# STANDING YOUR GROUND: EXAMINING THE SIGNALING EFFECTS OF PATENT LITIGATION IN UNIVERSITY TECHNOLOGY LICENSING

# Abstract

The licensing of university technologies to private firms has become an important part of the technology transfer mission of many universities. An inherent challenge for the technology licensing of universities is that potential licensees find it difficult to judge the early stage technologies and their ultimate commercial value. We reason that patent litigation against universities can have unintended signaling effects about the commercial value of its technologies and results in increased licensing income for the university. We ground this hypothesis in theory integrating signaling mechanisms from patent enforcement research into theoretical models explaining university technology licensing. Within our logic, the public and costly nature of patent litigation against universities creates strong, credible signals to potential licensees about the technologies of a university even if the signal was not created for that specific purpose. We isolate the signaling mechanism that is central to our theorizing by exploring two moderation factors that reveal additional information to potential licensees, i.e. the licensing track-record of the university and whether the lawsuit involves private firms as co-defendants. We test our theory with a unique dataset of 157 US universities and the 1,408 patent infringement cases in which they were involved as defendants over the period 2005-2016. Results show that defending against claims of patent infringement enhances technology licensing revenues, particularly when universities are already adept at licensing technology and when they are co-defendants with private firms.

Keywords: Commercialization, University Technology Transfer, Licensing, Signaling Theory, Patent Litigation

# INTRODUCTION

Universities are major producers of patented technologies and the commercialization of their patents is a growing source of income (Grimaldi et al., 2011; Hsu et al., 2021). However, a university’s capacity for generating licensing income is limited since it is difficult for potential licensees to gain reliable information and effectively estimate the quality and commercialization potential of university patents before signing a licensing agreement (Hsu et al., 2021; Macho-Stadler et al., 2007; Siegel et al., 2007). The consensus of existing research is that universities overcome this information problem through larger Technology Transfer Offices (TTOs), their licensing performance and research intensity (Hewitt-Dundas, 2012; Marco-Stadler et al., 2007; Sine et al., 2003; Thursby and Kemp, 2002). Within the licensing context, patent litigation is considered to be mostly a distraction for TTOs (Shane and Somaya, 2007). This assumption is at odds with theory about patent strategy in which patent litigation is not merely a legal exchange but reveals important information about the commercial value of patents to investors, competitors and the broader public (Agarwal et al., 2009; Choi, 1998; Kafouros et al., 2021; Kiebzak et al., 2016). The disconnect in existing theory about the effect of patent litigation on university licensing income is consequential because universities may systematically avoid patent litigation as defendants and enter unfavorable pre-litigation agreements with potential plaintiffs because of concerns about how litigation will affect their overall licensing income.

In this study, we want to shift the consensus of existing research by investigating the impact of universities becoming defendants in patent litigation on their licensing income. To address this research question, we integrate theoretical mechanisms from signaling theory (Connelly et al., 2011; Spence, 2002) in general and patent litigation in particular (Somaya, 2012) into models explaining the licensing income of universities (Sengupta and Ray, 2017; Siegel et al., 2003). We predict that the licensing income of universities is higher when they are defendants in patent litigations because the latter produces an unintended signal about the commercial value of the university’s patents. This signal can overcome the information asymmetry between a university and potential licensees, which cannot directly observe the commercial value of university technologies. We reason that this signaling effect is strong since (a) patent litigation is costly, (b) observable to other firms interested in the technological field as well as (c) has a strong fit with the unobserved quality of a university producing technology with commercial value. Further, we theorize that the signaling effect for universities as defendants in patent litigation has boundary conditions based on the scale of the university’s licensing activities and scope of the patent litigation in which they are defendants, i.e. whether the university has private firms as co-defendants which already use the technology.

Our integrated theoretical logic builds on studies that have started to explore issues related to patent litigation in the context of university technology licensing (Shane and Somaya, 2007), connecting research on university technology transfer with research on patent enforcement strategy. On the one hand, university patenting as a prerequisite for licensing technologies and generating royalty income is largely acknowledged as a priority for universities (Perkmann et al., 2013a; Thursby et al., 2001). Naturally, this exposes universities to the management of their patent rights (Feller and Feldman, 2010) including defending them in litigation (Shane and Somaya, 2007). However, the broader consequences that patent litigation cases have for the perception of a university’s overall technological capabilities within a broader community of potential licensees is not well understood. On the other hand, research on patent strategy of firms delineates how patent litigation is not just a legal act concerning the infringement of a specific technology but has symbolic meaning, shaping a firm’s reputation (Agarwal et al., 2009) or attractiveness for investors (Kiebzak et al., 2016). Hence, a theory incorporating the signaling effects of universities defending their patents in court provides a more comprehensive understanding of factors determining the licensing income of universities.

We test our theoretical predictions by using a unique dataset combining both university participation in patent litigation and technology licensing performance in the US. Our data consists of 1,408 university-year observations that include 157 unique US universities over the period 2005-2016. We rely on a combination of entropy balancing and university-fixed effect panel regressions for conducting the empirical tests. The results of our modelling provide support for all hypotheses. The licensing income for universities increases with the number of patent litigations that they defend in court and this effect is stronger for universities with more licensing experience and when the patent litigation involves private firms which are already using the technology.

Thus, our study makes two main contributions to academic research. First, we extend the scope of existing theory explaining how universities can provide information to prospective licensees effectively and increase their potential for generating new licensing income (Hsu et al., 2021; Macho-Stadler et al., 2007; Siegel et al., 2007). Within our logic, valuable information is not just created by universities themselves but also by third parties incurring substantial costs by filing for patent litigation. While the resulting signal is unintended, potential licensees can infer from the signal that the university develops technologies with substantial commercial value. Hence, our theoretical reasoning provides a more comprehensive understanding about (a) the sources of information that potential licensees take into account and (b) defending patent litigation, that does not necessarily send negative signals to them. This theoretical model can be extended to other unintended signaling effects, e.g. university scientists being hired by high-technology firms because of the usefulness of their research outside of academia.

Second, unintended signals are an understudied topic of signaling theory (Connelly et al., 2011). This is due to the fact that many organizations are unaware of the multitude of signals that they are sending through a variety of actions which can be interpreted heterogeneously (Spence, 2002). These unintended signaling effects should also enter theory on patent strategy and patent litigation (Somaya, 2012). We show how plaintiffs in patent litigation might actually improve the perception of the commercial value of university technologies instead of having a punitive effect. This insight has wider theoretical implications for the strategic considerations of patent litigation because plaintiffs might have increased incentives to settle cases with universities before they file a patent lawsuit given the positive signaling effect for universities as defendants.

# Theory and Hypotheses

## University patenting and its importance for university income

Following legislative developments that encouraged the assignment of patent rights to academic institutions, such as the Bayh-Dole act, a dramatic increase in university patenting activity has been observed (Grimaldi et al., 2011; Martin, 2012). Patenting lies at the core of university commercialization efforts (Perkmann et al., 2013a) which focus on the commercial exploitation of university-owned intellectual property (IP). Commercialization typically unfolds either through the establishment of a spin-off firm (i.e. academic entrepreneurship) or through licensing agreements with non-academic organizations. A core objective of commercialization, for both academic entrepreneurship and licensing, is the generation of revenues for the university, either through sales of shares in spin-off firms or through royalties from licensing agreements (Perkmann et al., 2013a; Thursby et al., 2001).

Despite increased levels of patenting across all types of universities, the efficiency of commercialization efforts across institutions varies significantly (Chapple et al., 2005a; Siegel and Wright, 2015a; Wright et al., 2008). It is increasingly acknowledged that not all universities may be able to productively engage in technology commercialization (Siegel and Wright, 2015b), yet commercialization remains an important priority for university administrators (Horner et al., 2019; Lockett et al., 2015; Siegel and Wright, 2015b). This is largely due to competitive and financial pressures facing universities and the perceived complementarities to the wider research mission of universities (Larsen, 2011; Siegel and Wright, 2015b).

## The challenge of attracting licensees for university patents

Despite the increasing importance of commercialization to university administrators, and the development of complementary research and commercialization capabilities within universities, the licensing of university-generated IP remains a fraught affair (Feller and Feldman, 2010). In principle, universities are attractive licensing partners for firms (Hsu et al., 2021). Universities typically lack complementary capabilities required to commercialize their patents internally, despite the increasing prevalence of incubator and accelerator programs (Sengupta and Ray, 2017; Siegel and Wright, 2015b). However, the uncertainty about the commercial value of university patents presents a persistent problem for firms looking to universities as a source of technology (Bercovitz and Feldman, 2007; Cohen et al., 2002; Siegel et al., 2003).

