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, and 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 an outsized academic stars role: 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; academic stars.

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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). This 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, university technology licensing and commercialization efforts are particularly important.[1] Moreover, some studies have suggested that universities are disproportionately responsible for *breakthrough* commercial technologies (Colyvas, et al. 2002). Although some studies have examined the university technology commercialization process (e.g., Rosenberg and Nelson, 1994; Mowery et al., 2004; Etzkowitz & Zhou, 2017), scholars often 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.[2]

In this study we focus on the technology transfer office (TTO) managers who must make judgments 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

[1] 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).
[2] 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.

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, requiring TTO managers to decide not only whether to file a patent application, but also whether to continue to invest in its prosecution and post-grant renewal. Such investment entails foregone opportunity costs of other activities which could also help fulfill the TTO's mission.[3]

To better understand university technology commercialization, we examine the resource-allocation decisions of one TTO, "PRU" (prominent research university), over a 30-year period. This new dataset includes both patenting decisions and commercial outcomes (including patents *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 academic prominence (but not commercialization experience) predicts patent application filing, while commercialization experience (but not academic prominence) predicts patent impact and commercialization success. Although our results support various explanations, they suggest that academic stars may play an outsized role 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

[3] 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." 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."

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 (Atkinsion & Blanpied, 2008).[4] This change, along with the 1980 Patent and Trademark Amendments (Public Law 96-517, 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 the universities conducting the research (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 sometimes clashing with commercial interests.[5] For example, universities often exhibit close ties with industry (Mowery, et

[4] 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 that such efforts should also be funded during peacetime, and pushed for the formation of the National Science Foundation (which was established in 1950). See Gross & Sampat (2020) for more detail about the OSRD and its long-run effects.

[5] For example, Harvard's "oncomouse" (a genetically engineered mouse for cancer studies) patent was exclusively licensed to DuPont in 1984, which imposed commercial norms (such as corporate review prior to scientific publication) that led to conflict with academic researchers (Murray, 2010). During this period, academic norms were challenged but slowly became more accepting of commercial science (Merton, 1968; Stuart & Ding, 2006).

al., 2004) and often serve local economic interests (Rosenberg & Nelson, 1994), leading to a "triple-helix" among universities, governments, and industry (Etzkowitz & Zhou, 2017).

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 apart from two exploratory studies, the literature on university TTOs has paid little attention to other aspects of internal organizational decision making (Bercovitz, et al., 2001; Siegel, Waldman & Link, 2003). 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 university actors 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 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 and 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.

3. DATA

3.1 Institutional context of PRU's patent data. One of our key data sources is from internal invention disclosure and patenting data from a prominent research university's (PRU's) TTO. In this section, we give institutional context of the organization, taking care not to be too specific on certain dimensions in order to avoid compromising the organization's identity (at the request of its senior officers). In addition to gaining access to this TTO's archival data, we conducted post-hoc interviews with all of the senior officers of the organization (including the chief executive), several of whom have worked for PRU's TTO for over 20 years.[6]

PRU's TTO is among the most-established in the US and enjoys a resource-munificent environment. One consequence of not being as resource constrained is that PRU's TTO gives their IP managers wide latitude to devote resources as they see fit. Another consequence is that the TTO

[6] We thank an anonymous reviewer for encouraging us to do this. We incorporate insights from those interviews in our discussion of the possible mechanisms for our main results in Section 4.3

officers feel that they have the ability to "take fliers" on technologies which they believe to have substantial upside, whether because of a large addressable market, or because of the potential for being a technological game changer. Nevertheless, each patent application represents a significant commitment of resources since the TTO (not the academic) pays for application preparation, examination, and patent renewal. This TTO in the recent past moved forward with patenting for about half of their invention disclosures (down from about 70% a decade ago) through a consultative process with approximately two dozen internal and external experts to assess potential patentability and commercial interest. More generally, our informants told us that each resource decision from patent filing to renewal is "considered" rather than "rubber stamped."[7]

