The Outsized Role of Academic Stars in University Technology Licensing[*]

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Abstract: The decline in U.S. corporate R&D over time raises the importance of university-based research in the innovation ecosystem. We examine the process by which university technology transfer offices (TTOs) allocate internal resources, which provides insight into technologies offered for commercialization to the private sector. We compare resource allocation according to academic "star" status against a commercial experience logic. We analyze detailed administrative records of patenting decisions and outcomes by one prominent U.S. research-based university's TTO over a 30-year period. We find academic stars wield outsized influence: their patent applications are more likely to be filed, yet are less likely to be issued; they are no more likely to have their patents licensed and their patents are no different (statistically) in their licensing revenue from non-stars.

Keywords: University technology licensing; patents; decision-making; administrative data.

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1. INTRODUCTION

Universities are an important part of the entrepreneurship and innovation ecosystem, both in their training and research activities (e.g., Nelson, 1993; Furman, Porter & Stern, 2002). The knowledge they generate is also directly and indirectly important for industrial managers in their product and service development (e.g., Mansfield, 1991; Cohen, et al. 2002; Foray & Lissoni, 2010; Cohen, 2010). The reliance on university science, often federally funded (Fleming et al. 2019), is likely exacerbated by the secular decline in research (as opposed to development) efforts in U.S. corporations over the past 40 years (Arora, Belenzon & Patacconi, 2018).

While academia-industry knowledge linkages can occur in various ways, technology licensing and commercialization efforts are particularly important. In 2018 alone, over 17,000 patent applications were filed, over 7,600 patents were granted, 828 new products were created, and over 1,000 start-ups were formed (as reported by the Association of University Technology Managers). Moreover, some studies have suggested that universities are disproportionately responsible for *breakthrough* commercial technologies (Colyvas, et al. 2002). Nevertheless, scholars typically treat university technologies as exogenous (e.g., Nerkar and Shane, 2007). Since university missions increasingly include economic development and commercial translation (e.g., Sanberg, et al. 2013), treating such technologies as given unfortunately obscures organizational resource decision-making underpinning the commercialization process. An important exception is recent work by Cohen, Sauermann, and Stephan (2020), who examine how scientists' motives to engage in commercial activity vary across technological fields.

In this study we focus on the technology transfer office (TTO) managers who must make judgements on allocating resources to pursue patent application filings on inventions disclosed by intellectual property (IP) producers (i.e., academic scientists and engineers). Patent protection is often a prerequisite to attracting potential technology licensees, which is a necessary step to commercialization success (and associated licensing revenues). The patenting process is costly, however, and also entails foregone opportunity costs of other activities which could also help fulfill the TTO's mission.[1] The large majority of patents are issued only after being initially rejected and amended, often many times, a potentially expensive process known as "patent prosecution." Accordingly, TTO managers must decide not only whether to file a patent application, but also whether to continue to invest resources in its prosecution and post-grant renewal.

To better understand university technology commercialization, we examine the resource-allocation decisions of one TTO which we term "PRU" (prominent research university) over a 30-year time period. This new dataset includes both patenting decisions and commercial outcomes (including, importantly, those *not* yielding commercial value). We examine two logics under which TTO mangers may be making their decisions to engage in patent prosecution and technology commercialization given the typically uncertain and embryonic nature of the technology: IP producers' (1) scientific and academic eminence (the traditional currency of merit in research universities) and (2) prior commercialization experience. Given the dearth of prior work, we refrain from forming specific hypotheses, but end the paper with implications and directions for future research.

We find that both commercialization experience and academic prominence predict patent application filing, but only past commercialization experience predicts future commercialization success. Academic prominence is nevertheless a strong predictor of renewal fee payment for

[1] Most university TTOs seek to promote both the public good and private value. For example, the MIT TTOs mission is "to move innovations and discoveries from the lab to the marketplace for the benefit of the public and to amplify MIT's global impact." (http://www.tlo.mit.edu). Similarly, Stanford's mission is to "promote the transfer of Stanford technology for society's use and benefit while generating unrestricted income to support research and education." (http://otl.stanford.edu).

unlicensed patents. Our empirical results thus suggest that academic stars wield outsized influence in resource allocation.