Markets for IP are beset by uncertainty about its value and quality, and these issues are exacerbated by the ‘embryonic’ nature of university-generated technology, which is typically licensed at the proof-of-concept stage before commercial feasibility can be established (Thursby et al., 2001; Ziedonis, 2007). At these early stages, the commercial potential of university technologies is either impossible to predict or suffers from information asymmetries, i.e. the university as the seller has more information than the buyer (i.e. potential licensee) about the quality of the technology and the conditions under which it functions effectively (Hsu et al., 2021; Macho-Stadler et al., 2007; Ray and Sengupta, 2021; Siegel et al., 2007). Many buyers consider university patents merely as technological options for future products (Ziedonis, 2007) or expect that academic inventors remain involved (Feller and Feldman, 2010; Thursby et al., 2001). Even when firms identify promising university technologies negotiations about licensing fees can be contentious (Clarysse et al., 2007; Dowling, 2015) or firms prefer non-commercial forms of university-industry interaction (Perkmann et al., 2021, 2013b).

Often times, universities try to attract licensees by building a reputation for technology development with substantial commercial potential. Macho-Stadler et al (2007) develop a reputation argument, suggesting that once TTOs reach a critical size, they can be more selective in their commercialization activity which raises the quality expectations of licensees. This builds on earlier work by Sine et al (2003) who show that past licensing performance and scholarly reputation are used by firms to address information problems related to the quality of university technology. These reputation-based arguments are supported by research that demonstrates positive associations between the ‘quality’ of university research and licensing performance (Hewitt-Dundas, 2012; Thursby and Kemp, 2002). More recently, Ray and Sengupta (2021) focus on contexts in which it is difficult for industrial stakeholders to make quality assessments of university research, such as emerging and developing countries. Drawing on signaling theory, they suggest universities in these contexts may file patents to send signals about research quality and commercialization intentions to external commercial parties (Ray and Sengupta, 2021). It is also found that some university characteristics exhibit passive signaling effects, which influence firm engagement in other channels of knowledge exchange, such as sponsored research and academic consulting (Perkmann et al., 2011; Ray and Sengupta, 2021). Others have suggested that patenting activity by SMEs has a signaling effect, revealing information about technical and scientific capabilities of firms to potential university partners. This signaling activity increased the intensity of R&D collaboration between innovative SMEs and universities (Fontana et al., 2006)

In sum, uncertainties and information asymmetries about the commercial value of patented technologies constrain the licensing opportunities of universities. Extant research suggests that universities can mitigate the problem by providing more information to potential licensees, e.g. through large TTOs. We reason that an alternative mechanism for information revealing are instances in which universities have to defend against patent litigation. Such patent litigations can send signals about the commercial value of a university’s patents to a wider audience of potential licensees.

## Patent litigation and its signaling effects

Emerging out of efforts to capture the informational aspects of market structures, signaling theory focuses on how information asymmetries between two parties can be alleviated (Connelly et al., 2011; Spence, 2002). Under conditions of information asymmetry, where the underlying ‘quality’ of a target object (e.g. job candidate, firm, product, technology) remains unclear, transacting parties that have access to different information about underlying quality may engage in signaling behavior to reduce information asymmetries (Connelly et al., 2011; Spence, 2002). Quality typically refers to “the underlying, unobservable ability of a signaler to fulfil the needs or demands of an outsider observing the signal” (Connelly et al., 2011, p. 43). A signaler, who has access to private information that would enable outsiders to make more informed assessments of quality, can “take actions to intentionally communicate the positive, imperceptible qualities”.(Connelly et al., 2011).

Through engaging in signaling, insiders can reduce information asymmetries, enabling external parties to make more robust assessments of quality, thus lowering the transaction costs and risks associated with information asymmetries (e.g. moral hazard, adverse selection). Of course, some actors may engage in signaling behavior despite lacking underlying quality, in order to deceive external parties into making (incorrect) assessments (false signaling). However, when the cost of signaling itself is substantial, then the risks of false signaling are obviated, and signaling can be used to differentiate high-quality options from low-quality options (Spence, 1973).

Important for our theorizing is the notion that signals can be unintentional, i.e. actors are unaware about the information that their behavior or actions reveal (Spence, 2002). If signals are unintentional, the interpretation of receivers becomes salient, i.e. the way in which they turn the signal into a perceived meaning (Connelly et al., 2011; Grecu et al., 2022). The interpretation process has two major components (Branzei et al., 2004): (a) the signal needs to be strong enough to reach receivers and (b) receivers need to be able to infer meaning from it. Within our specific logic, we reason that universities becoming defendants in patent litigation creates unintended but strong signals for potential licensees as receivers who can infer meaning about the commercial value of university patents from it. We develop each step of this theoretical logic.

First, patent litigation creates unintended signals. The filing of a patent litigation case is a strategic decision that plaintiffs take when their initial amicable attempts to resolve and settle a patent infringement dispute with a defendant fail. When plaintiffs identify the potential infringement of their patent rights and decide to act against the infringer (defendant), they first attempt to engage in private negotiations to resolve the dispute with an out of court settlement such as a licensing agreement (Cremers, 2004). The event of a patent litigation being filed to a court is relatively rare, with most patent infringement disputes ending without litigation (Lanjouw and Schankerman, 2004; Somaya, 2012). However, when patent litigation is filed the costs are high, reaching between 3 to 5 million US$ for a case with average levels of complexity (Agarwal et al., 2009).

The distinctive feature separating plaintiffs and defendants in a litigation case is that the plaintiff is the active party. Plaintiffs choose to act and file a lawsuit in the expectation that the potential benefits from engaging in patent litigation are greater than the risks related to litigation (Kiebzak et al., 2016). However, while defendants do not trigger the filing of a patent litigation case, their actions and negotiating position in not settling the dispute in pre-litigation private negotiations with the plaintiff also demonstrates their confidence in that they can successfully defend their interests despite the high costs and significant disruptions of patent litigation which affect defendants in particular (Somaya, 2004). From the outset, direct financial costs such as the fees of attorneys are substantial, but pursing patent litigation also makes significant demands of managers in terms of their attentional resources, which can result in disruptions to organizational activity (Shane and Somaya, 2007; Somaya, 2004).

Second, the interpretation of unintended signals depends on their observability since only strong signals cross the cognitive filters for being recognized, processed and acted on by receivers (Ilmola and Kuusi, 2006). Patent litigation creates such strong signals for two reasons. First, patent litigation filings enter public records and detail the involved parties, the patents under consideration and the supposed infringements. Even if potential licensees do not inspect court documents directly, the information enters databases of specialized suppliers which are readily searchable. Second, the signaling strength is amplified by media coverage. Patent litigation cases are frequently reported by the media and observable for investors and other external stakeholders (Nam et al., 2015; Tan, 2016; Yang, 2019). Media coverage can be so substantial that lawyers encourage defendants to settle and avoid a patent litigation case in the first place (Tan, 2016).

Finally, receivers infer meaning from unintended signals based on the information that is available to them (Srivastava, 2001). Potential licensees cannot objectively observe the commercial value of a university’s patented technologies but patent litigation provides them with a signal that allows them to develop subjective perceptions. These perceptions are not created in isolation but rely on a collective belief system (Park and Mezias, 2005). Within our context, this refers to the collective belief system about the type of technology for which a plaintiff would litigate and a university would defend its rights against litigation. These decisions occur generally in situations in which patent rights confer substantial competitive advantages for example, when they enable firms to generate rents from co-specialized resources, or when they facilitate product development and follow-on innovation (Somaya, 2012, 2004, 2003). Hence, a potential licensee is likely to infer that the plaintiff has private information about the competitive value of a university’s patents that is important enough to incur the substantial costs of litigation (Cremers and Schliessler, 2015; Waldfogel, 1998). Potential licensees may therefore reasonably conclude that the substantial commercial value of a university’s patents is not limited to the technologies that are currently litigated but applies to the wider set of university technologies. These inferences would make universities defending against patent litigation more attractive licensing partners which should ultimately increase their licensing income.