3.2 Data sources. With that brief overview, we now discuss our data more generally, which stem from several sources: (1) internal invention disclosure, patenting, and licensing data from PRU's TTO, as just discussed; (2) the publicly available Microsoft Academic Graph (MAG) covering academic publications; 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 invention disclosures submitted to and patent applications filed by the TTO at the PRU over a 30-year period (starting in 1985), as well as the names of the inventors. 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 invention disclosures as well as pending and abandoned patent applications, they provide a unique perspective on PRU patenting activity. Importantly, the PRU

[7] Much like other TTOs, this one devotes effort to educating academics across its university about the patenting and commercialization process. The TTO pays the fees associated with the due diligence and patenting processes (and if necessary, litigation and patent enforcement). Licensees pay upfront fees, together with milestone and royalty fees, and revenues are split between the TTO, the inventor's school/department, and the inventor herself.

data also include technology and transaction-level licensing information such as whether a patent application was licensed and its lifetime licensing revenue. The commercialization information is particularly noteworthy as it is rare to observe prices in the market for technology, and especially in a way which is not severely selected (e.g., patents which are the subject of litigation).

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, and authors for more than 160 million academic publications published since 1800. 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, and inventors.

3.3 Sample selection. Our sample period extends to disclosures submitted from 1985 to 2015 due to data availability. We start by identifying a total of 8,846 patent disclosures submitted during this period. We uniquely identify all 6,183 inventors who are listed on any of these patent applications and who are affiliated with PRU in the MAG data. We then parse the PRU records 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. Accordingly, limiting our analysis to the initial patent application for each patent family[8] and each license is a conservative approach that helps to avoid double counting decisions and outcomes.

[8] 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." 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,

3.4 Variable definitions and summary statistics. Table 1 provides summary statistics for the invention disclosure data sample. Pairwise correlations between variables suggest that multicollinearity is not a problem for any of the regression models. 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. We first weight each publication by its journal impact factor (JIF), following Azoulay, Graff Zivin & Wang (2010). To account for career length, we then run an OLS regression predicting each inventor's JIF-weighted publication count in a calendar year (P_{iy}) as a function of years since the inventor's first academic publication (C_{iy}), controlling for calendar year (Y). An inventor's year-specific *Publications* count is then determined by ranking from zero to one all inventors in a calendar year by the regression residual—the difference between an inventor's actual and predicted JIF-weighted publication count.[9]

$$P_{iy} = C_{iy} + C_{iy}^2 + Y, \qquad Publications_{iy} = rank_y\left(P_{iy} - \widehat{P_{iy}}\right)$$

We designate the inventor having the highest raw JIF-weighted publication count as the lead inventor for a given patent disclosure. To measure inventors' commercial experience, *Prior License?* identifies whether the inventor was listed on a patent licensed in the past – 16% of disclosures were submitted by inventors with previous licensing. We also count the inventor's prior patent applications and patents. We label an inventor in the top decile as a "star" academic, although our results are robust to other thresholds.

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

[9] Many prior measures of academic prominence rely on context-specific, detailed data (e.g., Zucker and Darby, 1996; Azoulay et al., 2010) . Our measure, although admittedly more coarse, is both calculable and interpretable for scientists drawn from a range of fields across a 30 year time period. However, due to limitations in the data, our measure does not correct for any field-level differences in JIF-weighted publication counts.

Is filed, *Is issued*, and *Is licensed* indicate whether the invention disclosure led to a patent application, issued patent, or license agreement. We find that about 30% of invention disclosures led to at least one patent, 14% led to at least one issued patent, and 2% led to at least one license. Finally, we determine whether all of the renewal fees were paid for each eligible issued patent (*Renewed*), and count the forward patent citations received by each issued patent (*Citations*).

4. EMPIRICAL RESULTS

4.1 TTO resources devoted to academic stars. Table 2 presents the results of regression models of patent application filing and issuance at the invention disclosure and patent application levels to evaluate the academic prominence and commercial experience variables. All models include year fixed effects. Columns 1-4 suggest that the PRU TTO is more likely to file patent applications as an inventor's academic prominence increases – an invention disclosure by an academic star is 7.4 percentage points ($p<0.001$) more likely to be filed in column 1. In column 2, a 10 percentage point increase in *Publications* is associated with a 0.93 percentage point ($p<0.001$) increase in the probability of filing. However, across all models, prior commercialization experience is not positively linked with patent application filing.