2. BACKGROUND & LITERATURE

2.1 Historical background of TTO evolution. The period after the US Civil War was a crucial one for U.S. research universities. For example, Goldin & Katz (1999, p. 45) note: "For most of the 19th century, American institutions of higher education were centers of learning, not research. That began to change in the latter part of the 19th century with the founding of Johns Hopkins University (1876), the first dedicated research center in the US." One policy trigger was the 1862 and 1890 Morrill Acts, in which the US government transferred land to states to endow colleges and universities specializing in practical sciences such as agriculture and mechanical arts. Some 432 colleges and universities were established in the US between 1860-1899, whereas only 289 such institutions had been formed in the US in the preceding 222 years (Goldin & Katz, 1999).

While the US federal government was important in establishing these "land grant" universities, the government provided almost no university research funding prior to World War II, a pattern which was reversed after 1945 (Atkinson & Blanpied, 2008).[2] Along with the subsequent rise of federal research funding, the 1980 Patent and Trademark Amendments (Public Law 96-517, also known as the Bayh-Dole Act) accelerated university efforts in establishing technology transfer and licensing offices by granting intellectual property rights to federally-funded research to entities (universities, not individual researchers) conducting the research

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[2] In that year, Vannevar Bush, a prominent science advisor who had chaired the US National Defense Research Committee and then became the chair of the US Office of Scientific Research and Development (OSRD), submitted a report to President Truman entitled, "Science—The Endless Frontier." Bush argued that funding (basic) research and science leads to general knowledge, which then provides a means of approaching a number of practical problems, and so funding science is a proper concern of government. Research efforts, which had been so important during war-time, helped develop important innovations such as radar, penicillin, and plastics, Bush argued, should also be funded during peacetime, and pushed for the formation of the National Science Foundation (which was established in 1950). For more discussion about the OSRD and an analysis of its long-run effects (on direction of US invention and location of high-tech industrial employment) of the research it supported, please see Gross & Sampat (2020).

(Henderson, Jaffe & Trajtenberg, 1998). Both qualitative (Murray, 2010) and quantitative (Owen-Smith, 2003) accounts find a period of ferment following the Act in which norms associated with traditional research and academia began intersecting and clashing with commercial interests.[3]

2.2 Institutional context of modern university technology transfer operations. In the modern era, TTO managers are charged with supporting a mission of both societal benefit (i.e., knowledge transfer and use) and commercial return (i.e., licensing revenue) associated with university-owned IP. Scholars have investigated contracting policies such as royalty revenue splits and ownership between the various stakeholders (Jensen & Thursby, 2001; Lach & Schankerman, 2008; Hvide & Jones, 2018), but the literature on university TTOs has paid little attention to other aspects of internal organizational decision making. Notably, two studies in this domain (Bercovitz, et al., 2001; Siegel, Waldman & Link, 2003) both have the words "exploratory study" in their titles. Bercovitz et al. (2001) discuss variation in the way TTOs are organized (e.g., decentralized, centralized, cross-functional) as an explanatory variable for patenting and licensing behavior across three university TTOs. Such differences in organizational structure shape information processing and coordination capacity and incentive alignment. Siegel, Waldman & Link (2003) broaden this investigation to also include survey-based information not just about internal operations, but also how internal operations might interact with external potential licensees to further educate them on academic culture and develop mutual understanding.

Given the limited prior literature on internal TTO organization resource allocation decision-making, we suggest that inventors' commercial experience and academic standing may be

[3] To illustrate one episode, Harvard's patent on an "oncomouse," a genetically engineered mouse for cancer studies, was exclusively licensed to the DuPont Company in 1984, which when the company imposed commercial norms (such as corporate review prior to scientific publication), led to conflict with academic researchers (Murray, 2010). During this period, social norms of the scientific field (Merton, 1968) were challenged, but the norms of academic science slowly became more accepting of commercial science (Stuart & Ding, 2006).

important predictors of TTO managers' resource allocation calculus. Scientists' commercial experience may signal the presence of skills or knowledge helpful in technology commercialization. In particular, prior licensing experience may indicate knowledge of not only the subject matter which is likely to be demanded by the marketplace, but also possible familiarity with potential licensees. Without such commercial experience, the TTO manager may be uncertain of scientists' understanding of industry demand conditions.