Naturally, the positive signaling effects should be judged relative to the substantial administrative costs for universities defending against patent litigation. The limited existing research suggests that involvement in patent litigation has adverse effects on university technology licensing efforts, principally due to the high attentional costs, which limit the capacity of TTOs to develop new licensing agreements (Shane and Somaya, 2007). We formulate a testable hypothesis for the positive signaling effect of universities defending against patent litigation on their licensing income while being cognizant of the fact that the presence of substantial TTO attention tradeoffs reduces the odds of finding significant effects.

In sum, we conclude that universities becoming defendants in patent litigation sends unintended signals about the commercial value of their patents to potential licensees. The latter are likely to respond to the patent litigation signal because of the strength of the signal which is publicly observable and often times covered in the media. What is more, they can infer from the patent litigation signal that the university’s technology has substantial competitive importance for plaintiffs and the university to engage in a litigation instead of settling the dispute out of court. Hence, potential licensees are likely to perceive the technologies of those universities as having comparatively more commercial value and are worth licensing, Therefore, we hypothesize:

*Hypothesis 1: Controlling for prior licensing activity, the licensing income of universities increases with the number of patent litigation cases that they face as defendants.*

## Boundary conditions for the strength of the signaling effect from patent litigation

We establish boundary conditions for isolating the signaling mechanism which is at the heart of our theorizing. An important assumption in our theoretical reasoning is that potential licensees will interpret a university’s defending against patent litigation as a signal for the commercial value of its technologies. However, this inference may not apply for all types of universities and all types of patent litigations. We reason that the strength of the signaling effect depends on the consistency of the patent litigation signal with university and litigation attributes (Connelly et al., 2011; Gulati and Higgins, 2003). The consistency of a signal concerns the concordance of multiple signals from a single source, meaning that signaling behavior needs to be consistent with other signals that might be perceived by external parties (Connelly et al., 2011; Gao et al., 2008). We consider two types of consistency which tie directly with the commercial value of university patents, i.e. the licensing track-record of the university and the co-defendants of the university in the patent litigation case.

As indicated above, existing research concerned with university technology licensing shows that universities are heterogenous in terms of their capacity to engage in technology commercialization (Siegel and Wright, 2015b; Wright et al., 2008). This heterogeneity is reflected by empirical observations demonstrating that the distribution of commercialization activity is concentrated in a relatively small number of universities that are typically research intensive, have well-developed support infrastructure and prestigious reputations (Chapple et al., 2005b; Hughes and Kitson, 2012; Link and Siegel, 2005; Siegel et al., 2003; Siegel and Wright, 2015; Wright, 2014). Furthermore, evidence suggests that even amongst those universities that are engaged in technology licensing, revenues are largely derived from a small number of profitable licenses, with many universities amassing portfolios of non-preforming IP assets (Sengupta and Ray, 2017).

Given the heterogeneity of university commercialization activity, we suggest that the signaling value of defending patent infringement cases through litigation will be diminished for those universities that have a poor track-record of technology licensing. This contention is based on the consistency argument outlined above. Specifically, the regularity with which universities license technologies indicates the commercial value of university IP and the signaling behavior of defending patent litigation is *consistent* with this other indication of quality. Conversely, for those universities that do not regularly license their IP, the signal of defending patent infringement litigation is *inconsistent* with other indications of quality. In these scenarios, defending patent infringement charges may instead signal the inexperience of the university in technology commercialization. Thus, we hypothesize:

*Hypothesis 2: Controlling for prior licensing activity, the licensing income of universities increases with the number of patent litigation cases that they face as defendants, and this effect is stronger for universities licensing many of their patents.*

At the litigation level, some litigations may carry more signaling value when they are increasingly consistent with the perception of potential licensees that the university creates technology with high commercial value. More specifically, we focus on a situation in which plaintiffs sue multiple defendants, including a university, at the same time. Potential licensees can then infer information from the litigation not just about the university but also from the presence of private firms as co-defendants.

In the absence of co-defendants, potential licensees can have doubts about how they can interpret a patent litigation case against a university. As outlined above, establishing reliable perceptions of the commercial potential of university patents is particularly difficult, given the embryonic nature of such technology (Ziedonis, 2007). Furthermore, there is evidence to suggest that the patenting activity of universities is not always strategic and is partially driven by isomorphic pressures (Lockett et al., 2015), resulting in a situation in which universities develop large, but non-performing, patent portfolios (Sengupta and Ray, 2017). Typically, universities generate licensing revenues from a very small number of ‘blockbuster’ patents, whilst most of their patent portfolio remains unproductive (Chapple et al., 2005a; Sengupta and Ray, 2017). The skewed nature of university patent portfolios makes the role of university’s co-defendants in a patent lawsuit salient for its signaling effect to potential licenses.

Litigations involving both a university and private firms as co-defendants indicate that not just the plaintiff has substantial commercial interests in the university’s technologies but that other private firms are already using the technology in question. These co-defendants can increase the consistency of the litigation signal because they also had opportunities to settle and avoid the litigation.

Thus, we hypothesize:

*Hypothesis 3: Controlling for prior licensing activity, the increase of licensing income for universities is stronger for universities facing patent litigation cases as co-defendants compared with cases as sole defendant.*

# Data and Methods

## Data

We test our hypotheses using data from US universities. US universities are an appropriate setting for studying patent litigation, as the contribution of universities to domestic patenting activity is particularly high in the US (Blumenstyk, 2010; Farmer, 2007). We construct a unique dataset by merging two data sources. The first database consists of university-level responses in the annual licensing surveys of the Association of University Technology Managers (AUTM STATT). AUTM STATT covers the technology transfer activity of all US universities. The second source is the USPTO’s Patent Litigation Docket Reports Data, which is used to access patent infringement litigations data for all US universities (Schwartz et al., 2019; USPTO, 2021). The data cover the period between 2005 and 2016. After excluding cases with missing data, our sample consists of 1,408 university-year observations from 157 unique US universities.

## Measures

### Dependent variable.

To measure licensing income, we use the value of gross licensing revenues from both licensing fees and royalties in the next year (t+1) (*Licensing Revenues*). All of our models use logarithmic transformations of the dependent variable because licensing income is strongly skewed.

*Explanatory variables.*

Our independent variable in hypothesis 1 measures the number of patent litigation cases that a university faces as a defendant in a given year (*Litigations as Defendant*). To measure our moderating variable in hypothesis 2, *Licensing Patents*, we use the total number of licenses executed by the university scaled by the total number of patents issued to the university for a given year. We compute two additional independent variables for testing hypothesis 3: The number of patent litigation cases that a university faces as a co-defendant (*Litigations as Co-defendant*) and the number of patent litigation cases that a university faces as a sole defendant (*Litigations as Sole Defendant*) in a given year.

*Control variables.*

To mitigate the possibility that our results are driven by omitted variable biases (Barkema, 1996), we include a rich set of control variables in our models. In line with earlier research, these control variables fall into four broad categories, covering differences at the level of technologies, TTOs, the overall university and its litigation experiences.

At the technology level, the number of patents affects potential licensing income, so we control for the total number of patents issued to the university (*No. of Patents*). We also control for the logarithmic transformation of total research expenses (*Research Expenses*) and research expenses that come from industry sources as a percentage of total research expenses (*Applied Research*), which is a proxy for the university’s 'commercial proclivity' and dedication to 'applied' research (Hewitt-Dundas, 2012; Link and Siegel, 2005).

At the TTO level, prior research has also shown that older technology transfer offices tend to out-perform their younger counterparts (Friedman and Silberman, 2003). We thus include the age of the transfer offices (*TTO Age*), to control for the impact of their experience on licensing income. We also include the number of full-time employees (FTEs) working in the university’s technology transfer office (*Total FTEs*), as this number determines a university’s capacity for technology transfer (Lockett and Wright, 2005). We further include legal fees in our models (*Legal Fees*), to proxy protection of the university’s IP, which is deemed to be a decisive driver of licensing income (Lockett and Wright, 2005). We use the natural logarithm of this measure.

At the university level, prior research has shown that having a medical school can have positive influence on licensing income (Powers and McDougall, 2005; Thursby and Kemp, 2002). Therefore, we use a dummy variable indicating the presence of a medical school in the university (*Medical School*). Private universities can be more effective in generating licensing income compared with public universities (e.g. Lach and Schankerman, 2008). We include a dummy variable which indicates whether the university is private as control (*Private*).