---- Insert Tables 1-3 here ----

Columns 5-8 suggest that patent applications by prominent academics are less likely to be granted. In column 4, a patent application filed by a star academic is 5.5 percentage points ($p<0.05$) less likely to issue than a patent application filed by a non-star. We find no evidence that prior commercialization experience is linked with patent application issuance.

Collectively these results suggest a puzzle. If academic prominence negatively predicts patent application issuance, then why does it strongly predict patent application filing? Further, why should past licensing experience not be linked to future patent application filings? To investigate these issues, we now examine indications of the significance and commercial performance of the issued patents that result from the process.

4.2 Commercial outcomes associated with academic star patents. One explanation for the above results is that academic prominence may positively predict the performance of granted patents while commercialization experience may not. That is, whether an idea is patentable may be unclear at the outset, but patents on ideas submitted by prominent academics may prove to be more impactful if granted, on average, than patents by less prominent academics. To test this possibility, Table 3 presents the results of regression models of various indicators of patent impact. All models include year fixed effects.

In columns 1 and 3, we find that patents by academic stars are no more likely to be licensed and generate no more revenue, on average, than patents by other academics. Similarly, in column 2, academic prominence predicts neither the presence of a licensing agreement for a granted patent nor the lifetime revenue accrued by that patent. Patents by academic stars fare even worse when considering outcomes the literature has related to economic value. In column 5, we find that patents by stars are 10.6 percentage points ($p<0.10$) less likely to be renewed than patents by other academics. In column 6, a 10 percentage point increase in *Publications* is associated with a 2.3 percentage point decrease ($p<0.01$) in the probability that a patent is renewed to its full term.[10] Patents by academic stars also receive 17.8 percent ($p<0.05$) fewer citations than patents by other academics, with a 10 percentage point increase in *Publications* corresponding to a 2.3 percent ($p<0.05$) decrease in citations received.

Although academic prominence is associated with more negative outcomes overall, the reverse is true for commercialization experience. In columns 1 and 3, a patent by an inventor who

[10] In unreported results, we find a similar outcome if we confine our attention just to the second renewal fee, which is a particularly consequential one.

has previously licensed a different patent is 15.2 percentage points ($p<0.001$) more likely to be licensed and generates 158 percent ($p<0.001$) more revenue on average than a patent by an inventor without such experience. In columns 5 and 7, we find that patents by lead inventors who have licensed other patents in the past are also 21 percentage points ($p<0.001$) more likely to be renewed to full term and receive 25.2 percent ($p<0.001$) more citations than patents by other inventors.

Collectively these results suggest that academic prominence is not only a negative predictor of application issuance, but also a poor predictor of the commercial success of an issued patent and a negative predictor of the patent's private value and impact. Conversely, while prior licensing experience does not predict patent application filing, it strongly predicts the probability a granted patent will be licensed and renewed, as well as its expected licensing revenue and citations.[11]

4.3 Possible mechanisms. We discuss two possible mechanisms in this section for the main empirical relationship documented above, that academic stars seem to receive more resources, yet are less successful commercially. First, it could be the case that inventions from academic stars are substantively different. For instance, they may have a longer gestation period before being ripe for commercialization, perhaps by virtue of relating to different types of technology than patents by other inventors. Alternatively, they may have a higher variance of commercial outcomes (which may be perhaps more important in the TTO context since a small number of inventions are typically disproportionately responsible for the lion's share of overall commercial returns). As still another possibility, academic stars may be more inclined to submit invention disclosures to the TTO, even when they are of relatively low quality. Second, it could be the case that academic stars are important symbolically or politically for the TTO, even if their inventions are not more commercially valuable as compared to inventions by non-stars. We discuss each explanation in

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[11] We find no systematic interactions between academic prominence and prior commercialization experience.

turn using both quantitative information (based on archival data) and qualitative insights we garnered via our interviews with the senior executive officer team at PRU's TTO.