TTO managers may also consider scientific eminence, which in a traditional academic environment provides a status ordering (Merton, 1957; Stephan, 1996). For this reason, tenure and promotion decisions at research universities are often tied to such scientific accomplishments (see Siouw, 1998 for both a history and economic explanation for academic promotion and tenure). From the perspective of TTO managers, the effect of accomplished academics approaching the licensing office may come in two forms: first, their (perceived or actual) scientific merit may be higher than average and so may form the basis of differentiated technical advance which may translate into enhanced patentability and/or the potential for broader and more valuable IP. A second effect, however, may be that the TTO officer may have a harder time imposing discipline or withholding resources to the high academic status individual. Therefore, while we expect academic status to correlate with resource allocation, the net commercial effect is ambiguous.

There may also be an interaction effect between commercial and scientific eminence in influencing TTO managers' resource allocation decisions. Individuals who patent appear not to suffer an academic productivity penalty (Fabrizio & Di Minin, 2008). Whether such individuals achieve better commercialization outcomes is an open question, and one which we will examine in the context of resource-allocation decisions in the face of a skewed distribution of commercialization outcomes. The average patent is worth very little, and most of the private value in the patent system is concentrated in a small percentage of patents.[4] For example, in a large sample survey of European patent holders, Gambardella, Harhoff & Verspagen (2008) found that although the median value of a patent is only 300 thousand Euros, a small proportion – about eight percent – were worth more than 10 million Euros. Representative valuation data for academic patents is also scarce, but a limited literature suggests that valuable academic patents are just as rare as valuable patents in the private sector (Sapsalis, de la Potterie, & R Navon, 2006).

3. DATA

3.1 Data sources. Our data are from several sources: (1) internal patenting and licensing data from a TTO at a prominent research university (PRU); (2) the publicly available Microsoft Academic Graph (MAG); and (3) publicly available bibliographic patent data provided by the United States Patent and Trademark Office (USPTO). We also conducted an extensive inventor disambiguation and matching exercise to link inventors across the datasets.

The PRU data identify patent applications filed by the TTO at the PRU over a 30-year period (starting in 1986), as well as the names of inventors listed on those patent applications. Analysis of patent data is typically limited to granted patents, since data on pending and abandoned patent applications is either quite limited or not publicly available. Because the PRU administrative records include data on pending and abandoned patent applications, they provide a unique perspective on PRU patenting activity. As we will show, the decision to file and later abandon a patent application seems to be a crucial component of PRU's patent strategy. Even more importantly, the PRU data include technology and transaction-level licensing information such as whether a patent application was licensed, the number of licensing agreements, and its lifetime

[4] Observing the full distribution of patent values, both in the not-for-profit organization (e.g., TTOs) setting, as well as in the for-profit company arena, is rare. Typically, patent valuation is revealed only in select circumstances which are unrepresentative of the entire patent value distribution, such as in the course of patent litigation (typically only observed for highly valuable patents or those with high strategic value).

licensing revenue. The commercialization information is particularly noteworthy as it is rare to observe prices in the market for technology (at all, as such transactions are typically private), and especially in a way which is not severely selected (e.g., patents which are the subject of litigation, which are likely to be disproportionately drawn from the right tail of the value distribution).

We rely on the Microsoft Academic Graph (MAG) dataset as redistributed by Marx & Fuegi (2020) for information on inventors' publication records. The MAG dataset identifies bibliographic information such as dates, journals, authors, and journal impact factors (JIFs) for more than 160 million academic publications published since 1800 (weighting academic publications by JIF is a common way to adjust for quality). Scholars analyzing randomized samples have found that MAG provides significantly higher coverage than the better-known Google Scholar and Web of Science databases (Hug & Brändle, 2017).