Finally, universities can have a variety of patent litigation experiences. They can be involved in a litigation as defendants, plaintiffs, counter defendants or counter plaintiffs. Therefore, we also include in the models testing hypothesis 1 & 2 separate measures that reflect the number of patent litigation cases that a university faces as a plaintiff (*Litigations as Plaintiff*), counter defendant (*Litigations as Counter Defendant*), and counter plaintiff (*Litigations as Counter Plaintiff*) in a given year. Accordingly, in the model testing hypothesis 3, we include separate measures for the number of patent litigation cases that a university faces as a counter defendant (*Litigations as Counter Defendant*), counter plaintiff (*Litigations as Counter Plaintiff*), co-plaintiff (*Litigations as Co-plaintiff*) and sole plaintiff (*Litigations as Sole Plaintiff*) as control variables. Further, we control for both year- and state-fixed effects in all models. All the independent and control variables are lagged by one year to rule out reverse causality.

## Estimation approach

Our independent variable, licensing income, is a continuous variable, making ordinary least squares (OLS) regression analysis the estimation method of choice. We use university fixed-effects models to eliminate any potential bias from unobserved time-invariant heterogeneity at the university level. As empirical confirmation, we run a Hausman specification test which indicated that a fixed-effects model was indeed appropriate for our panel data. Further, we account for potentially endogenous relationships. Specifically, many predictors of licensing income may covary with involvement in patent litigation as defendant. This close coupling of involvement in patent litigation as defendant to other predictors of licensing income is likely to create a covariate imbalance between universities involved in patent litigations as defendants and those universities that do not. Such imbalance can potentially lead to biased estimates of causal effects (e.g. Altonji et al., 2005).

To address this issue, we apply entropy balancing (Hainmueller, 2012). This approach creates a control group, reweighting its observations in such a way that the distributional moments (mean, standard deviation and skewness) of the matching variables for this sample are indistinguishable from the moments of the distributions of the matching variables for the sample of the treatment group (Abadie et al., 2010; Hainmueller, 2012). In the current application, our entropy-balancing algorithm develops weights that balance sample moments between universities with involvement and universities with no involvement in patent litigations as defendants, approximating the statistical equivalence achieved via true random assignment. Such a pre-processing step reduces model dependence for the subsequent estimation of treatment effects with regression (Abadie and Imbens, 2011; Ho et al., 2007).

Re-weighting was carried out by feeding into our entropy-balancing algorithm a set of covariates or pre-treatment variables that are likely to influence the university’s involvement in patent litigation as defendant. In particular, we employ the total number of patents issued to the university, the number of FTEs working in the university’s technology transfer office and the age of the technology transfer office. We also include two dummy variables that indicate whether the university has a medical school and whether the university is private. Table 1 reports descriptive statistics for the treatment and control group before and after entropy balancing. It is evident from the results that weights determined by entropy balancing were successful at constraining the means, standard deviations and skewness for all pre-treatment variables. As the distributions reveal, there are no significant differences between the control and the treatment group after implementing the entropy balancing approach. As a next step, we apply the entropy balancing weights in all regression models. In addition to applying entropy balancing weights in our regressions, we also employed university-clustered standard errors to control for unobserved university effects (Petersen, 2009).

[Insert Table 1 about here]

Entropy balancing compares favorably with other types of matching approaches. As noted above, entropy balancing has the advantage of improving covariate balance not just based on variable means but also other variable moments such as standard deviation (Ho et al., 2007). Further, as entropy balancing algorithmically searches for an optimal weighting solution, it is less sensitive to researcher discretion compared to propensity score matching approaches or the definition of appropriate strata in coarsened exact matching (CEM). Finally, in propensity score matching, researchers should manually search for matching and subsequently trim data sets of unmatched cases. In contrast, with entropy matching such cases do not have to be discarded but have weights attached to them and thus, the efficiency of the estimation procedure is significantly improved (Distel et al., 2019). In sum, we adopt the entropy balancing approach for testing our hypotheses in the main models but go through alternative approaches as robustness checks to demonstrate the stability of the findings.

# Results

Table 2 reports the descriptive statistics for the entire sample. On average, universities issue 24 patents per year. The average of licenses executed by a university scaled by the total number of patents issued to the university is 1.506. The average number of litigations where a university acts as a defendant ranges from 0 to 8 and the mean is 0.03. The average university engages in 0.023 litigation cases where it acts as a co-defendant and in 0.007 cases where it acts as a sole defendant. The overall sample mean of licensing revenue is 13.581.

Table 3 shows correlation coefficients of the variables used in the analyses. We inspect the regression diagnostics and find that the highest average variance inflation factor (VIF) in our models is 2.38. The maximum estimated VIF for each coefficient also is 4.02, far below the critical value of 10 (Gujarati, 2003). We further use the Durbin-Watson test statistic to assess whether our results are biased by serial correlation. The Durbin-Watson scores for the analyses presented here range from 1.90 to 1.99, supporting the conclusion that there is no significant serial correlation bias present in our models.

[Insert Table 2 about here]

[Insert Table 3 about here]

Table 4 shows the fixed effect regression results step-wise. We first estimate a baseline model including only control variables. Model 2 estimates additionally the coefficient of the number of patent litigation cases that the university faces as defendant. As hypothesized, this model demonstrates a positive and significant relationship between litigations as defendant and licensing income (b=0.217, p<0.01). These results support Hypothesis 1. In model 3, we interact the number of patent litigation cases that the university faces as defendant with universities licensing and expect the coefficient for the interaction term to be positive. As predicted, the results indicate that the coefficient of the interaction term, Litigations as Defendant\*Licensing Patents, is both positive and significant (b=0.184, p<0.01). To facilitate interpretation, we plot the respective moderating effects and test the simple slope of universities licensing at one standard deviation below and above the mean. We find that the number of patent litigation cases that a university faces as defendant is more positively related to licensing income when universities licensing is higher (simple slope test: b=0.564, p<0.01). Figure 1 graphically depicts these findings. These results jointly render support to Hypothesis 2.

Model 4 examines whether the licensing income increases more with the number of patent litigations that universities face as co-defendants compared to the number of patent litigations that universities face as sole defendants. To explore this asymmetric effect, we introduce two variables in model 4, namely litigations as co-defendant and litigations as sole defendant. As can be seen, the coefficient of litigations as co-defendant is positive and significant (b= 0.200, p<0.01). The effect of the number of litigations as sole defendant is insignificant (p=>0.10). Hence, hypothesis 3, is supported.

Among our control variables, five variables are statistically significant across all models. The amount of legal fees spent by the university has a positive effect on licensing income, suggesting its important role in protecting IP. Similarly, universities with a medical school and those who are private have significantly higher licensing income compared to their counterparts. Interestingly, the number of full-time employees working in the university’s technology transfer office and the number of patent litigation cases that a university faces as a counter plaintiff both had a negative effect on licensing income. The coefficients should be interpreted directly since they are re-weighted based on the likelihood to become a defendant in patent litigation.

[Insert Table 4 about here]

### Robustness checks

To check the robustness of our results, we run a number of additional analyses. These consistency checks fall into three broad categories, i.e. the operationalization of the dependent variable (licensing income and time lags), the operationalization of the independent variable (patent litigation as defendant) and the estimation procedures (alternative matching approaches). We include the results in table 5 for major findings. All other regression tables are available upon request.

[Insert Table 5 about here]

First, we explore the consistency of our estimation results with regards to the operationalization of licensing income as our dependent variable. Inherent in our theoretical reasoning is the notion that patent litigations as defendants will have a signaling affect for many potential licensees. Accordingly, it should not just affect the overall licensing income but also the average licensing deal. Hence, we use the average annual income per license in models 5, 6 and 7 of table 5 as an alternative dependent variable. All hypothesized effects remain consistent. Further, the signaling effect might take time to translate into additional licensing income. Accordingly, we use the average licensing income over the subsequent two years as dependent variable in line with prior literature (Shane and Somaya, 2007) and find consistent results (models 8, 9 and 10 of table 5). The coefficient of the main effect relationship is larger for the two-year time lag compared with the main models. Subsequently, we repeat the analysis using the average of licensing income over the next three years as dependent variable and find consistent results. Finally, we use time lags separately, i.e. in each one of the four subsequent years to explore the dynamic pattern of the effect. Interestingly, these results suggest that the signaling effect grows in strength over the short term (t+1, t+2) but weakens after t+3.[[1]](#footnote-2) These results are consistent with our signaling logic, in that the strength of the signal is contingent on their observability. Potential licensees need time to observe the litigation signal, interpret it and initiate licensing negotiations. Then again, they are less likely to rely on a signal that is potentially no longer reliable several years after the litigation has occurred.