Regarding the finding that commercialization experience is associated with an increased likelihood of future licenses, we note that inventors with commercialization experience may be better at identifying interested licensees. Subsequent inventions and licenses may also build cumulatively upon earlier licenses. Finally, successful commercializers may experience a "publicity effect" that could draw the interest of potential licensees for future patents (e.g., Lanjouw & Schankerman, 2001; Sampat & Ziedonis, 2004). Regardless, we find it surprising that a proven track record of commercialization does not increase the rate of patent application filing.

Differences in licensing outcomes may also reflect differences not only in means, but also variance. Azoulay, Graff Zivin, and Manso (2011) argue that scientists working at the frontier pursue more risky research leading to both more breakthroughs and more failures, while Ziedonis (2007) found that licensees of university technology were more likely to license technologies exhibiting greater uncertainty under an option contract. To compare the variance of commercialization outcomes as it relates to academic prominence, Figure 1 plots the density of lifetime revenue for PRU patents for both star scientists and other academics. Across the distribution, patents by non-star scientists are associated with somewhat less revenue, although as noted with respect to Table 3 the difference is not statistically significant.

---- Insert Figures 1 and 2 here ----

To compare variance in commercialization timing, Figure 2 plots the density of time in years from patent application filing to license execution date for both star scientists and other academics. Licenses to patents by star scientists are executed longer after patent application filing, on average, compared to licenses to patents by other scientists. However, this difference may be due not to intrinsic characteristics of the underlying technology but rather to a selection effect. For example, a less prominent scientist may exert more effort to identifying a commercialization opportunity before approaching the TTO, and/or PRU TTO officers may be more inclined to demand evidence of commercial potential for patent disclosures submitted by less prominent academics.

We are unable to conclusively evaluate whether prominent academics conduct research in markedly different areas of technology than less prominent academics.[12] However, in unreported results (available upon request), we find that the effects we observe are robust to including fixed effects for internal PRU classification categories or for USPC patent main classes.

In a university setting, scientists tend to initiate interactions with TTOs, and an academic's prestige may influence both the costs and benefits of disclosure (Owen-Smith & Powell, 2001). However, we are unable to empirically evaluate whether academic stars are more inclined than other academics to approach the TTO. To bolster our empirical analysis, we briefed the executive team with our findings and asked them for the most likely explanations. As background, they noted that star principal investigators typically have the most resources because publishing success typically breeds more success in securing research grants for R&D. In turn, these resources attract and can fund more experiments and more post-doctoral fellows to conduct research, in keeping with the findings of Owen-Smith & Powell (2001). This results in more developed technology, which perhaps could be of more interest to industry licensees. Academic stars may also have a track record with industry or have links with industry. Having said this, our informants suggested that typical inventors at PRU are unfamiliar with the market and are simply optimizing their efforts to succeed in the federal government grant-making process for research and development.

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[12] Due to data limitations, we lack a comprehensive measure of technology – information on patent class is available only for published patent applications and granted patents, while internal PRU records omit technological classification for many records. Also, technological classifications are necessarily coarse and therefore fail to capture the full range of technological heterogeneity.

One explanation for the main empirical finding is that non-stars are treated differently than stars at the front-end of the commercialization process in areas such as due diligence. Our informants told us that most of the technology generated at PRU is quite embryonic (a characterization consistent with the academic literature's portrayal of many university technologies), thus limiting their ability to conduct due diligence in the first place, however.[13] For this reason, in contrast to prior studies which found that TTOs often seek out a license before investing in a patent (e.g., Mowery et al., 2004), our PRU informants disavowed any such requirements. Moreover, one of our PRU informants noted that: "[The licensing officers] treat all inventors the same, regardless of prior licensing experience." On the other hand, however, there is a possibility of unconscious behavior with regard to academic star treatment, especially given the institutional context of capturing political or symbolic capital associated with academic star affiliation (who hold the currency traditionally valued in an academic environment). This explanation is particularly salient given the fact that one informant told us that she spends considerable time educating academics at PRU about the TTO efforts and the patenting and commercialization process more generally. One could imagine that this educational process could very well be eased by referencing academic stars who have engaged with the TTO and who are known by audience scientific staff.