We employ the USPTO PatentsView dataset to identify bibliographic information such as patent application filing date, patent grant date, patent citations, assignee, and inventors for granted U.S. patents. One drawback of the PatentsView dataset is that its coverage extends only to granted patents. Because many of the patent applications in the PRU patenting and licensing data were abandoned or still pending at the time of our data collection, limiting our analysis to granted patents would miss significant aspects of institutional behavior. For information on pending and abandoned applications, we turn to the USPTO Patent Examination Research Dataset ("Public PAIR"), which is described by Graham, Marco & Miller (2015).[5]

[5] A key advantage of the Public Pair dataset is its inclusion of data on continuity relationships. A patent application frequently includes many inventive concepts, but the USPTO limits the applicant to pursuing claims directed to a single basic idea in a patent application to avoid imposing an undue burden on the patent examiner. An applicant who wishes to pursue claims directed to multiple inventive concepts can file one or more "continuing" patent applications, effectively splitting the original application and potentially yielding multiple distinct patents that are collectively referred to as a "patent family." Accurately identifying patent families is important since they form a key component of patent strategy. Patents in the same family share inventors, descriptive material, and an effective filing date, and therefore should not be treated as independent observations in empirical analysis. Instead, the earliest patent in a family

3.2 Sample selection. Our sample period begins in 1985 due to data availability and ends in 2015 to allow adequate time to observe outcomes for patent applications. We start by identifying all patent applications filed by PRU during our sample period. We then parse the PRU licensing data and the USPTO Public PAIR patent continuity relationships to restrict our analysis to the first patent application in each patent family or patent license. The decision to pursue follow-on applications is often a consequence of commercialization prospects, and is not necessarily indicative of distinct and independent invention. Frequently these follow-on applications are linked to the initial patent application by a priority relationship, but sometimes they are not. Accordingly, limiting our analysis to the initial patent application for each patent family and each license is a conservative approach that helps to avoid double counting decisions and outcomes.

We identify a total of 1,189 initial patent applications, of which 145 are licensed. We uniquely identify all 4,446 inventors who are listed on any of these patent applications and who are affiliated with PRU in the MAG data. For our initial analysis, we construct a panel on the inventor-year level, excluding observations that predate or postdate the inventor's academic career. For subsequent analysis, we employ a cross-sectional sample on the inventor-application level.

3.3 Variable definitions and summary statistics. Table 1 provides variable definitions and summary statistics for the inventor-year data sample. In unreported results, pairwise correlations between variables suggest that multicollinearity is not a problem for any of the regression models. For each observation we identify whether the inventor was listed on a patent application filed in that year (*Filed?*). An application was filed in 9% of the inventor-year observations. Of the inventor-year observations in which an application was filed, 44% (i.e., 4% of all inventor-year observations) led to an issued patent (*Issued?*) and 11% (i.e., 1% of all inventor-year observations)

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indicates the genesis of the intellectual property, while later patents indicate an effort to provide more effective and comprehensive exclusive rights.

led to an issued and licensed patent. Of the inventor-year observations in which an application was filed and issued, 25% led to licensed patents. *Lifetime Revenue* identifies the total revenue in thousands of dollars received from all licenses with which the patent application is associated.

---- Insert Tables 1 & 2 and Figure 1 here ----

We believe there are two constructs which may guide TTO managers' resource allocation decisions: (1) academic status, and (2) commercial experience. To the first construct, the variable *Publications* is a standardized count of the inventor's academic publications. Following Azoulay, Graff Zivin & Wang (2010), we weight each publication by its journal impact factor (JIF). Because the raw measure is skewed, we take the log value, demean it, and divide it by its standard deviation to produce a z-score. We define an academic star as having a JIF-weighted publication count at least two standard deviations above the mean. To measure inventors' commercial experience, *Prior License?* identifies whether the inventor was listed on a patent licensed in a previous calendar year – 12% of inventor-year observations were associated with previous licensing. As a control variable, *Career Length* measures the time in years since an inventor's first academic publication.

Figure 1 plots patent application outcomes over time. The application filing rate increased substantially over time. Whereas the PRU filed fewer than 50 applications per year prior to 1995, most years from 2001-2015 saw more than 150 applications filed. Interestingly, the rate of abandoned patents climbed even more steeply, from 21.3% of patent applications filed in the first 10 years of the sample period to around 54.6% of patent applications filed in the last 10 years of the sample period. PRU's abandonment rate is therefore much higher than that of all patent applications (20.8% as reported by Carley, Hegde & Marco, 2015). This suggests that the PRU TTO often abandons the prosecution of patent applications deemed to be strategically unimportant.