Second, we assess the stability of results with regard to the independent variable. Shane and Somaya (2007) show that patent litigation imposes a significant strain on TTO attentional resources. Hence, effects may depend on TTO size. To account for this effect, we rerun our main analyses incorporating an additional interaction term— the number of full-time employees working in the office (*Total FTEs*) and the number of patent litigation cases that the university faces as defendant (*Litigations as Defendant*). Model 11 of table 5 shows the results. The interaction term has a negative and significant effect but the main effect of litigations as defendant remains positive and significant, as hypothesized. Unreported models also consider two alternative proxies for TTO capacity, namely the age of TTO and the invention stock of the TTO measured by the number of disclosures. Again, the overall effect of our main dependent variable remains positive and significant. In sum, TTO capacity is important for dealing with the administrative burdens of patent litigation and/or informing potential licensees but it does not dominate the signaling mechanism. In a separate consistency check estimation, we explore whether the positive effects of patent litigation as defendant on licensing income diminish with increasing numbers and add the squared term of the number of patent litigation cases that the university faces as defendant to our regression model. This is not the case. The squared term has no significant effect. We suspect that the signaling effect of patent litigation remains strong even if it occurs repeatedly, given the public nature of the legal process and the substantial costs for every case.

Third, we explore the sensitivity of results with regards to alternative estimation approaches in terms of matching techniques. Specifically, we focus on the frequently used propensity score (PSM) and coarsened exact matching (CEM) approaches and use the same vector of matching variables that we apply in the entropy balancing. Propensity-score matching (PSM) matches universities with involvement in patent litigations as defendants (treatment group) with comparable universities with no involvement in patent litigations as defendants (control group) based on their probability (i.e. estimated propensity) to be treated (Dehejia and Wahba, 2002; Leuven and Sianesi, 2003). In contrast to entropy balancing, PSM requires the discretion of researchers for trimming the sample until balance between the treated and control group is achieved at the expense of reducing the sample size by dropping cases that cannot be matched. Therefore, entropy balancing is still our preferred method. Nevertheless, results of the OLS regression with PSM of the treatment and control groups are consistent with our main analysis.

Subsequently, we use CEM as an alternative matching approach. CEM requires researchers to specify appropriate cut-off points for each variable and matching of treated and control universities occurs within these strata. CEM is demanding in terms of the number of observations, as the model drops all the observations that cannot be matched (Chen and Feldman, 2018; Hendricks, Howell, and Bingham, 2019). The latter concern applies also to our case and the number of matched observations drops substantially to 680. Such a loss in sample size can impact the statistical power of our model parameters. Nevertheless, model 12 reports the results and supports the results of the entropy balance approach in the main models. We conclude that the type of matching approach does not affect the hypothesis tests.

For further comparison, we also demonstrate the validity of our original results, via a difference-in-differences approach on the matched sample. Rather than estimating the before-to-after change in licensing income for the treatment group and assuming the difference is the effect of being involved in patent litigation as defendant, this approach adjusts for the counterfactual trend of what would have happened to the treatment group in the absence of the treatment. The difference-in-differences approach can achieve this adjustment by estimating the change of the licensing income of universities with involvement in patent litigations as defendants and the change of licensing income in comparison universities and then taking the difference of those differences. In our analysis, we compare licensing income changes between one year before and one year after universities become involved in patent litigations as defendants. To ensure that control universities are as similar as possible to the treated universities ex ante, we match each treated university with the nearest neighbor in terms of the same pre-treatment variables employed in the entropy balancing procedure. The nearest neighbor is the university with the lowest Mahalanobis distance to the treated university across these characteristics. In model 13, we include an indicator for universities being involved in patent litigations as defendants (Defendants), an indicator for post-litigations as defendants (Post), and the interaction between both variables for assessing the effect (Defendants × Post). The positive and significant coefficient for this interaction term indicates that universities involved in patent litigations as defendants enjoy higher licensing income following the litigation. Overall, all consistency checks confirm the findings of the main models.

# Discussion

Technology licensing is a major channel of universities for generating income and fulfilling their technology transfer mission (Feller and Feldman, 2010; Hsu et al., 2021; Macho-Stadler et al., 2007). The prerequisite for licensing is that universities manage their patent rights professionally and this necessarily includes dealing with disputes which can reach the level of patent litigation in court. However, the consequences for universities facing patent litigation are not well understood and mostly described as a distraction (Shane and Somaya, 2007). We challenge this assumption and draw from theory in patent strategy emphasizing the potential of patent litigation to reveal information about an organization’s patents that is otherwise hard to observe (Agarwal et al., 2009; Kiebzak et al., 2016; Somaya, 2012). When we integrate these mechanisms into models of university licensing, we conclude that plaintiffs suing universities for patent infringement might inadvertently reveal to potential licensees that the university produces technologies with substantial commercial value, a quality that is typically hard to judge for licensees given the early stage character of university research (Ziedonis, 2007). As a consequence, we hypothesize that this unintended signaling effect from universities facing patent litigation as defendants increases their licensing income. We use boundary conditions from signaling theory to isolate our core mechanism, i.e. the signaling effects for commercial value become stronger when their level of consistency with university (track-record of licensing) and litigation characteristics (private firms as co-defendants) increases. The results of the empirical study support all of our hypotheses.

Our insights have important implications for two specific streams of academic research. First, a rich body of research on the commercialization of university patents acknowledges how difficult it is for universities to attract licensees for technologies that are often times new, unproven and hardly developed (Bozeman et al., 2015; Horner et al., 2019). Existing research suggests that some university characteristics are associated with higher licensing revenues, for example research quality[[2]](#footnote-3) (Hewitt-Dundas, 2012; Lach and Schankerman, 2004; Sengupta and Ray, 2017), past licensing performance (Conti and Gaule, 2011; Heisey and Adelman, 2011; Sengupta and Ray, 2017), and incentive structures for academic inventors (Arqué-Castells et al., 2016; Belenzon and Schankerman, 2009; Lach and Schankerman, 2004). Alternatively, TTO characteristics such as size and licensing experience have been demonstrated to have an effect on licensing revenues (Chapple et al., 2005a; Link and Siegel, 2005; Siegel et al., 2003). Our research makes a distinct contribution to extant theory suggesting that the asymmetric information problem that characterizes university technology licensing may be overcome if universities provide more information for potential licensees, either through passive or active signaling (Kotha et al., 2018; Ray and Sengupta, 2021). Recent research suggests that some university characteristics function to improve knowledge exchange through passive signaling effects that indicate the quality of underlying research and knowledge exchange motivations of universities to external parties (Ray and Sengupta, 2021). This research also suggests that universities can signal their commercialization intentions to potential licensees by filing patents (Ray and Sengupta, 2021). Alternatively, experienced TTO managers may signal the value of university-generated technology by offering particular contract payment structures to potential licensees, for example by trading up-front payment for deferred royalties (Kotha et al., 2018). It is suggested that TTO managers are only willing to offer such contract payment structures if they believe that the value generated from royalties will exceed up-front payments, and thus offering these payment structures communicates TTO manager beliefs about the value of the technology (Kotha et al., 2018).

All of these approaches have in common that they ask universities to produce a type of information for potential licensees that they cannot credibly produce, i.e. whether a university technology can be successfully developed into a product that proves superior in competition. We suggest an alternative theoretical mechanism for revealing this information about the technologies of a university. Within our logic, the commercial potential of university technologies is revealed when a plaintiff considers them as strategically important enough to incur the substantial costs for suing the university. This action produces an unintended but credible signal for potential licensees about a university’s technologies. This logic has wider implications for research on technology licensing by universities because it (a) shifts the focus to credible information sources outside of the university and (b) introduces potentially adverse effects for universities, such as facing patent litigation, as having substantial signaling power. Hence, our integrated theory can be a platform for taking a fresh look at the type of information that potential licensees consider and judge as credible, e.g. university scientists joining private firms as indications for university research with substantial commercial potential.