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

[13] This, coupled with PRU's TTO unique policy of rendering a patenting decision in relatively short order following an invention disclosure, we are somewhat skeptical that most firm commitments from industry could take place in this narrow time window. Note that this may be a different process relative to the Stanford, Columbia, and University of California TTOs, as described by Mowery, et al. (2004) in that the patenting decision in these institutions have been characterized to depend, at least in part, on ex ante commitments made by licensees. Our PRU informants told us that common reasons to not go forward on a patent application include patentability concerns or if there is a general sense in which it may not be worth the investments.

role in the U.S. innovation ecosystem. We investigate the organizational process resulting in technologies available for licensing and commercialization 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.

Our findings may in part reflect a distinction between science and technology. Although scientific and technology developments co-evolve, they nevertheless involve distinct but overlapping networks (Murray, 2002). Moreover, academic and commercialization success are often in tension, and individuals who succeed at one may be less likely to succeed at the other (Gittelman, 2007). However, 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 patentees. 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.

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, particularly as they pertain to possibly divergent objectives of key stakeholders (Bercovitz & Feldman, 2006; Siegel et al., 2003),[14] an issue that has thus far not received much attention in the literature despite the increasing prevalence of dual-mission organization (e.g., social and/or environmental responsibility at the same time as commercial returns). 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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[14] 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 should take into account possibly different objectives for the parties' participation in the first place.

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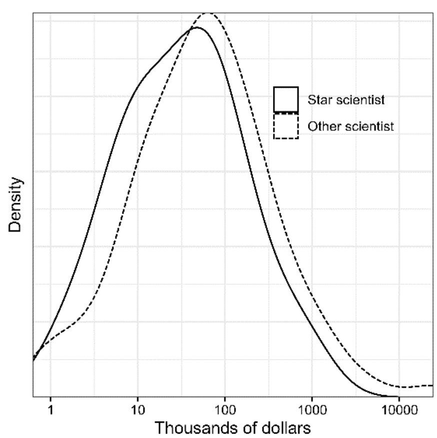

Figure 1. Density of lifetime licensing revenue for PRU patents

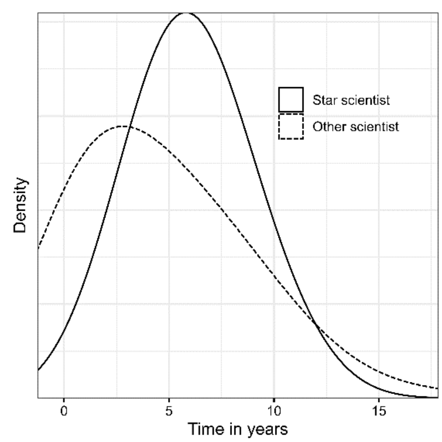

Figure 2. Density of time between patent filing and license execution

Table 1. Summary Statistics

	Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1	Publications	0.52	0.31	1.00									
2	Career length	12.61	8.41	-0.07	1.00								
3	Has licensed	0.16	0.37	0.10	0.33	1.00							
4	Prior applications	7.97	23.03	-0.14	0.30	0.25	1.00						
5	Prior patents	4.74	16.22	-0.17	0.28	0.18	0.98	1.00					
6	Citations	4.73	12.47	0.01	0.05	0.19	-0.04	-0.04	1.00				
7	Renewed	0.40	0.49	-0.11	0.11	0.12	0.00	0.00	0.18	1.00			
8	Is licensed	0.02	0.12	0.00	0.01	0.00	-0.01	-0.01	0.07	0.35	1.00		
9	Lifetime revenue	5.46	268.45	0.01	0.00	-0.01	0.00	0.00	-0.01	0.07	0.16	1.00	
10	Is filed	0.30	0.46	0.04	-0.01	0.01	0.02	0.02			0.19	0.03	1.00
11	Is issued	0.14	0.35	0.01	0.03	0.02	0.02	0.02			0.27	0.05	0.61
12	Observations	8,846											

Table 2. Predictors of patent application filing and issuance.