4. EMPIRICAL RESULTS

Table 3 presents the results of regression models of patent application filing at the inventor-year level to evaluate the academic prominence and commercial experience variables. All models include year fixed effects. Column 1 suggests that the PRU TTO is more likely to file patent applications as an inventor's academic prominence increases - a standard deviation increase in publications corresponds with a 3.4 percentage point increase in the probability of patent application filing in a given year. An academic star is 6.8 percentage points more likely to file an application. Prior commercialization experience is also positively linked with patent application filing. In column 2, an academic who has previously licensed a patent is 5.8 percentage points more likely to file a patent application in a given year than one who has not. Column 3 includes both variables and adds an interaction term. At the mean, prior licensing experience increases the probability of patent application filing by 3.5 percentage points. However, patent application filing is 4.8 percentage points more probable for an academic star who has not previously licensed and 17.2 percentage points more probable for one who has. All coefficients are statistically significant, and the results are robust to the alternative logit specifications included in columns 3 and 4.

Collectively these results suggest that both commercialization experience and academic prominence are strong predictors of future patent filings, and that prominent academics with commercialization experience are particularly likely to file patent applications. One explanation for these results is that both variables may be predictors of patenting and commercialization success. To test this theory, Table 3 presents the results of OLS models of patent application outcomes at the inventor-application level. All models include year fixed effects.

---- Insert Tables 3 & 4 here ----

Interestingly, although previous commercialization experience is associated with more positive outcomes overall, the reverse is true for academic prominence. In columns 1, 3, and 5, a patent application by an inventor who has previously licensed a different patent is 2.2 percentage points more likely to be licensed itself and is expected to generate 9.0 percent more revenue than a patent application by an inventor without prior licensing experience. Previous licensing experience is also associated with a 12.3 percent increase in patent citations. In contrast, academic prominence is at worst negatively predictive and at best unpredictive of commercialization success. In column 1, an academic star is associated with a 5.0 percentage point decrease in the probability that a patent application will be issued. If a patent does issue, then in column 4 a patent by an academic star will receive 23.2 percent fewer forward citations, on average.

The interaction of commercialization experience and academic prominence is a particularly negative predictor of future outcomes. In column 4, previous licensing experience is associated with a 4.1 percentage point increase in the probability that a future patent is licensed, but being an academic star decreases this probability by 5.4 percentage points. Similarly, in columns 6 and 8, licensing experience is associated with a 15.5 percent increase in expected licensing revenue and a 25.5 percent increase in forward citations, but being an academic star is associated with a 19.0 percent and 49.4 percent decrease, respectively. The results are robust to unreported logit and negative binomial specifications.

Collectively these results suggest that prior commercialization experience is a good predictor of future patenting and commercialization success, but that academic prominence is not. Indeed, patents by prominent academics with commercialization experience, precisely those characteristics that predict patent application filing, are particularly unlikely to succeed. Why do we observe these empirical patterns? We identify two possibilities. First prominent academics may be highly prolific but produce inventions where commercial quality is highly variable. Second, prominent academics may exert undue influence on the PRU TTO. That is, TTO managers may find it difficult to withhold resources from prominent academics, who likely command substantial power and status at the PRU, even if TTO managers are privately pessimistic about a disclosed invention. Under this explanation, TTO managers may prefer that a negative decision come from the external U.S. patent office rather than from the internal TTO.

Although we cannot conclusively distinguish between these two possibilities (and so is ripe for future research), one way to shed light is to examine the payment of patent renewal fees. After a patent is issued, the patent holder must periodically pay to maintain the patent or else it will lapse. If prominent academics exert undue influence on the PRU TTO, then we expect that as a consequence of that influence, the PRU TTO may pay to maintain their patents even in the absence of a license (evidence of commercial value). Accordingly, Table 4 presents the results of OLS models of patent application renewal eight years after issuance.[6] We control for forward citations (logged) to address the quality difference shown in Table 3.