Second, our findings have implications for research on signaling in the context of patent strategy, which has focused principally on the signaling effects of patenting (Fontana et al., 2006; Levitas and McFadyen, 2021; Somaya, 2012; Yang, 2019). For example, existing research suggests that patenting signals the underlying quality of SME technology to external investors (typically venture-capitalists), that impacts the likelihood of investment (Conti et al., 2013; Hall, 2019). Others suggest that patenting signals the underlying quality of proprietary technology to potential licensees (Gans et al., 2008; Ray and Sengupta, 2021) and potential collaboration partners (Fontana et al., 2006). There is comparatively little known about the signaling functions of litigation within this literature, which mostly addresses litigation from the plaintiff’s perspective. For example, some studies have shown that filing for litigation against rival firms creates deterrent effects (Agarwal et al., 2009; Clarkson and Toh, 2010). The defendant perspective is much less understood. However, our findings shed light on this issue and contribute to the signaling and IP literature by elaborating new signaling functions of litigation. In doing so, we advance existing literature that has begun to explore the strategic outcomes of defending patent infringement claims, such as Awate and Makhija (2021) who show that firms accused of patent infringement may benefit from knowledge spillovers. Naturally, our context is different because universities do not develop products and compete with firms. Nevertheless, our theory integration provides new opportunities for theorizing about patent enforcement because rational plaintiffs in patent litigation should not just consider the immediate benefits of enforcing their rights but also the unintended signaling effects for defendants which might be interpreted positively by relevant outside parties such as potential licensees. This makes the interpretation of unintended patent litigation signals salient for future theorizing, e.g. about the perceptions of students when potential employers litigate against their university.

Collectively, these results have important practical implications for universities seeking to maximize licensing revenues. When universities are confronted with claims of patent infringement, an initial response may be to avoid conflict, due to the potential reputational damage and operational disruption associated with litigation (Shane and Somaya, 2007). This systematic avoidance of litigation means that universities may often enter into unfavorable pre-litigation agreements. Our results indicate that in fact, universities should be more robust in their defense of patent infringement claims, particularly when they have a strong track-record in commercialization and when commercial partners are co-defendants. This sheds a new light on commercialization research (Chapple et al., 2005a; Siegel et al., 2003) proposing that universities seeking to grow revenues from commercialization should invest resources in legal functions or on external legal representation. Within our logic, these investments pay off because they put universities in positions for defending patent litigations where they create important signals about the commercial value of their technologies to a broader audience.

Another key strategic implication of our findings is that a potential moral hazard problem arises, if universities become aware of the signaling value of defending infringement claims in litigation[[3]](#footnote-4). Specifically, if a university knows the signaling value of patent litigation, it may be more inclined to undertake costly and risky litigation to enhance future licensing revenues than if this signaling value was unknown to them. In considering this strategic trade-off, it is important to remain mindful of the boundary conditions of the signaling effect of litigation that we elaborate above. Importantly, university administrators need to be mindful that signaling effects are stronger when they are consistent with previous licensing performance, so we may conclude that moral hazard problems are more likely to arise when the university has a strong record in technology licensing. Another important consideration in relation to this trade-off is the drain on attentional and human resources that patent litigation imposes on university TTOs (Shane and Somaya, 2007), suggesting that moral hazard problems are more likely to arise in TTOs with greater human resource endowments.

## Limitations and directions for future research

Although we offer insights into the relationship between patent litigation and university technology licensing, our research has limitations which we do not address in detail and that fall beyond the scope of a single study. Important limitations can be grouped into four broad categories.

First, we conduct our research in the context of the US, which may limit the generalizability of our findings. Recent research highlights that there is substantial heterogeneity in the effectiveness and efficiency of patent enforcement across different national and institutional contexts (Papageorgiadis and Sofka, 2020). According to this research, the US is characterized by institutional arrangements that facilitate effective and efficient enforcement, meaning the threat of litigation is more likely to have consequences on the behavior of firms participating in technology markets. Thus, it may be suggested that the findings of our research are generalizable only to other contexts where institutional arrangements for enforcement are similarly well-developed (e.g. Western Europe and Japan). To address this limitation, we call for future research in emerging and developing contexts, where patent enforcement may not be as effective or efficient (Papageorgiadis and Sofka, 2020) and where information asymmetries between universities and industry may be more pronounced (Ray and Sengupta, 2021).

Second, we currently lack data on motivations and the decision-making process that underpin university decisions to defend against allegations of patent infringement. Consequently, we cannot make any assessment of university patent strategies with regards to enforcement, for example we cannot determine whether or not universities are overly cautious or overly aggressive in their litigation activity. This lack of data on litigation motivations and decision-making also makes it difficult to determine the scope for moral hazard problems. Future research may adopt qualitative designs to uncover the motivations, intentions and decision-making processes through which litigation strategy emerges to further develop our understandings of patent litigation in the context of university technology licensing. Specifically, research might explore the linkages between ‘proactive’ patent litigation strategies on technology licensing revenues and ‘passive’ patent litigation strategies (Rudy and Black, 2018). Future research might also investigate the effects of litigation outcomes on university technology licensing efforts, for example by examining how litigation success/failure impacts technology licensing efforts, perhaps exploring the tradeoffs between signaling and reputational effects.

Third, recent research has indicated that the media prominence of parties involved in patent disputes has an effect on litigation (Tan, 2016). Specifically, it is demonstrated that more high-profile litigants (i.e. parties that have greater media coverage) can use their profile to influence rivals decisions about engaging in patent litigation. In our study, we have no data on the media coverage that the universities (defendants) and firms (plaintiffs) receive, but we might expect this to have an influence on the strength of the signaling effect of litigation (i.e. for universities with greater media coverage, the signaling effect of litigation may be stronger). Similarly, we do not have data on the level of media coverage that litigation cases themselves receive, but we suspect that the more high-profile the case the stronger the signaling effect of litigation. Future research may collect data on the media coverage of litigants and litigation cases to explore these issues further.

Fourth, patent litigation can result in knowledge spillovers about the technologies under dispute (Awate and Makhija, 2021). We suspect that the signaling effect from universities facing patent litigations is similarly specific, i.e. has the strongest effect on licensing for the faculties and research areas of the technologies that are litigated. Then again, there might be a general signaling effect for the university as a whole. Due to limitations with our dataset, we are unable to distinguish signialing effects for particular faculties from broader university-level signaling effects. Future studies with dedicated research designs might be able to disentangle these effects within universities.

## Conclusion

In sum, this study sought to elaborate the impact of patent litigation on university technology licensing income. The limited existing research suggests that participation in litigation is mostly distracting for TTOs (Shane and Somaya, 2007). We show that there are unintentional signaling effects of defending against claims of patent infringement, which reveal information about the underlying quality, robustness and defensibility of university-generated IP. We show that, somewhat paradoxically, firms seeking the punitive and deterrent effects associated with patent enforcement, may actually enhance the perceived value of a university’s technology.

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# Tables

Table 1. Descriptive statistics by involvement in patent litigation as defendant, with and without entropy balanced matching

Before: without weighting

|  |  |  |
| --- | --- | --- |
|  | Universities with involvement | Universities with no involvement |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Mean | SD | Skewness | Mean | SD | Skewness |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. of Patents | 75.860 | 10.290 | 2.567 | 25.140 | 1.518 | 4.635 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Total FTEs | 33.930 | 2.112 | 2.588 | 9.854 | 233.700 | 6.218 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| TTO Age | 27.730 | 136.700 | 0.801 | 19.140 | 182.600 | 1.984 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Private | 0.696 | 0.215 | -0.854 | 0.297 | 0.209 | 0.888 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Medical School | 0.893 | 0.097 | -2.540 | 0.591 | 0.242 | -0.369 |

After: with weighting

|  |  |  |
| --- | --- | --- |
|  | Universities with involvement | Universities with no involvement |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Mean | SD | skewness | Mean | SD | Skewness |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. of Patents | 75.860 | 10.290 | 2.567 | 75.650 | 10.262 | 2.577 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Total FTEs | 33.930 | 2.112 | 2.588 | 33.840 | 2.106 | 2.598 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| TTO Age | 27.730 | 136.700 | 0.801 | 27.660 | 136.400 | 0.821 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Private | 0.696 | 0.215 | -0.854 | 0.691 | 0.214 | -0.827 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Medical School | 0.893 | 0.097 | -2.540 | 0.891 | 0.097 | -2.503 |