	Application filing				Application issuance			
	OLS		*logistic*		*OLS*		*logistic*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Is star	0.074		0.358		−0.055		−0.256	
	(0.014)		(0.068)		(0.026)		(0.119)	
Publications		0.093		0.471		−0.083		−0.382
		(0.015)		(0.078)		(0.030)		(0.138)
Has licensed	−0.005	−0.012	−0.021	−0.059	0.005	0.012	0.017	0.048
	(0.015)	(0.015)	(0.076)	(0.077)	(0.028)	(0.028)	(0.125)	(0.126)
Prior applications	0.060	0.060	0.302	0.300	0.011	0.013	0.054	0.061
	(0.010)	(0.010)	(0.051)	(0.051)	(0.026)	(0.026)	(0.118)	(0.118)
Prior patents	−0.043	−0.040	−0.218	−0.202	0.025	0.021	0.113	0.096
	(0.011)	(0.011)	(0.055)	(0.055)	(0.022)	(0.022)	(0.102)	(0.102)
Career length	0.0001	0.001	0.001	0.007	−0.001	−0.002	−0.003	−0.008
	(0.001)	(0.001)	(0.004)	(0.004)	(0.002)	(0.001)	(0.007)	(0.007)
Constant	0.641	0.598	0.568	0.347	0.389	0.425	−0.497	−0.333
	(0.060)	(0.061)	(0.296)	(0.299)	(0.133)	(0.134)	(0.576)	(0.578)
Observations	8,846	8,846	8,846	8,846	2,618	2,618	2,618	2,618
R^2	0.074	0.075			0.126	0.127		
Adjusted R^2	0.070	0.071			0.114	0.115		
Log Likelihood			−5,123.756	−5,119.307			−1,627.320	−1,625.844

The unit of analysis is the invention disclosure for models 1-4 and the patent application for models 5-8. All models include year fixed effects. *Prior applications* and *Prior patents* are zero-inflated and logged. Standard errors in parentheses.

Table 3. Predictors of post-grant outcomes for issued patents.

	Is Licensed		Lifetime revenue		Renewed		Citations	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Is star	−0.028		−0.273		−0.106		−0.177	
	(0.025)		(0.272)		(0.063)		(0.089)	
Publications		−0.038		−0.406		−0.228		−0.233
		(0.029)		(0.306)		(0.068)		(0.101)
Has licensed	0.152	0.154	1.583	1.606	0.210	0.219	0.245	0.252
	(0.023)	(0.023)	(0.244)	(0.245)	(0.058)	(0.058)	(0.080)	(0.080)
Prior applications	0.033	0.034	0.438	0.447	0.057	0.067	−0.011	−0.001
	(0.026)	(0.026)	(0.282)	(0.282)	(0.064)	(0.063)	(0.096)	(0.096)
Prior patents	−0.080	−0.082	−0.983	−1.016	−0.053	−0.075	0.053	0.029
	(0.028)	(0.028)	(0.296)	(0.298)	(0.068)	(0.068)	(0.101)	(0.102)
Career length	0.002	0.001	0.019	0.015	−0.003	−0.006	−0.011	−0.014
	(0.001)	(0.001)	(0.014)	(0.014)	(0.004)	(0.004)	(0.005)	(0.005)
Constant	0.050	0.071	0.575	0.794	0.341	0.462	0.041	0.169
	(0.165)	(0.166)	(1.775)	(1.780)	(0.274)	(0.274)	(0.487)	(0.489)
Observations	1,132	1,132	1,132	1,132	592	592	814	814
R^2	0.097	0.097	0.104	0.105	0.125	0.138	0.505	0.506
Adjusted R^2	0.067	0.068	0.075	0.075	0.082	0.095	0.484	0.485

The unit of analysis is the invention disclosure for models 1-4 and the patent application for models 5-8. All models include year fixed effects. *Lifetime revenue*, *Citations*, *Prior applications*, and *Prior patents* are zero-inflated and logged. Standard errors in parentheses.