---- Insert Table 4 here ----

The results in Table 4 are a striking contrast to those presented in Table 3. In column 1, which includes year fixed effects, licensing experience is associated with a 7.4 percentage point *decrease* in the probability of paying the renewal fee, while being an academic star is associated with a 9.0 percentage point *increase* in the same probability. Column 2 replaces the year fixed effect with a linear control variable. The probability of the PRU TTO paying the renewal fee for unlicensed patents is increasing by 2.3 percentage points each year. All results are statistically significant and

[6] Renewal fees are due at 4, 8, and 12 years. We examine the renewal fee payment at 8 years since the renewal fee at 4 years is quite low, while the 12-year window imposes significant rightward truncation on our sample. Since licensed patents are nearly always maintained, we exclude such patents from the sample.

robust to the alternative logit models in columns 3 and 4. Collectively these results suggest that when a patent proves unlikely to generate licensing revenue, as evidenced by the passage of eight years from its issuance with no license in place, the PRU TTO is more likely to pay to renew the patent as the inventor's academic prominence increases, despite the fact that academic prominence is a poor predictor of commercialization success.

Overall, the PRU TTO seems to be actively searching for highly elusive licensing revenue by filing a large and growing number of patent applications. As shown in Figure 1, the PRU TTO seems to have adopted a strategy of filing many patent applications but abandoning a large percentage prior to issuance, presumably those that seem unlikely to lead to licensing revenue.[7] Nevertheless, the increasing rate of both application filing and patent renewal fee payment has led to a large and growing portfolio of issued and maintained, but unlicensed, patents (Figure 2). Given the difficulty of finding paying licensees and the dearth of alternative revenue streams, TTO officers facing pressure to generate revenue may consider selling or licensing patents to other nonpracticing entities, in violation of AUTM's suggested licensing guidelines.[8] Thus, selecting patents for filing and renewal based on inaccurate heuristics such as academic prominence may lead to unintended consequences such as university patents being used for so-called patent trolling, perhaps bolstering some scholars' concerns about university patenting (Ouellette & Weires, 2019).

---- Insert Figure 2 here ----

5. DISCUSSION

With the decline in corporate investments in basic science since 1980 documented by Arora, Belenzon & Patacconi (2018), university technology is likely playing an increasingly important role in the U.S. innovation ecosystem. Rather than taking such technology as given as is the case

[7] According to one TTO officer, "We do a lot of provisional filing, but we stop if it doesn't look like licenses are forthcoming."
[8] https://www.autm.net/AUTMMain/media/Advocacy/Documents/Points_to_Consider.pdf

in much of the literature, we investigate the organizational process resulting in technologies available for licensing and commercialization. We do so by taking a deep dive into a single prominent research university's experience in technology transfer operations over a 30-year period. Given the historic importance of academic status in this context, perhaps it is not surprising that there is a significant association between academic prominence and patent application filings at PRU. These results are consistent with our discussions with several TTO officers, one of whom reported that "Stars have a lot of political clout. . . . We're just not going to turn them down, and we don't imagine anyone else would do so." However, when we examine correlates of commercialization success, academic prominence is *negatively* associated with patent grants and uncorrelated with lifetime revenues, even for those with previous licensing experience.

The literature on academic technology transfer typically studies individual *academic* outcomes for those engaging in patenting For example, Fabrizio and Minin (2008) find that academic publication and patenting are complementary, but that citations to publications decline for repeat patenters. Likewise, Zucker and Darby (1996) find that star scientists who enter the commercial realm experience an increase in academic productivity. In contrast, our results examine *commercial* outcomes by presenting evidence that for academic inventors, publication is associated with an increased rate of patent application filing but a decreased probability of commercialization success.

The relative over-representation of prominent academics at the patent application stage but not at the commercialization outcome stage illustrates a broader strategic management issue which has thus far not received much attention in the literature. Organizations are increasingly taking on dual missions (e.g., social and/or environmental responsibility at the same time as commercial returns). Particularly when the organization adds one of those missions later in its lifecycle, and the dimensions of merit in the expanded mission may not be the same as in the original organization, there may be conflict in resource allocation. Our study illustrates this phenomenon in the commercial academic science setting.