Table 2. Descriptive statistics for the entire sample

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Mean | SD | Min | Max |
|  Licensing Revenues | 13.581 | 3.196 | 0 | 20.53 |
|  Litigations as Defendant | 0.03 | 0.286 | 0 | 8 |
|  Litigations as Plaintiff | 0.079 | 0.777 | 0 | 39 |
|  Litigations as Counter Defendant | 0.047 | 0.473 | 0 | 16 |
|  Litigations as Counter Plaintiff | 0.002 | 0.101 | 0 | 6 |
|  Litigations as Sole Plaintiff | 0.031 | 0.649 | 0 | 38 |
|  Litigations as Co-plaintiff | 0.047 | 0.399 | 0 | 11 |
|  Litigations as Sole Defendant | 0.007 | 0.127 | 0 | 6 |
|  Litigations as Co-defendant | 0.023 | 0.239 | 0 | 7 |
|  No. of Patents t | 24.279 | 39.771 | 0 | 519 |
|  Research Expenses | 18.626 | 1.647 | 0 | 22.463 |
|  Licensing Patents | 1.506 | 2.471 | 0 | 52.5 |
|  Total FTEs | 9.65 | 16.054 | 0 | 223.9 |
|  Legal Fees | 12.962 | 2.147 | 0 | 17.836 |
|  Applied Research | 0.085 | 0.078 | 0 | 0.773 |
|  TTO Age | 18.471 | 13.646 | 0 | 92 |
|  Medical School | 0.579 | 0.494 | 0 | 1 |
|  Private | 0.312 | 0.463 | 0 | 1 |
|  |  |  |  |  |

Table 3. Pairwise correlations

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  Variables |  (1) |  (2) |  (3) |  (4) |  (5) |  (6) |  (7) |  (8) |  (9) |  (10) |  (11) |  (12) |  (13) |  (14) |  (15) |  (16) |  (17) |
|  (1) Licensing Revenues  |  |
|  (2) Litigations as Defendant | 0.108 |  |
|  (3) Litigations as Plaintiff | 0.106 | 0.059 |  |
|  (4) Litigations as Counter Defendant | 0.119 | 0.029 | 0.812 |  |
|  (5) Litigations as Counter Plaintiff | -0.019 | 0.182 | -0.003 | 0.107 |  |
|  (6) Litigations as Sole Plaintiff | 0.057 | 0.052 | 0.880 | 0.635 | -0.002 |  |
|  (7) Litigations as Co-plaintiff | 0.119 | 0.030 | 0.514 | 0.560 | -0.004 | 0.044 |  |
|  (8) Litigations as Sole Defendant | 0.088 | 0.362 | 0.012 | 0.058 | -0.002 | 0.015 | -0.000 |  |
|  (9) Litigations as Co-defendant | 0.083 | 0.938 | 0.059 | 0.010 | 0.196 | 0.050 | 0.033 | 0.017 |  |
|  (10) No. of Patents | 0.461 | 0.123 | 0.131 | 0.140 | -0.009 | 0.080 | 0.131 | 0.150 | 0.076 |  |
|  (11) Research Expenses | 0.683 | 0.114 | 0.112 | 0.134 | -0.002 | 0.063 | 0.122 | 0.082 | 0.092 | 0.604 |  |
|  (12) Licensing Patents | 0.041 | -0.014 | -0.026 | -0.024 | -0.001 | -0.021 | -0.018 | -0.030 | -0.004 | -0.151 | -0.033 |  |
|  (13) Total FTEs | 0.480 | 0.147 | 0.111 | 0.114 | -0.007 | 0.057 | 0.132 | 0.142 | 0.105 | 0.828 | 0.626 | -0.053 |  |
|  (14) Legal Fees | 0.662 | 0.122 | 0.107 | 0.134 | 0.025 | 0.058 | 0.119 | 0.108 | 0.091 | 0.623 | 0.747 | -0.116 | 0.587 |  |
|  (15) Applied Research | -0.006 | 0.019 | -0.005 | -0.005 | 0.054 | -0.024 | 0.032 | 0.013 | 0.016 | 0.023 | -0.061 | -0.046 | -0.059 | 0.009 |  |
|  (16) TTO Age | 0.398 | 0.077 | 0.094 | 0.115 | 0.005 | 0.078 | 0.057 | 0.064 | 0.059 | 0.380 | 0.424 | -0.000 | 0.300 | 0.392 | 0.039 |  |
|  (17) Medical School | 0.345 | 0.077 | 0.067 | 0.072 | 0.021 | 0.031 | 0.085 | 0.037 | 0.069 | 0.161 | 0.428 | -0.150 | 0.272 | 0.372 | -0.035 | -0.002 |  |
|  (18) Private | 0.289 | 0.100 | 0.057 | 0.065 | 0.041 | 0.058 | 0.015 | 0.085 | 0.075 | 0.258 | 0.181 | -0.099 | 0.222 | 0.317 | 0.025 | 0.130 | 0.141 |
|  |

Note: The high correlations for sole and co-defendant (as well as plaintiffs) occur because the overall number of litigations as defendant comprise both categories. We report them for completeness but they do not create issues with multicollinearity since they are not used in the same estimation models with the overall number of defendant and plaintiff cases.

Table 4: Fixed effect OLS regression models (dependent variable: ln (Licensing Revenues))

|   | Model (1) | Model (2) | Model (3) | Model (4) |
| --- | --- | --- | --- | --- |
|  Litigations as Defendant |  | 0.217\*\*\* | -0.064 |  |
|   |  | (0.077) | (0.114) |  |
|  Litigations as Plaintiff |  | -0.075\* | -0.058 |  |
|   |  | (0.041) | (0.041) |  |
|  Litigations as Defendant\*Licensing Patents |  |  | 0.184\*\*\* |  |
|   |  |  | (0.044) |  |
|  Litigations as Sole Defendant |  |  |  | 0.308 |
|   |  |  |  | (0.208) |
|  Litigations as Co-defendant |  |  |  | 0.200\*\*\* |
|   |  |  |  | (0.070) |
|  Litigations as Sole Plaintiff |  |  |  | -0.067\* |
|   |  |  |  | (0.036) |
|  Litigations as Co-plaintiff |  |  |  | 0.066 |
|   |  |  |  | (0.104) |
|  Litigations as Counter Defendant | 0.054 | 0.171\* | 0.154\*\* | 0.110 |
|   | (0.035) | (0.094) | (0.074) | (0.102) |
|  Litigations as Counter Plaintiff | -0.597\*\*\* | -0.720\*\*\* | -0.721\*\*\* | -0.687\*\*\* |
|   | (0.100) | (0.107) | (0.099) | (0.115) |
|  No. of Patents | 0.002 | 0.003 | 0.003 | 0.003 |
|   | (0.003) | (0.003) | (0.003) | (0.003) |
|  Research Expenses | 0.497\* | 0.464\* | 0.420 | 0.450\* |
|   | (0.280) | (0.269) | (0.276) | (0.267) |
|  Licensing Patents | 0.097\*\* | 0.090\*\* | 0.047 | 0.090\*\* |
|   | (0.043) | (0.039) | (0.029) | (0.039) |
|  Total FTEs | -0.008\* | -0.008\* | -0.007\* | -0.007\* |
|   | (0.004) | (0.004) | (0.004) | (0.004) |
|  Legal Fees | 0.625\* | 0.604\* | 0.633\* | 0.606\* |
|   | (0.319) | (0.309) | (0.321) | (0.311) |
|  Applied Research | 0.637 | 0.441 | 0.399 | 0.435 |
|   | (1.111) | (1.126) | (0.970) | (1.126) |
|  TTO Age | -0.005 | -0.005 | 0.002 | -0.002 |
|   | (0.016) | (0.014) | (0.011) | (0.013) |
|  Medical School | 0.519\*\* | 0.586\*\* | 0.491\* | 0.576\*\* |
|   | (0.260) | (0.254) | (0.259) | (0.263) |
|  Private | 0.768\*\* | 0.840\*\*\* | 0.959\*\*\* | 0.831\*\*\* |
|   | (0.313) | (0.291) | (0.270) | (0.294) |
|  Constant | -3.963 | -3.268 | -2.970 | -3.139 |
|   | (2.519) | (2.402) | (2.462) | (2.320) |
|  State fixed effects | Yes | Yes | Yes | Yes |
|  Year fixed effects | Yes | Yes | Yes | Yes |
|  Observations | 1408 | 1408 | 1408 | 1408 |
|  R-squared  | 0.797 | 0.805 | 0.815 | 0.807 |
|  F | 27.51 | 33.80 | 41.44 | 41.70 |
|  |
| Standard errors are in parenthesis. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1  |

