferent. The open-ended responses provide evidence of this, as several faculty members expressed a strong ethical imperative already to freely share all their intellectual contributions globally, that academic publishers were "cartels," or that "democratization of knowledge is desperately needed." A notably much smaller number of faculty members argued forcefully they "deserve the fruits of my labors" and would never give up their IP and the potential future profits that it could create because they were, for example, undercompensated for their work currently. Response bias is common and well known in survey research, but has also been found to be minimal in faculty surveys (Menachemi, 2011). In this particular case, it did not appear to present a major issue in terms of data quality.

4. Conclusions

In this work, the potential and the barriers to increasing open access to science is examined, specifically by surveying university professors in the U.S. to ask about their willingness to participate in scientific work that applies open source principles to the entirety of their scientific process. Findings demonstrate a clear willingness to expand open access to science, which would hasten scientific progress while also making science more just and inclusive, moving toward an institution of science that actually upholds the institutional norms of its foundation. The vast majority (87.3%) of survey respondents indicated they would consider an open source endowed chair for themselves by selecting their preferred type of compensation. An increased salary (41.2%) and an annual discretionary budget (38.8%) were most frequently selected by respondents as their preferred terms, irrespective of discipline. The survey results suggest that there is shared sentiment in favor of knowledge sharing among some academics, which substantiates the viability and practicality of developing open source endowed professorships to increase information sharing in the pursuit of scientific progress for all. It can be concluded that science funders interested in accelerating scientific progress and open science should consider offering open source endowed chairs to top performing academics in areas of interest.

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