Future research in this and other domains would benefit from deep understanding of possibly divergent objectives of the key stakeholders (Bercovitz & Feldman, 2006; Siegel et al., 2003).[9] Avenues for investigation include whether decentralized decisionmaking would better align outcomes with resource allocations and how to design TTOs to shield decisionmakers from the power of dominant stakeholders. For example, an idea's commercial potential could be evaluated partially via double-blind anonymous review, which may render resource allocation decisions not only more efficient but also less biased, furthering efforts to ensure diversity, equity, and inclusion.

Our study, while broadening the work in the internal management and resource decision-making of university technology transfer organizations, also contain several limitations and domains ripe for future study. Among the highest priority domains is a better understanding of how the potential licensees factor into the resource allocation process. A second area relates to the generalizability of our findings. For example, would we see the same findings in a hybrid, for-profit organization such as a B-Corporation (see, e.g., Battilana & Dorado, 2010)? Or the case of corporate venture capitalists (who invest in companies for both strategic and financial return reasons)? There is much work ahead for this field; we hope that this initial effort spurs others to better understand the organization and management of dual-mission organizations.

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[9] In the university TTO setting, there may be a mismatch between participants' objectives in commercialization efforts. Through a survey of 62 US TTOs in the 1991-1995 period, Jensen & Thursby (2001) report that 71% of surveyed TTO officers (but only 41% of faculty) stated that royalties and license fees are "extremely important" measure of licensing success, while 73% of faculty (but only 34% of TTO officers) said "sponsored research funds" is an extremely important measure of licensing success. This divergence, if also true at PRU, may help explain the disparity in correlates of patent application as compared to commercialization outcomes. One implication is that incentives for the parties should take into account possibly different objectives for the parties' participation in the first place.

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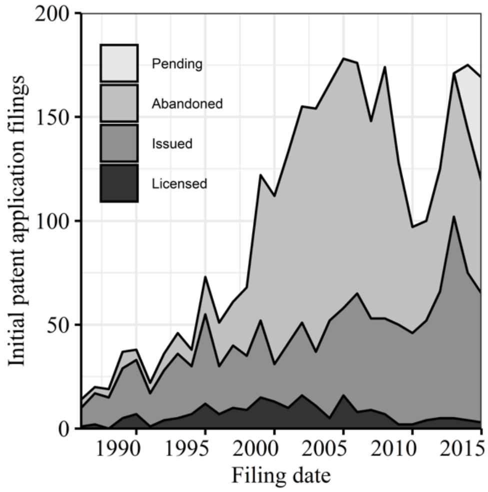

Figure 1. Outcomes for PRU patent applications.

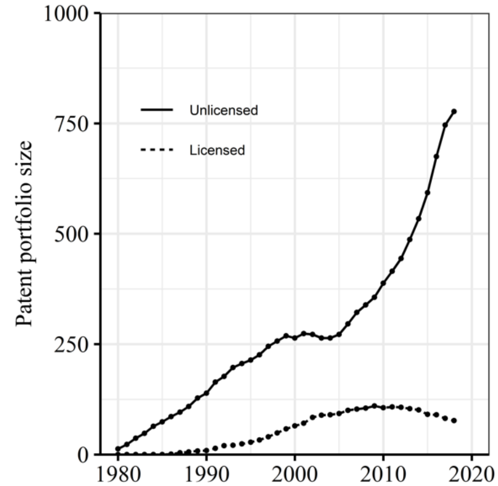

Figure 2. Volume of licensed and unlicensed patents over time.

Table 1. Summary Statistics

Variable	Definition	Mean	S.D.	Min	Max
Year	Year of observation	2002	8.33	1985	2015
Years for inventor	Number of years inventor is active as an academic	21.89	8.68	1.00	31.00
Filed?	Indicates whether a patent application was filed	0.09	0.29	0.00	1.00
Issued?	Indicates whether a subsequently-issued patent was filed	0.04	0.21	0.00	1.00
Licensed?	Indicates whether a subsequently-licensed patent was filed	0.01	0.09	0.00	1.00
Lifetime Revenue	Total revenue ($M) from patents filed this year	6.22	309.56	0.00	22,511.83
Career Length	Years since first application filing or paper publication	16.37	11.46	1.00	55.00
Prior License?	Indicates whether inventor previously licensed a patent	0.12	0.33	0.00	1.00
Publications	Standardized logged JIF-weighted count of publications	0.00	1.00	-3.25	3.03
Observations		49,231			

The sample includes all active academics at the institution who file at least one patent application. Observations are at the inventor-year level, for each year the inventor is active as an academic.