Table 5. Results of the robustness checks using university fixed effects regressions

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | Model (5) | Model (6) | Model (7) | Model (8) | Model (9) | Model (10) | Model (11) | Model (12) | Model (13) |
| Consistency check | DV: Average licensing income | DV: Average licensing income | DV: Average licensing income | DV: Licensing income over next two years | DV: Licensing income over next two years | DV: Licensing income over next two years | Sensitivity to TTO size | CEM matching | Difference-in-differences  |
|  Litigations as Defendant | 0.151\*\* | -0.011 |  | 0.279\*\*\* | 0.138 |  | 0.333\*\*\* | 0.160\*\* |  |
|   | (0.066) | (0.098) |  | (0.074) | (0.109) |  | (0.094) | (0.080) |  |
|  Litigations as Plaintiff | -0.094\*\*\* | -0.084\*\* |  | -0.025 | -0.018 |  | -0.076\* | 0.031 | -0.042 |
|   | (0.035) | (0.033) |  | (0.038) | (0.037) |  | (0.042) | (0.042) | (0.044) |
|  Litigations as Defendant\*Licensing Patents |  | 0.106\*\*\* |  |  | 0.092\*\* |  |  |  |  |
|   |  | (0.038) |  |  | (0.042) |  |  |  |  |
|  Litigations as Sole Defendant |  |  | 0.016 |  |  | 0.492\*\* |  |  |  |
|   |  |  | (0.157) |  |  | (0.237) |  |  |  |
|  Litigations as Co-defendant |  |  | 0.177\*\* |  |  | 0.236\*\*\* |  |  |  |
|   |  |  | (0.068) |  |  | (0.066) |  |  |  |
|  Litigations as Sole Plaintiff |  |  | -0.107\*\*\* |  |  | -0.009 |  |  |  |
|   |  |  | (0.036) |  |  | (0.035) |  |  |  |
|  Litigations as Co-plaintiff |  |  | -0.015 |  |  | 0.102 |  |  |  |
|   |  |  | (0.086) |  |  | (0.078) |  |  |  |
|  Litigations as Defendant\*Total FTEs |  |  |  |  |  |  | -0.004\*\*\* |  |  |
|   |  |  |  |  |  |  | (0.001) |  |  |
|  Defendant |  |  |  |  |  |  |  |  | 0.290\*\* |
|  |  |  |  |  |  |  |  |  | (0.137) |
|  Post |  |  |  |  |  |  |  |  | 0.389\*\* |
|  |  |  |  |  |  |  |  |  | (0.186) |
|  Defendant x Post |  |  |  |  |  |  |  |  | 0.425\* |
|  |  |  |  |  |  |  |  |  | (0.252) |
|  Litigations as Counter Defendant | 0.169\*\* | 0.160\*\* | 0.170\* | 0.088 | 0.080 | 0.010 | 0.175\* | -0.011 | 0.074 |
|   | (0.080) | (0.071) | (0.092) | (0.070) | (0.069) | (0.072) | (0.097) | (0.099) | (0.088) |
|  Litigations as Counter Plaintiff | 0.160 | 0.159 | 0.152 | -0.536\*\*\* | -0.538\*\*\* | -0.487\*\*\* | -0.766\*\*\* | -0.715\*\*\* | -0.042 |
|   | (0.117) | (0.115) | (0.123) | (0.096) | (0.094) | (0.102) | (0.105) | (0.146) | (0.044) |
|  No. of Patents | 0.002 | 0.002 | 0.002 | 0.005 | 0.005 | 0.004 | 0.004 | 0.009\*\* | 0.003 |
|   | (0.002) | (0.002) | (0.002) | (0.004) | (0.004) | (0.003) | (0.003) | (0.004) | (0.003) |
|  Research Expenses | -0.305\* | -0.326\* | -0.329\* | 0.282 | 0.258 | 0.289 | 0.431 | 0.447 | 0.419 |
|   | (0.175) | (0.179) | (0.175) | (0.262) | (0.266) | (0.258) | (0.267) | (0.308) | (0.299) |
|  Licensing Patents | -0.088\*\* | -0.111\*\* | -0.092\*\* | 0.081\*\* | 0.060\* | 0.083\*\* | 0.090\*\* | 0.053 | 0.171\* |
|   | (0.043) | (0.047) | (0.044) | (0.035) | (0.032) | (0.035) | (0.039) | (0.037) | (0.101) |
|  Total FTEs | -0.002 | -0.002 | -0.002 | -0.010\*\* | -0.010\*\* | -0.009\*\* | -0.007\* | -0.013\*\* | -0.01\*\* |
|   | (0.004) | (0.003) | (0.003) | (0.005) | (0.005) | (0.005) | (0.004) | (0.006) | (0.005) |
|  Legal Fees | 0.354\* | 0.370\* | 0.369\*\* | 0.777\*\* | 0.797\*\* | 0.762\*\* | 0.604\* | 0.525\* | 0.663\* |
|   | (0.182) | (0.187) | (0.186) | (0.309) | (0.314) | (0.309) | (0.309) | (0.313) | (0.343) |
|  Applied Research | -0.077 | -0.090 | -0.174 | -0.487 | -0.515 | -0.397 | 0.521 | 0.967 | 0.542 |
|   | (0.875) | (0.829) | (0.869) | (0.987) | (0.904) | (0.970) | (1.110) | (1.200) | (1.344) |
|  TTO Age | -0.006 | -0.002 | -0.004 | -0.007 | -0.003 | -0.004 | -0.005 | -0.005 | -0.006 |
|   | (0.012) | (0.011) | (0.012) | (0.014) | (0.012) | (0.013) | (0.014) | (0.018) | (0.021) |
|  Medical School | 0.797\*\*\* | 0.739\*\*\* | 0.753\*\*\* | 0.487\* | 0.434 | 0.497\* | 0.614\*\* | 0.093 | 0.44 |
|   | (0.204) | (0.200) | (0.208) | (0.265) | (0.274) | (0.277) | (0.252) | (0.472) | (0.309) |
|  Private | 0.839\*\* | 0.902\*\* | 0.871\*\* | 0.700\*\* | 0.760\*\* | 0.649\*\* | 0.855\*\*\* | 0.581 | 0.792\*\* |
|   | (0.358) | (0.354) | (0.357) | (0.315) | (0.304) | (0.325) | (0.290) | (0.360) | (0.384) |
|  Constant | 12.282\*\*\* | 12.395\*\*\* | 12.488\*\*\* | -1.943 | -1.840 | -1.974 | -2.759 | -1.305 | -3.100 |
|   | (2.148) | (2.195) | (2.145) | (2.456) | (2.490) | (2.318) | (2.380) | (3.879) | (3.101) |
|  State fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
|  Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
|  Observations | 1523 | 1523 | 1523 | 1261 | 1261 | 1261 | 1408 | 680 | 434 |
|  R-squared  | 0.559 | 0.566 | 0.562 | 0.831 | 0.834 | 0.833 | 0.807 | 0.731 | 0.824 |
|  F | 7.36 | 8.62 | 7.57 | 18.67 | 19.90 | 21.47 | 32.75 | 17.03 | 16.58 |
|  |  |  |
| Standard errors are in parenthesis. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |  |  |

# Figures

Figure 1. Moderating effects of licensing track record (licenses per patent) on the relationship between litigations as defendant and licensing income.

#

1. We are grateful to one of our reviewers for suggesting the examination of temporal dimensions [↑](#footnote-ref-2)
2. In contexts where institutional arrnagements exist for the systematic evaluation of research quality such as the UK, the US and the EU (see Ray and Sengupta, 2021) [↑](#footnote-ref-3)
3. We are indebted to one of our reviewers for pointing out this key strategic implication. [↑](#footnote-ref-4)