Table 2. Predictors of patent application filing (inventor-year level of analysis).

	OLS			Logit		
	(1)	(2)	(3)	(4)	(5)	(6)
Publications	0.034		0.024	0.455		0.340
	(0.002)		(0.002)	(0.023)		(0.024)
Has Licensed		0.058	0.035		0.530	0.238
		(0.004)	(0.004)		(0.041)	(0.050)
Publications * Has Licensed			0.062			0.504
			(0.004)			(0.046)
Career length	−0.003	−0.001	−0.003	−0.041	−0.012	−0.040
	(0.0002)	(0.0001)	(0.0002)	(0.002)	(0.002)	(0.002)
Career length squared	0.00005	−0.00000	0.00003	0.001	−0.00001	0.001
	(0.00001)	(0.00001)	(0.00001)	(0.0001)	(0.0001)	(0.0001)
Constant				−3.495	−3.353	−3.483
				(0.200)	(0.200)	(0.200)
Observations	49,231	49,231	49,231	49,231	49,231	49,231
Adjusted R^2	0.024	0.020	0.032			

All models include year fixed effects. Career length counts years since first patent application filing or paper publication. Two-tailed tests in parentheses.

Table 3. Outcome regressions (inventor-application level of analysis, OLS).

	Issued		Licensed		Revenue		Citations	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Publications	−0.025	−0.024	−0.002	0.006	−0.002	0.026	−0.116	−0.056
	(0.009)	(0.010)	(0.004)	(0.005)	(0.020)	(0.022)	(0.031)	(0.034)
Has Licensed	0.017	0.020	0.022	0.041	0.090	0.155	0.123	0.255
	(0.016)	(0.019)	(0.008)	(0.010)	(0.037)	(0.043)	(0.058)	(0.067)
Pubs * Licensed		−0.005		−0.027		−0.095		−0.197
		(0.014)		(0.007)		(0.033)		(0.051)
Career length	0.001	0.001	−0.0004	−0.001	−0.002	−0.003	−0.0001	−0.003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
Career length sq.	−0.00002	−0.00002	0.00001	0.00003	0.00005	0.0001	0.00004	0.0003
	(0.00004)	(0.00005)	(0.00002)	(0.00002)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Observations	5,922	5,922	5,922	5,922	5,922	5,922	2,570	2,570
R^2	0.091	0.091	0.039	0.041	0.043	0.045	0.302	0.307
Adjusted R^2	0.085	0.085	0.033	0.035	0.038	0.039	0.293	0.297

All models include year fixed effects. Forward citations are logged. Column 4 is conditional on patent application issuance. Career length counts years since first patent application filing or paper publication. Two-tailed tests in parentheses.

Table 4. Predictors of second renewal fee payment (inventor-application level of analysis).

	OLS		Logistic	
	(1)	(2)	(3)	(4)
Publications	0.045	0.056	0.259	0.288
	(0.015)	(0.015)	(0.083)	(0.076)
Has Licensed	−0.074	−0.054	−0.493	−0.280
	(0.029)	(0.029)	(0.172)	(0.160)
Career length	−0.004	−0.006	−0.021	−0.028
	(0.002)	(0.002)	(0.010)	(0.009)
Career length squared	0.0003	0.0003	0.002	0.002
	(0.0001)	(0.0001)	(0.001)	(0.0005)
Forward citations	0.088	0.088	0.510	0.482
	(0.009)	(0.009)	(0.055)	(0.052)
Filing Year		0.023		0.118
		(0.002)		(0.010)
Constant		0.711	−0.304	1.017
		(0.014)	(0.392)	(0.077)
Year FE	*Y*	*N*	*Y*	*N*
Observations	1,663	1,663	1,663	1,663
Adjusted R^2	0.155	0.114		

All models are conditional on the patent application being issued at least eight years prior to the end of our sample period but not being licensed. Career length counts years since first patent application filing or paper publication. Forward citations are logged and demeaned. Two-tailed tests in parentheses.